GUIDE TO USING THIS BINDER

Draft

Remedial Design Package
Parcel E-2

Hunters Point Naval Shipyard
San Francisco, California

June 28, 2013

This binder contains the following five components, which together are the draft remedial design for Parcel E-2. Institutional controls in the land use control remedial design apply to activities discussed in the remedial action monitoring plan and the operation and maintenance plan.

Design Basis Report: This report describes the remedy to be constructed (excavation and offsite disposal of hot spots, soil cover and protective liner, shoreline revetment, groundwater and landfill gas controls, and restored tidal and freshwater wetlands). The report also describes the basis for the design and contains design drawings, project specifications, and supporting engineering calculations.

Remedial Action Monitoring Plan: This plan presents the approach for monitoring groundwater, landfill gas, stormwater, and restored wetlands. The plan also presents details of the planned monitoring and the process for reporting.

Land Use Control Remedial Design: This document addresses the institutional controls required by the Record of Decision for Parcel E-2. The institutional controls will limit exposure to future users of the property and maintain the integrity of the remedy.

Operation and Maintenance Plan: This plan describes the inspection, maintenance, monitoring, and repair approach for maintenance of the remedy at Parcel E-2. Details of this plan will be revised after construction to reflect actual as-built conditions and materials.

Construction Quality Assurance Plan: This plan describes the quality control and quality assurance inspections and tests required during construction of the remedy. This plan will be supplemented by a separate construction quality control plan that will be prepared by the remedial action contractor and approved prior to construction.

Draft

Remedial Design Package, Parcel E-2

Design Basis Report
Remedial Action Monitoring Plan
Land Use Control Remedial Design
Preconstruction Operation and Maintenance Plan
Construction Quality Assurance Plan

Hunters Point Naval Shipyard
San Francisco, California

June 2013

Prepared for:
Department of the Navy
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104

Prepared under:
Naval Facilities Engineering Command Southwest
Contract Number N68711-05-C-6011
DCN: ERRG-6011-0000-0034

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Parcel E-2

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Design Basis Report
Parcel E-2
Hunters Point Naval Shipyard
San Francisco, California

Submitted by:
Engineering/Remediation Resources Group, Inc.

Signature	June 25, 2013 Date
Doug Bielskis, PE Name	Project Manager Title

CERTIFICATION

I hereby certify that this Design Basis Report has been prepared in accordance with good engineering practices.

Doug Bielskis, P.E.
Civil Engineer No. C63113

Executive Summary

This design basis report (DBR) presents the remedial design (RD) for the remedy selected in the Record of Decision (ROD) for Parcel E-2 at Hunters Point Naval Shipyard (HPNS). The selected remedy for Parcel E-2 consists of three primary components: (1) excavation of contaminated soil, sediment, and debris; (2) containment of remaining contamination; and (3) monitoring, maintenance, and institutional controls to protect human health and the environment and to ensure the integrity of the remedy.

The chemicals of concern at Parcel E-2 identified in the ROD are summarized below by impacted media:

- Soil – metals (antimony, arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc), pesticides, polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), dioxins, and radionuclides (cesium-137 [^{137}Cs], cobalt-60 [^{60}Co], radium-226 [^{226}Ra], and strontium-90 [^{90}Sr])
- Shoreline sediment – metals (antimony, copper, lead, mercury, nickel, and zinc), pesticides, and PCBs, and radionuclides (^{226}Ra, ^{137}Cs, and ^{90}Sr)
- Landfill gas – methane and volatile organic compounds (VOCs)
- Groundwater – metals (arsenic, chromium VI, iron, lead, and thallium), pesticides, PCBs, SVOCs, TPH, VOCs, anions (such as cyanide, sulfide, and un-ionized ammonia), and radionuclides (^{226}Ra, ^{137}Cs, and ^{90}Sr)

The following primary components of the selected remedy in the ROD are described in this DBR:

- Excavation and offsite disposal of hot spots
- Onsite consolidation of waste
- Radiological actions
- Soil cover and protective liners
- Shoreline revetment
- Groundwater controls
- Landfill gas controls
- Tidal and freshwater wetlands mitigation
- Monitoring, maintenance, and ICs

This DBR addresses the above elements. The Navy intends to transfer Parcel E-2 to the Successor Agency of the San Francisco Redevelopment Agency.

This DBR is one component of the overall RD for Parcel E-2. The other components include the Remedial Action Monitoring Plan, Land Use Control RD, Operations and Maintenance Plan, and Construction Quality Assurance Plan. All of these components of the RD are included in this binder with this report. In addition, an engineer's opinion of probable cost will be developed and included in the Draft Final version of the DBR.

Table of Contents

EXECUTIVE SUMMARY ES-1

SECTION 1. INTRODUCTION 1-1

SECTION 2. BACKGROUND 2-1

2.1. Site Description 2-1
2.2. History 2-1
2.3. Geology 2-3
2.4. Hydrogeology 2-4
2.5. Nature and Extent of Contamination 2-4
2.5.1. Solid Waste and Soil in the Parcel E-2 Landfill Area 2-5
2.5.2. Landfill Gas 2-6
2.5.3. Soil and Isolated Solid Waste in the Panhandle and East Adjacent Areas 2-6
2.5.4. Groundwater 2-7
2.5.5. Surface Water 2-8
2.5.6. Shoreline Sediment 2-8
2.5.7. Radionuclides in Soil, Sediment, and Groundwater 2-8
2.6. Previous Removal Actions 2-10
2.7. Institutional and Engineering Controls 2-13

SECTION 3. BASIS OF DESIGN 3-1

3.1. Site Preparation 3-3
3.1.1. Site Security Fencing 3-3
3.1.2. Preconstruction Utility and Land Surveys 3-4
3.1.3. Biological Assessment 3-4
3.1.4. Environmental Protection Measures 3-5
3.1.5. Radiological and Nonradiological Material Handling and Storage Areas 3-5
3.1.6. Existing Landfill Cover and Protective Liner 3-6
3.1.7. Existing Groundwater Monitoring Wells 3-6
3.1.8. Site Demolition, Clearing, and Grubbing 3-6
3.2. Excavation and Offsite Disposal of Hot Spots 3-7
3.2.1. Additional Excavation in PCB Hot Spot Area 3-8
3.2.2. Hot Spot Excavation Extents and Volumes 3-9
3.2.3. Preexcavation Characterization Sampling 3-10

3.2.4. Excavation and Confirmation Sampling 3-11
3.2.5. Backfilling of Hot Spot Excavations 3-11
3.2.6. Waste Characterization and Disposal of Hot Spot Soil 3-11
3.3. Grading and Onsite Consolidation of Soil, Sediment, and Debris 3-11
3.3.1. Excavation to Construct Shoreline Revetment 3-11
3.3.2. Excavation to Construct Wetlands 3-12
3.3.3. Excavation to Construct Groundwater Controls 3-13
3.3.4. Site Grading to Construct Final Cover Subgrade 3-13
3.3.5. Radiological Screening and Management of Soil and Sediment 3-14
3.3.6. Radiological Screening and Management of Debris 3-14
3.3.7. Waste Consolidation Criteria 3-15
3.4. Additional Radiological Actions 3-16
3.4.1. Additional Excavation in Ship-Shielding Area 3-16
3.4.2. Potential Refinement of Site-Specific Background Level for Radium-226 3-16
3.4.3. Removal of Sanitary Sewers, Storm Drains, and Septic Sewer Lines 3-16
3.4.4. Final Radiological Survey 3-17
3.5. Soil Cover and Protective Liner 3-18
3.5.1. Geotechnical Considerations 3-19
3.5.2. Soil Cover and Protective Liner for Parcel E-2 Landfill and Adjacent Non-Wetland Areas 3-22
3.5.3. Surface Water Drainage and Erosion Control 3-26
3.5.4. Other Design Considerations for Soil Cover and Protective Liner 3-28
3.5.5. Soil Cover and Demarcation Layer for Wetland Areas 3-29
3.6. Shoreline Revetment 3-29
3.6.1. Water-Level Ranges 3-31
3.6.2. Wind and Wave Dynamics 3-32
3.6.3. Selection of Armor Material 3-33
3.6.4. Revetment Slope Selection 3-34
3.6.5. Armor Unit Sizing 3-35
3.6.6. Crest Elevation 3-36
3.6.7. Filter and Underlayers 3-37
3.6.8. Materials Quantities 3-38
3.6.9. Other Design Considerations – Revetment 3-38

3.7. Groundwater Controls 3-40
3.7.1. Slurry Wall Alignments 3-41
3.7.2. Slurry Wall Dimensions 3-41
3.7.3. Slurry Wall Mix 3-43
3.7.4. Constructability Considerations 3-45
3.7.5. French Drain for Upland Slurry Wall 3-45
3.7.6. Monitoring/Extraction Wells and Piezometers for Nearshore Slurry Wall 3-46
3.7.7. Materials Quantities 3-46
3.8. Landfill Gas Controls 3-47
3.8.1. Existing System 3-48
3.8.2. Gas Collection and Control System 3-49
3.9. Tidal and Freshwater Wetlands 3-62
3.9.1. Water-Level Ranges 3-63
3.9.2. Wind and Wave Dynamics 3-64
3.9.3. Hydric Soil 3-65
3.9.4. Elevations and Planting Zones 3-65
3.9.5. Inlet Structure to Freshwater Wetlands from Subsurface Drain 3-67
3.9.6. Outlet Structure from Freshwater Wetlands to Bay 3-67
3.10. Monitoring, Maintenance, and Institutional Controls 3-68

SECTION 4. REFERENCES 4-1

List of Figures

Figure 1. Site Vicinity Map
Figure 2. Parcel E-2 Areas
Figure 3. Radiologically Impacted Areas
Figure 4. Parcel E-2 Cross-Section Locations
Figure 5. Cross-Section B-B'
Figure 6. Cross-Section G-G'
Figure 7. Cross-Section H-H' and I-I'
Figure 8. Designated Reuse Areas at Parcel E-2
Figure 9. Design Overview
Figure 10. Evaluation of Remaining Contamination After Phase 2 TCRA at PCB Hot Spot Area
Figure 11. Hot Spot Excavations in Shoreline and East Adjacent Areas
Figure 12. Hot Spot Excavations in Panhandle Area
Figure 13. Final Cover System
Figure 14. Final Cover Details
Figure 15. Shoreline Revetment Detail
Figure 16. Landfill Gas Collection System Plan
Figure 17. Impacted Wetlands at HPNS
Figure 18. Wetlands Planting Zones
Figure 19. Areas Requiring Institutional Controls

List of Tables

Table 1. ARARs for Design Components
Table 2. Remediation Goals for Nonradioactive Chemicals in Soil and Sediment
Table 3. Remediation Goals for Radionuclides in Soil and Sediment
Table 4. Remediation Goals for Groundwater
Table 5. Groundwater Monitoring Wells
Table 6. Hot Spot Goals for Soil and Sediment
Table 7. Proposed Hot Spot Excavations
Table 8. Hunters Point Tide Data
Table 9. Existing Gas Monitoring Probes (GMPs)
Table 10. LFG Flare Capacity Ranges Based on RI/FS LFG Generation Estimate
Table 11. LFG Blower Capacity Ranges Based on RI/FS LFG Generation Estimate
Table 12. LFG Generation Modeling Results
Table 13. LFG Condensate Generation Estimates
Table 14. Hunters Point Existing Impacted and Mitigation Wetlands, Areas in Acres
Table 15. Hunters Point Wetland Loss Areas, Actions, and Mitigation
Table 16. Wetland Planting Zones

List of Appendices

Appendix A. Design Calculations
Appendix B. Design Drawings
Appendix C. Project Specifications *(provided on CD only)*
Appendix D Preliminary Radiological Risk Modeling
Appendix E. Geotechnical Analyses Report
Appendix F. Groundwater Containment System Modeling

Acronyms and Abbreviations

AOC	area of contamination
ARARs	applicable or relevant and appropriate requirements
ARIC	area requiring institutional controls
BAAQMD	Bay Area Air Quality Management District
bgs	below ground surface
BMPs	best management practices
Cal. Code Regs.	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEB	clean emissions burner
^{60}Co	cobalt-60
CPT	cone penetrometer test
CQA	construction quality assurance
^{137}Cs	cesium-137
DBR	design basis report
DTSC	Department of Toxic Substances Control
EEC	Eagle Environmental Construction
EPA	U.S. Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group
FFA	Federal Facility Agreement
GAC	granular activated carbon
GCCS	gas collection and control system
GMPs	gas monitoring probes
GCL	geosynthetic clay liner
GSR	green and sustainable remediation
HDPE	high-density polyethylene
HPNS	Hunters Point Naval Shipyard
HRA	Historical Radiological Assessment
ICs	institutional controls
IPCC	Intergovernmental Panel on Climate Change

IR	Installation Restoration
LEL	low explosive limit
LFG	landfill gas
LUC RD	land use control remedial design
MCE	maximum credible earthquake
MHHW	mean higher high water level
MHW	mean high water level
MLLW	mean lower low water level
msl	mean sea level
M_w	moment magnitude
NAD	North American datum
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGVD	National Geodetic Vertical Datum
NMOCs	non-methane organic compounds
NOAA	National Oceanic and Atmospheric Administration
NRDL	Naval Radiological Defense Laboratory
OMP	operation and maintenance plan
pCi/g	picocuries per gram
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
ppmv	parts per million by volume
^{226}Ra	radium-226
RAMP	Remedial Action Monitoring Plan
RAOs	remedial action objectives
RAWP	remedial action work plan
RCA	radiologically controlled area
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RI/FS	Remedial Investigation/Feasibility Study
RIEC	remedial investigation evaluation criteria
ROC	radionuclide of concern
ROD	Record of Decision

RSRS	Radiological Survey and Remedial Services, LLC
RWQCB	Regional Water Quality Control Board
SB	soil-bentonite
SCB	soil-cement-bentonite
SFPUC	City of San Francisco Public Utilities Commission
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
Shaw	Shaw Environmental, Inc.
^{90}Sr	strontium-90
scfm	standard cubic feet per minute
Successor Agency	Successor Agency to the San Francisco Redevelopment Agency
SVOCs	semivolatile organic compounds
TCRA	time-critical removal action
tit.	Title
TOC	top of casing
TPH	total petroleum hydrocarbons
TtEMI	Tetra Tech EM Inc.
TtECI	Tetra Tech EC, Inc.
TtFW	Tetra Tech FW, Inc.
TW	temporary well
95 UCL	95th percent upper confidence limit of the mean activity level
UCSF	University of California, San Francisco
USACE	U.S. Army Corps of Engineers
VOCs	volatile organic compounds
WMMP	wetlands mitigation and monitoring plan
W_{50}	median rock size
W_{100}	largest rock obtained
µg/L	micrograms per liter
§	Section

Section 1. Introduction

This design basis report (DBR) presents the Department of the Navy's (Navy) remedial design (RD) for the remedy selected in the Record of Decision (ROD) for Parcel E-2 at Hunters Point Naval Shipyard (HPNS) (Navy, 2012). The selected remedy for Parcel E-2 consists of three primary components: (1) excavation of contaminated soil, sediment, and debris; (2) containment of remaining contamination; and (3) monitoring, maintenance, and institutional controls (ICs) to protect human health and the environment and to ensure the integrity of the remedy. The document was developed and the remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (Title 42 United States Code Section (§) 9601, et seq.), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 Code of Federal Regulations Part 300).

The remedy selected in the ROD protects the public health and welfare and the environment from actual or threatened releases of pollutants, chemicals, or hazardous substances from solid waste, soil, shoreline sediment, groundwater, and landfill gas (LFG) at Parcel E-2. The selected remedy was based on the following information:

- Site histories
- Field investigations and removal actions
- Laboratory analytical results
- Evaluation of potential risks to humans and wildlife
- Current and reasonably anticipated future land uses
- The 2012 Parcel E-2 ROD

This DBR describes how the remedy will meet the requirements of the approved ROD. Table 1 includes the applicable or relevant and appropriate requirements (ARARs) from the ROD and summarizes how each design component addresses the ARARs. Table 1 identifies only the ARARs and their substantive provisions that address the intent of the ROD in this DBR.

This DBR specifically addresses the following elements of the selected remedy:

- Site preparation
- Excavation and offsite disposal of hot spots

- Grading and onsite consolidation of waste
- Radiological actions
- Soil cover and protective liners
- Shoreline revetment
- Groundwater controls
- LFG controls
- Tidal and freshwater wetlands (i.e., mitigation and construction)
- Monitoring, maintenance, and ICs

Figures, tables, and appendices referenced in this DBR follow Section 4. The following appendices are included with this DBR:

- Design Calculations (Appendix A)
- Design Drawings (Appendix B)
- Project Specifications (Appendix C)
- Preliminary Radiological Risk Modeling (Appendix D)
- Geotechnical Analyses Report (Appendix E)
- Groundwater Containment System Modeling (Appendix F)

This DBR is one of several components that describe the selected remedy and its implementation. Additional documents related to the remedy include the land use control remedial design (LUC RD); the remedial action monitoring plan (RAMP) for groundwater, LFG, wetlands, and stormwater; the construction quality assurance (CQA) plan; pre-construction cost opinion; and the pre-construction operation and maintenance plan (OMP). These documents are included under the same cover as this DBR, except for the pre-construction cost opinion, which will be included in the Draft Final version of the design package. Other documents include future transfer documents, such as a Covenant to Restrict Use of Property and a Quitclaim Deed.

PARCEL E-2 SITE TRANSFER

The Navy intends to transfer Parcel E-2 to the Successor Agency to the San Francisco Redevelopment Agency (Successor Agency) before construction of the remedy is fully completed. However, excavation of contaminated soil, sediment, and debris and containment of remaining contamination will be complete. Transferring the site before the Navy fully completes the remedy will facilitate redevelopment of the site by the Successor Agency. The fully designed remedy, including monitoring, maintenance, and ICs, described in this document is required by the ROD if transfer were not to occur. The LFG mitigation systems will be designed, installed, and maintained by the Successor Agency consistent with U.S.

Environmental Protection Agency's (EPA) "Guidance for Evaluating Landfill Gas Emissions From Closed or Abandoned Facilities" (EPA, 2005) and in accordance with the substantive portions of the ARARs indicated for the LFG monitoring and control components of the design (Table 1).

After site transfer, the Successor Agency will complete implementation of the approved remedy. The Successor Agency will operate the LFG control system, and a leachate and groundwater control system, if future groundwater and leachate monitoring indicates the need for further remedial action. The RD includes leachate monitoring/extraction wells and piezometers along the nearshore Parcel E-2 Landfill cap and a slurry wall to monitor the remedy performance (see Section 3.7). Additionally, the Successor Agency will incorporate maintenance and construction of the specified final covers and shoreline revetment that meet the requirements of the ROD into redevelopment of the site. Redevelopment plans for the site and long-term land use have not been conclusively established. The Successor Agency will submit work plans and other similar design and construction planning documents to the regulatory agencies—including EPA, Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (SFRWQCB)—for review and approval before redevelopment begins to ensure the selected cover and revetment are protective of human health and the environment and to confirm that the cover and revetment meet the requirements of the ROD (Navy, 2012).

Section 2. Background

The following sections describe the facility, location, and general history of Parcel E-2. This background section is provided to summarize the general conditions at the site.

2.1. SITE DESCRIPTION

HPNS is located in southeastern San Francisco on a peninsula that extends east into San Francisco Bay (Figure 1). HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. Parcel E-2 consists of 47.4 acres of shoreline and lowland coast along the southwestern portion of HPNS, and contains four distinct areas (Figure 2):

- The "Parcel E-2 Landfill," located in the north-central part of Parcel E-2
- The "Panhandle Area," located west and southwest of the Parcel E-2 Landfill
- The "East Adjacent Area," located to the east of the Parcel E-2 Landfill
- The "Shoreline Area" located at the edge of San Francisco Bay

A small portion of the Parcel E-2 Landfill extends north onto property owned by the University of California, San Francisco (UCSF) (Figure 2).

2.2. HISTORY

The HPNS property was placed on the National Priorities List in 1989 as a Superfund site pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986, because past shipyard operations left hazardous materials on site. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPNS involve conducting environmental remediation and making the property available for nondefense use. As a management tool to accelerate site investigation, cleanup, and reuse, HPNS was divided into parcels. Sites within each parcel are evaluated concurrently. In September 2004, the Navy divided Parcel E into two parcels (Parcels E and E-2) to facilitate closure of the Parcel E-2 Landfill and its adjacent areas.

Parcel E-2 was created by filling in the bay margin with various materials, including native soil, rock, and sediment, as well as construction and industrial debris. The ground surface elevation at Parcel E-2 varies from approximately 30 feet above mean sea level (msl) in the northern portion of the parcel to a few feet above msl along the southwestern portion of the parcel. The Parcel E-2 Landfill is a 22-acre area where the Navy disposed of various shipyard wastes from the mid-1950s to the early-1970s. These wastes include:

- Construction debris (including wood, steel, concrete, and soil)
- Municipal-type trash (including paper, plastic, and metal)
- Industrial waste (including sandblast waste, paint sludge, solvents, and polychlorinated biphenyl [PCB]-containing waste oils)

The Navy's investigations showed that the Parcel E-2 Landfill waste consists of construction debris and trash, with small amounts of industrial waste. After the 22-acre landfill closed in the early 1970s, the Navy covered it with 2 to 5 feet of soil. As detailed in Section 2.5, the Navy has since performed several removal actions at Parcel E-2 to minimize potential exposure to hazardous chemicals. These actions included construction of an additional interim Parcel E-2 Landfill cap over 14.5 acres of the landfill that was burned during an August 2000 brush fire. The interim landfill cap was constructed to inhibit oxygen migration into the waste to prevent more fires from occurring under the capped area. The total volume of existing soil cover over the 22-acre landfill is estimated to be 393,500 cubic yards, and the volume of the Parcel E-2 Landfill waste is estimated to be 473,000 cubic yards.

Fill materials in the East Adjacent, Panhandle, and Shoreline Areas of Parcel E-2 are distinct from the Parcel E-2 Landfill. Specifically, fill materials in the East Adjacent, Panhandle, and Shoreline Areas consist primarily of soil, sediment, and rock with isolated solid waste locations that are not contiguous with solid waste in the Parcel E-2 Landfill. The characteristics of the East Adjacent, Panhandle, and Shoreline Areas are described below.

- The East Adjacent Area was created by filling in San Francisco Bay prior to the 1950s with soil and construction debris. Some industrial waste was disposed of in parts of the East Adjacent Area, including an area referred to as the "PCB Hot Spot Area." The PCB Hot Spot Area was partially addressed under an early removal action (see Section 2.5).
- The Panhandle Area was created by filling in San Francisco Bay in the 1950s with soil and construction debris. The Navy disposed of metal slag in a part of the Panhandle Area referred to as the Metal Slag Area. Also, the Navy tested ship-shielding technologies in another part of the Panhandle Area referred to as the Ship-Shielding Area. The Metal Slag Area and the Ship-Shielding Area were partially addressed under an earlier removal action (see Section 2.5).
- The Shoreline Area is adjacent to San Francisco Bay and contains contaminated sediment above msl that will be addressed by the selected remedy for Parcel E-2. Contaminated sediment below msl will be addressed by the selected remedy for Parcel F, the Navy's property offshore of HPNS.

Although several removal actions have been completed at Parcel E-2, chemicals of concern and chemicals of ecological concern still remain on site. The Historical Radiological Assessment (HRA) also identified areas where low-level radiological material may be located at Parcel E-2 (Naval Sea Systems Command [NAVSEA], 2004). These areas are shown on Figure 3.

The following radiological operations were identified at Parcel E-2:

- Dials, gauges, and deck markers painted with radioactive paint (containing low levels of radium-226 [^{226}Ra]) to make the devices glow in the dark) were disposed of at the Parcel E-2 Landfill and portions of the Panhandle Area and the East Adjacent Area (located within Installation Restoration [IR] Sites 01/21 and 02).
- Industrial debris and metal slag with dials, gauges, and deck markers painted with radioactive paint were disposed of at the Metal Slag Area (removed during a previous removal action).
- Small amounts of low-level radionuclides may be present in drain lines in the eastern part of Parcel E-2. Potential releases of low-level radionuclides into drain lines at former Naval Radiological Defense Laboratory (NRDL) buildings located outside of Parcel E-2 (in Parcel E) may have led to drain lines in the eastern part of Parcel E-2. The drain lines in Parcel E and any contamination in them are currently being excavated as part of an ongoing removal action being performed throughout HPNS.
- Materials used during radiological experiments by NRDL may have been disposed of at the Parcel E-2 Landfill and portions of the Panhandle Area and the East Adjacent Area (located within IR-01/21 and IR-02). However, historical records presented in the HRA suggest that such material was strictly controlled, particularly after 1954 when the U.S. Atomic Energy Commission began regulating the use of radionuclides at HPNS (NAVSEA, 2004). This information indicates that the volume of NRDL waste potentially disposed of in and around the Parcel E-2 Landfill was relatively low because most of these areas were filled after 1955.

Sandblast waste from cleaning ships used during weapons testing in the South Pacific may have been disposed of at the Parcel E-2 Landfill, the Panhandle Area, and portions of the East Adjacent Area (located within IR-01/21 and IR-02). However, historical records presented in the HRA indicate that waste with the highest levels of radioactivity was controlled and not disposed of anywhere at HPNS, including Parcel E-2 (NAVSEA, 2004).

2.3. GEOLOGY

The peninsula forming HPNS is within a northwest-trending belt of the Franciscan Complex bedrock known as the Hunters Point Shear zone. The natural geology at HPNS consists of unconsolidated Holocene sediment of estuarine and alluvial origin (Quaternary age) deposited on an uneven, eroded bedrock surface composed primarily of serpentinite (Jurassic-Cretaceous age). Artificial fill was deposited extensively over the natural sediment and bedrock during expansion of the shipyard in the early 1940s. Six individual geologic units have been identified at HPNS. Representative geologic cross sections from the Remedial Investigation/Feasibility Study (RI/FS) Report are provided on Figures 4 through 7 for information purposes in this DBR (Figures 6 and 7 also depict the hydrostratigraphy within Parcel E-2, which is described further in Section 2.4). In general, the stratigraphic sequence of the geologic units, from youngest (shallowest) to oldest (deepest), is as follows: (1) Artificial Fill; (2) Slope Debris and Ravine Fill; (3) Undifferentiated Upper Sand Deposits; (4) Bay Mud; (5) Undifferentiated

Sedimentary Deposits; and (6) Franciscan Complex Bedrock (Engineering/Remediation Resources Group, Inc. [ERRG] and Shaw Environmental, Inc. [Shaw], 2011).

2.4. HYDROGEOLOGY

The hydrostratigraphy of Parcel E-2 consists of four distinct units: the shallow A-aquifer, several aquitard zones, the deeper B-aquifer, and underlying bedrock water-bearing zone. An aquitard zone separates the A- and B-aquifer across most of Parcel E-2, except in the northwest corner. Additional aquitard zones within the B-aquifer sediment isolate the uppermost portions of the B-aquifer (that are interconnected with the A-aquifer) from the lower portions of the B-aquifer. Representative hydrogeologic cross sections from the RI/FS Report are provided on Figures 6 and 7 for information purposes in this DBR.

Groundwater is not currently used for any purpose at Parcel E-2. Groundwater in the A-aquifer is not suitable as a potential source of drinking water (Navy, 2012). Based on an evaluation of site-specific conditions relative to pertinent regulatory criteria, groundwater in the B-aquifer has a moderate potential to be used as a future source of drinking water (ERRG and Shaw, 2011).

Groundwater flow patterns at Parcel E-2 are complex because they are potentially affected by (1) a groundwater sink located in adjacent Parcel E; (2) leaks of groundwater into former sanitary sewers or storm drains; (3) recharge from water supply lines; and (4) tides in San Francisco Bay. Most groundwater at Parcel E-2 flows toward San Francisco Bay. In the northeastern portion of Parcel E-2, however, groundwater has historically flowed toward the groundwater sink in Parcel E, where groundwater elevations are below msl. The sink was likely caused by leaks of groundwater into sanitary sewer lines, which were then pumped to the offsite publicly owned treatment works, thereby lowering groundwater levels in the area (ERRG and Shaw, 2011). Flow patterns continue to change now that pumping has been discontinued and as sewer and storm drain lines are removed throughout Parcel E and other HPNS parcels. Sewer and storm drain lines remain in the northern and eastern portions of Parcel E-2 (Figure 3)

2.5. NATURE AND EXTENT OF CONTAMINATION

Activities associated with known or potential contaminant releases at Parcel E-2 were identified and environmental investigations were conducted to identify and assess the nature and extent of contaminants in the following media of concern at Parcel E-2: (1) solid waste and soil in the Parcel E-2 Landfill; (2) LFG; (3) soil and isolated solid waste in the Panhandle and East Adjacent Areas; (4) groundwater; (5) surface water; and (6) shoreline sediment. The following sections summarize the nature and extent of contamination in each medium, as well as the nature and extent of radionuclides in soil, sediment, and groundwater. The ROD (Navy, 2012), the RI/FS Report (ERRG and Shaw, 2011), and the radiological addendum to the RI/FS Report (ERRG and Radiological Survey and Remedial Services, LLC [RSRS], 2011) contain more details on the nature and extent of contamination at Parcel E-2.

The previous investigations and evaluations provided sufficient information to evaluate site risks, develop and evaluate remedial alternatives, select remediation goals, and support the remedy decision made in the ROD. Tables 2, 3, and 4 list the remediation goals for nonradioactive chemicals in soil and shoreline sediment, radionuclides in soil and shoreline sediment, and for nonradioactive chemicals in groundwater, respectively. The selected remedy prevents exposure to concentrations exceeding the remediation goals through (1) excavation and disposal of soil hot spots that are a continuing source of groundwater contamination and (2) containment of remaining contamination with monitoring, maintenance, and ICs.

2.5.1. Solid Waste and Soil in the Parcel E-2 Landfill Area

The contiguous solid waste in the Parcel E-2 Landfill is composed primarily of municipal-type waste and construction debris. The waste was observed in 28 soil borings, 18 monitoring wells, and 25 test pits extended within the Parcel E-2 Landfill. The solid waste includes wood, paper, plastic, metal, glass, asphalt, concrete, and bricks that are mixed with sand, clay, and gravel fill. Construction debris (such as asphalt, concrete, and brick) is typically inert and is not expected to generate leachate that would create potential risks to human health or the environment (ERRG and Shaw, 2011).

In addition to municipal-type waste and construction debris, historical information indicated that industrial wastes, including sandblast waste, radioluminescent devices, asbestos-containing debris, paint sludge, solvents, and waste oils, were also disposed of in or around the Parcel E-2 Landfill (Naval Energy and Environmental Support Activity, 1984; NAVSEA, 2004). The presence of some of these industrial wastes was confirmed during cleanup activities within the PCB Hot Spot Area, which extended into a small portion the Parcel E-2 Landfill (Navy, 2005a through 2005e; Tetra Tech EC, Inc. [TtECI], 2007a). The characterization data suggested that the quantity of industrial waste within the Parcel E-2 Landfill is less than the quantity of municipal-type waste and construction debris.

The areal extent of solid waste covers approximately 22 acres, and the estimated volume of the solid waste is 473,000 cubic yards. Waste across the Parcel E-2 Landfill varies from less than 10 feet thick to greater than 25 feet thick (with an average thickness of about 13 feet). In most areas of the Parcel E-2 Landfill, waste is in direct contact with groundwater (ERRG and Shaw, 2011).

The soil data set for the Parcel E-2 Landfill was derived from 333 soil samples collected from the intermittent soil fill mixed within the solid waste. Metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), PCBs, pesticides, and petroleum hydrocarbons were detected at concentrations exceeding remedial investigation evaluation criteria (RIEC) in soil samples collected at the Parcel E-2 Landfill. However, nearly all of the exceedances were of a limited extent relative to the overall waste volume. These results indicated that lesser quantities of potentially hazardous industrial wastes are present in the landfill as compared with municipal-type waste and construction debris.

The nature and extent of solid waste and chemicals in soil within the Parcel E-2 Landfill was adequately characterized to select the remedy within the ROD (Navy, 2012). This determination is based in large part on EPA presumptive remedy guidance for CERCLA landfills (EPA, 1993a, 1993b, 1994, and 1996b). Consistent with EPA guidance, characterization of the solid waste is not necessary or appropriate for selecting a remedy for the Parcel E-2 Landfill.

2.5.2. Landfill Gas

To characterize LFG, temporary soil gas borings and permanent gas monitoring probes (GMPs) were installed around the perimeter of the landfill and at adjacent locations. It was determined that methane was present at concentrations exceeding 25 percent of the lower explosive limit (LEL), equivalent to 1.25 percent methane by volume, north of the Parcel E-2 Landfill (including property owned by the UCSF). Methane was not detected at concentrations exceeding 25 percent of the LEL in locations along Crisp Road (approximately 200 feet north of the Parcel E-2 Landfill) or to the east, south, and west of the landfill. Nonmethane organic compounds (NMOCs) were detected in both the temporary soil gas borings and the permanent GMPs, with the highest concentrations immediately north of the Parcel E-2 Landfill (ERRG and Shaw, 2011).

Upon completion of the LFG characterization, the Navy conducted a removal action to (1) remove LFG and reduce subsurface methane concentrations at the UCSF compound to below the LEL (5 percent methane by volume in air) and (2) control future migration of LFG to offsite areas. The removal action involved installation and operation of a gas control, extraction, and treatment system. Monitoring is performed on a regular basis and includes notification and response procedures if hazardous concentrations of LFG (either methane or NMOCs) are detected beyond the fence line of the landfill and beneath the UCSF compound.

Data collected as part of the LFG characterization study, the removal action, and ongoing LFG monitoring have adequately defined the nature and extent of LFG at Parcel E-2. The Navy will perform a LFG survey to better estimate the gas generation rates from the Parcel E-2 Landfill and to determine the content of the LFG. The survey will also more thoroughly evaluate soil gas concentrations in the Panhandle, East Adjacent, and Shoreline Areas to determine if gas collection and control (such as passive subsurface venting) is required. The Navy prepared a draft work plan for the Parcel E-2 LFG survey (ITSI Gilbane Company, 2013) and fieldwork is planned for summer 2013. The results of the Parcel E-2 LFG survey will support the design of the LFG control system, which will be provided in the Draft Final RD and will detail the extraction and treatment of LFG.

2.5.3. Soil and Isolated Solid Waste in the Panhandle and East Adjacent Areas

The nature and extent of solid waste in the Panhandle and East Adjacent Areas are distinct from the solid waste defined in the Parcel E-2 Landfill. Specifically, fill material in the Panhandle and East Adjacent

Areas consists primarily of soil and rock with isolated solid waste locations that are not contiguous with solid waste in the Parcel E-2 Landfill. Solid waste within the Panhandle and East Adjacent Areas consists of a heterogeneous distribution of construction debris (primarily concrete, brick, wood, and asphalt) and isolated locations of industrial wastes (such as sandblast waste, metal slag, radioluminescent devices, and oily waste) (ERRG and Shaw, 2011). Industrial wastes were encountered in the Metal Slag Area (in the Panhandle Area) and PCB Hot Spot Area (in the East Adjacent Area) during recent removal actions and were removed and disposed of off site; however, chemical concentrations remain in soil at both areas and require further analysis, as discussed in Section 3.2.2 of this DBR.

The soil data set was derived from 754 soil samples (113 soil borings, 113 excavation grids within the PCB Hot Spot Area and Metal Slag Area, and 14 test pits) collected from surface and subsurface locations within the Panhandle and East Adjacent Areas. Metals, SVOCs, VOCs, pesticides, PCBs, dioxins and furans, and petroleum hydrocarbons were detected at concentrations exceeding RIECs in soil samples collected in the Panhandle and East Adjacent Areas. Soil contamination is more widely distributed in the Panhandle Area and the shallow zones (0 to 10 feet below ground surface [bgs]) of the East Adjacent Area. The distribution of soil contamination is smaller within the East Adjacent Area at depths greater than 10 feet bgs. This finding is attributed to the fact that deep soil within the East Adjacent Area consists of either natural sediment or naturally derived fill material placed during expansion of the shipyard in the early 1940s (ERRG and Shaw, 2011).

The heterogeneous distribution of solid waste and soil contamination makes delineation of potential areas of concern problematic; however, past characterization efforts have provided sufficient data to evaluate potential risks to humans and wildlife at Parcel E-2 because past sampling locations have focused, to the extent practical, on the most likely contaminant sources (based on a comprehensive review of historical aerial photographs and any visual evidence of contamination).

2.5.4. Groundwater

Groundwater contamination has been confirmed based on the results of groundwater samples collected across Parcel E-2 in both the A-aquifer and uppermost B-aquifer. The lateral and vertical extent of chemicals in groundwater has been defined across most of Parcel E-2 through a series of investigations and the ongoing groundwater monitoring program. In 2008, a focused data gaps investigation was performed along the Parcel E-2 shoreline, and results of the investigation helped to identify areas requiring remedial action (including excavation of remaining contaminant sources and containment of remaining low-level contamination). Primary potential migration pathways for contaminated groundwater include migration and discharge of A-aquifer groundwater into San Francisco Bay and wetlands and migration of A-aquifer groundwater (including the saturated waste layer) into the uppermost B-aquifer (ERRG and Shaw, 2011).

The primary groundwater analytical groups at Parcel E-2 include metals, SVOCs, VOCs, pesticides, PCBs, petroleum hydrocarbons, and anions (such as ammonia and cyanide). Groundwater sampling results indicated that the concentrations and extent of contamination in the uppermost B-aquifer are less than observed in the A-aquifer because of the hydrogeologic and geologic characteristics (i.e., the presence of Bay Mud between the A- and B-aquifers) across most of Parcel E-2. Overall, the number of detected chemicals and their detected concentrations in both aquifers have generally declined between 1990 and 2012 (ERRG and Shaw, 2011; CE2-Kleinfelder Joint Venture, 2012).

2.5.5. Surface Water

Potential exposure of wildlife to unacceptable chemical concentrations in surface water runoff is monitored in accordance with a Stormwater Discharge Management Program (Accord MACTEC Joint Venture, 2012). Results to date indicated no incidents of noncompliance at Parcel E-2 except in isolated locations where best management practices (BMPs) require modification to better control erosion and sediment transport from neighboring properties (Tetra Tech EM Inc. [TtEMI], 2004b; AFA Construction Group and Eagle Environmental Construction [EEC], 2005; EEC, 2006 and 2007; MARRS Services, Inc. and MACTEC Engineering and Consulting, 2008, 2009, and 2010). The ongoing maintenance of the interim cap and implementation of BMPs serves to minimize erosion from surface water runoff and potential exposure to wildlife. Implementation of the remedy at Parcel E-2 includes continued management (through BMPs) and monitoring of surface water runoff to ensure that surface water from Parcel E-2 does not impact aquatic wildlife in San Francisco Bay.

2.5.6. Shoreline Sediment

Potential risks to wildlife, specifically benthic invertebrates, birds, and mammals, exposed to intertidal sediment at Parcel E-2 were evaluated in a screening-level ecological risk assessment (ERRG and Shaw, 2011). Concentrations of chemicals in surface and subsurface sediment samples collected from the Shoreline Area were screened against toxicological benchmarks for invertebrates, birds, and mammals. The shoreline risk assessment concluded that concentrations of copper and lead in sediment along the Parcel E-2 shoreline are a potential source of contamination to Parcel F. In addition, benthic invertebrates, birds, and mammals are at risk from exposure to PCBs in surface sediment along the Parcel E-2 shoreline.

Containment measures are warranted along the Parcel E-2 shoreline to control potential releases of copper and lead to Parcel F and prevent unacceptable exposure to benthic invertebrates, birds, and mammals that may inhabit the shoreline.

2.5.7. Radionuclides in Soil, Sediment, and Groundwater

Past radiological investigations, which were performed at various HPNS locations in five different phases, have involved collection of more than 1,000 soil samples at Parcel E-2 within the upper 6 inches of the ground surface and analysis for a suite of 17 radionuclides (ERRG and RSRS, 2011). The most

extensive investigation at Parcel E-2 was the Phase V radiological investigation during which the parcel was divided into 73 survey units (each 2,000 square meters, or 21,528 square feet); however, one entire survey unit was subsequently excavated during the Phase 1 time-critical removal action (TCRA) at the PCB Hot Spot Area, resulting in data remaining from 72 of the original 73 survey units. Within each survey unit, pertinent statistics for each radionuclide of concern (ROC), including the mean and maximum activity levels and the 95th percent upper confidence limit of the mean activity level (95 UCL activity level), were calculated. For evaluation purposes, the 95 UCL activity levels for each ROC were compared against residential and outdoor worker remediation goals, as established in an action memorandum for the basewide radiological TCRA to provide the following general assessment of the distribution of ROCs in surface soil at Parcel E-2 (ERRG and RSRS, 2011).

- Cesium-137 (^{137}Cs) (an ROC in all radiologically impacted areas at Parcel E-2) – The extent of ^{137}Cs in surface soil is moderately extensive, with the 95 UCL activity level exceeding the remediation goal (0.113 picocuries per gram [pCi/g]; residential and outdoor worker remediation goals are identical) in 16 out of 72 survey units.
- Radium-226 (^{226}Ra) (an ROC in all radiologically impacted areas at Parcel E-2) – The extent of ^{226}Ra in surface soil is widespread, with the 95 UCL activity level exceeding the remediation goal (1 pCi/g above background not to exceed 2 pCi/g; residential and outdoor worker remediation goals are identical) in 69 out of 72 survey units.
- Cobalt-60 (^{60}Co) (an ROC in the Ship-Shielding Area at Parcel E-2) – The ROC ^{60}Co was suspected to be present in soil in the vicinity of the former Ship-Shielding Area, based on the nature of historical activities conducted at that location. As described in Section 2.6, the Navy completed a TCRA in the Ship-Shielding Area to address potential ^{60}Co contamination. The TCRA did not identify ^{60}Co concentrations exceeding the remediation goal (0.252 pCi/g) (Shaw, 2013a; Navy, 2012).
- Strontium-90 (^{90}Sr) (an ROC in all radiologically impacted areas at Parcel E-2) – ^{90}Sr is not present in surface soil at radioactivity levels exceeding the outdoor worker remediation goal (10.8 pCi/g); however, using the more conservative residential remediation goal (0.331 pCi/g), the extent of ^{90}Sr in surface soil in Parcel E-2 is moderately extensive, with the 95 UCL activity level exceeding the remediation goal for residents in 37 of the 72 survey units.

The Phase V investigation of Parcel E-2 was conducted as a scoping survey to determine what additional action, if any, would be required. Based on the results of the Phase V investigation, in particular the consistent low activity levels of ^{226}Ra (3 to 4 pCi/g) throughout the survey units, the selected remedy addresses potential radionuclides in surface soil throughout the radiologically impacted portions of Parcel E-2. In addition, the results of the Phase V investigation were not used to eliminate further evaluation of ROCs identified in the HRA. For example, the relative lack of ^{90}Sr exceeding the outdoor worker release criterion is not adequate to eliminate consideration of this ROC, and ^{90}Sr will remain an ROC throughout the cleanup process at Parcel E-2 to ensure that potential ^{90}Sr contamination is addressed.

The extent of radioactive contamination in subsurface soil and shoreline sediment (Figure 3) has not been completely defined; however, the selected remedy conservatively assumes, consistent with the findings of the HRA (NAVSEA, 2004) and radiological addendum to the RI/FS Report (ERRG and RSRS, 2011), that potential radionuclides (specifically ^{137}Cs, ^{226}Ra, and ^{90}Sr) may be present in subsurface soil and shoreline sediment at Parcel E-2 and will therefore require remedial action. In addition, the RI/FS Report concluded that subsurface soil and shoreline sediment throughout Parcel E-2 contain nonradioactive chemicals that require remedial action (ERRG and Shaw, 2011). As a result, the selected remedy addresses the potential radionuclides and nonradioactive chemicals in subsurface soil and shoreline sediment at Parcel E-2.

The groundwater data set from two investigations, performed in 2002 and 2008, consists of samples collected from 78 A-aquifer wells and 1 B-aquifer well that were analyzed for ^{137}Cs, ^{226}Ra, and ^{90}Sr. The radionuclide groundwater data were evaluated by simple (non-statistical) threshold comparisons with a fixed standard (such as drinking water standards) and by statistical tests comparing the site data with fixed standards (one-sample statistical tests) (ERRG and RSRS, 2011). Through these comparisons, the radiological addendum concluded that groundwater does not appear to have been impacted by radionuclides at activity levels that warrant remedial action. However, the selected remedy includes future monitoring to demonstrate, consistent with the findings of previous radiological investigations, that radionuclides are not present in groundwater at activity levels that are both statistically significant and pose an unacceptable risk to human health and the environment. The determination of statistical significance will be made in accordance with the substantive provisions of Title 22 of the California Code of Regulations (Cal. Code Regs.) § 66264.98(i). The duration of the groundwater monitoring for radionuclides will be determined in accordance with Title 22 Cal. Code Regs. § 66264.90(c).

2.6. PREVIOUS REMOVAL ACTIONS

Several CERCLA removal actions and other interim actions have been performed at Parcel E-2, which are summarized in the following table. All information included in each summary was derived from the corresponding document listed in the first column. A more detailed summary of the removal actions completed through 2006 can be found in Section 3.8 of the RI/FS Report (ERRG and Shaw, 2011), and the post-excavation conditions following these actions were considered in evaluating the nature and extent of contamination in the RI/FS Report and its radiological addendum (as summarized in Section 2.5). Two TCRAs (at the PCB Hot Spot Area and the Ship-Shielding Area) were completed in late 2012 and documented in removal action completion reports finalized in 2013 (Shaw, 2013a and 2013b). The table below briefly summarizes the results of the recent TCRAs at the PCB Hot Spot Area and the Ship-Shielding Area. The post-excavation conditions at the PCB Hot Spot Area are further discussed in Section 3.2.1. The post-excavation conditions at the Ship-Shielding Area are further discussed in Section 3.4.1.

Summary of Previous Removal Actions

Removal Action[a]	Date(s)	Removal Action Activities
Sandblast Waste Fixation (Battelle Memorial Institute, 1996)	1991 to 1995	In total, 4,665 tons of sandblast waste was collected from eight small piles around HPNS. The removal was completed in 1995.
Storm Drain Sediment Removal Action (International Technology Corporation, 1997)	1996 to 1997	The Navy removed accumulated sediment from the storm system at HPNS to limit potential transport of contaminated sediment to San Francisco Bay as part of a non-time-critical removal action. Less than 1,000 feet of the HPNS storm drain system extended into Parcel E-2. Most storm drain lines within Parcel E-2 were inaccessible during the removal action, except for a short section of storm drain (less than 200 feet) southwest of Building 810. Activities consisted of (1) removing sediment and debris from accessible storm drain lines, catch basins, and manholes; (2) pre- and post-cleaning video inspections of the pipelines; and (3) water jetting of the pipelines, catch basins, and manholes. Sediment generated during cleaning of the accessible sewers was dewatered, sampled, analyzed for waste characterization purposes, and disposed of at a licensed, offsite facility.
Groundwater Extraction System and Containment Barrier (International Technology Corporation, 1999)	1997 to 1998	A vertical sheet-pile wall and groundwater extraction system were installed at the southeast portion of Parcel E-2 to control contaminated groundwater next to San Francisco Bay. The sheet-pile wall, which remains in place, consists of interlocking steel panels and limits the flow of groundwater to the bay. The extraction system consisted of horizontal and vertical pipes and groundwater pumps, and removed contaminated groundwater that was transported to the offsite publicly owned treatment works. The Navy operated the extraction system until 2005, when it was removed so that the contaminant source (i.e., the PCB Hot Spot Area) could be excavated and disposed of at one or more approved offsite landfills. During its 6 years of operation, extracted groundwater was tested for chemical contaminants and found to meet the City and County of San Francisco's requirements for direct discharge to the sanitary sewer system.
Interim Landfill Cap Construction (TtEMI, 2005a)	2000 to 2001	A protective liner and soil cover were installed over part of the landfill (about 14.5 acres) to stop smoldering below ground following a brush fire. The fire started on August 16, 2000, and was extinguished at the surface within 6 hours, but small areas continued to smolder below ground for approximately 1 month. Because the protective liner and soil cover limit oxygen from entering into the landfill, they prevent more fires from occurring under the capped area. An extensive air monitoring program was performed during cap construction to demonstrate that public health and the environment of the nearby community were not compromised by air emissions from the subsurface smoldering and landfill capping activities.
Landfill Gas TCRA (TtEMI, 2004a)	August 2002 to May 2003	An LFG barrier wall, monitoring probes, and extraction wells were installed along the northern Parcel E-2 boundary to control gas from moving past the landfill boundary. The barrier wall, which consists of thick interlocking plastic panels, limits LFG from moving past the wall and directs it into a collection trench. The monitoring probes are used to verify that LFG is properly controlled. The extraction wells, which were used from 2002 to 2003 to remove LFG that had migrated under the UCSF facility, are currently used for monitoring purposes only. The Navy continues to operate and maintain the barrier wall to control the migration of LFG.
Metal Slag Area Removal Action (TtECI, 2007b)	June 2005 to May 2006	The TCRA at the Metal Slag Area was performed to remove metal slag and debris containing low-level radiological material, as well as nonradiological chemical contamination incidental to the area. Approximately 8,200 cubic yards of contaminated soil and sediment, including 119 cubic yards of material with radionuclides, was excavated from this area in the southwest portion of the Panhandle Area at Parcel E-2 and disposed of at one or more approved offsite landfills.

Removal Action[a]	Date(s)	Removal Action Activities
PCB Hot Spot Area Removal Action (Phase 1) (TtECI, 2007a)	June 2005 to September 2006	The TCRA at the PCB Hot Spot Area was designed to remove PCB- and petroleum hydrocarbon-contaminated soil and debris, possibly containing low-level radiological material. The removal action goals also included removal of free-phase petroleum hydrocarbons to a practical extent. Approximately 44,500 cubic yards of contaminated soil, including 611 cubic yards of material with radionuclides, was excavated from this area in the southeast portion of Parcel E-2 and disposed of at one or more approved offsite landfills.
PCB Hot Spot Area Removal Action (Phase 2) (Shaw, 2013b)	March 2010 to November 2012	The Phase 2 TCRA at the PCB Hot Spot Area was designed to remove contaminated soil and debris from the shoreline portion of the PCB Hot Spot Area, and other select hot spots identified in the RI/FS Report. Approximately 42,200 cubic yards of contaminated soil and 3,000 cubic yards of large debris were excavated from areas not addressed during the Phase 1 TCRA. The excavated soil and debris were disposed of at one or more approved offsite landfills. The fieldwork was completed in 2012.
Ship-Shielding Area Removal Action (Shaw, 2013a)	May 2012 to October 2012	The TCRA at the Ship-Shielding Area was designed to remove soil and debris potentially containing low-level radiological material (containing ^{60}Co) in the southwest portion of the Panhandle Area at Parcel E-2. Approximately 3,800 cubic yards of soil was excavated and screened for radioactivity. The excavated soil and debris were disposed of at one or more approved offsite landfills, including approximately 120 cubic yards of material with radionuclides. ^{60}Co was not identified at activity levels exceeding the remediation goals during either the radiological screening of the excavated soil or the final survey of the ground surface following excavation. However, the final survey of the ground surface identified several areas with elevated activity levels of ^{137}Cs and ^{90}Sr exceeding the remediation goals. The fieldwork was completed in 2012.

Notes:

a = The documents listed are available in the Administrative Record and provide detailed information used to support remedy selection at Parcel E-2.

2.7. INSTITUTIONAL AND ENGINEERING CONTROLS

The ROD requires implementation of ICs, which are legal and administrative mechanisms for the continued protection of human health and the environment. In Parcel E-2, the objectives of the ICs are to implement land use and activity restrictions that are used to limit the exposure of future landowner(s) or user(s) of the property to hazardous substances present on the property and in groundwater. ICs will also ensure the integrity of the remedy, including any current or future remedial or monitoring systems such as monitoring wells, LFG monitoring and collection systems, and subsurface groundwater control barriers. ICs are required on a property where the selected remedy results in contamination remaining at the property above levels that allow for unlimited use and unrestricted exposure. The ICs for Parcel E-2 will restrict the development, land use, and activities on Parcel E-2 property as described in the LUC RD (which is part of this RD).

This DBR includes engineering controls (specifically fencing and signs) to control access as part of the remedy that the Navy would construct if transfer did not occur; fencing and signs are not requirements of the ROD and may not be necessary after the site is transferred and redeveloped.

Parcel E-2 is owned by the federal government under the jurisdiction of the Navy and is planned to be transferred to the Successor Agency. Based on the City and County of San Francisco's 2010 "Hunters Point Shipyard Redevelopment Plan" (San Francisco Redevelopment Agency, 2010), the future reuse of Parcel E-2 will be open space (Figure 8). Accordingly, Parcel E-2 shall be restricted to open space and recreational uses, unless written approval for other uses is granted by the Federal Facility Agreement (FFA) signatories (i.e., the Navy, EPA, DTSC, and SFRWQCB). However, considering that reuse plans are subject to change by the local government, the LUC RD describes the procedure to modify the land use and activity restrictions for Parcel E-2.

Section 3. Basis of Design

This section describes the basis of design for the components of the final remedy for Parcel E-2. The basis for the design was developed from the criteria described in the ROD (Navy, 2012). The criteria for the design are based on the remedial action objectives (RAOs) and ARARs specified in the ROD, as well as engineering best practices, professional judgment, and green and sustainable remediation (GSR) principles (as identified in Navy guidance [Battelle Memorial Institute, 2012]).

Table 1 identifies the ARARs that informed the design and describes how specific design components address the substantive provisions of these ARARs. Additional ARARs from the ROD, that relate to monitoring and maintenance requirements, are presented in the RAMP and OMP, respectively. The final remedy for Parcel E-2 is an onsite response action to be performed pursuant to CERCLA; therefore, per Section 121(e) of CERCLA, the remedy is exempt from the administrative requirements of ARARs identified in the ROD.

GSR principles will primarily be incorporated into implementation of the remedy, and will be outlined in the future remedial action work plan (RAWP) produced to support the remedy. Where appropriate, GSR practices were incorporated into the basis of design and the project specifications to identify aspects of the RD where they might apply.

The design elements presented in this section are supported with calculations (Appendix A), design drawings (Appendix B), and project specifications (Appendix C). The project specifications include references to the regulations that must be followed during construction of the remedy to comply with ARARs and meet the RAOs. Prior to construction, a RAWP will be prepared (by the construction contractor) to expand upon information presented in the RD, and identify the specific implementation procedures for the final remedy at Parcel E-2. For example, the RAWP will identify specific procedures for the radiological-related remediation (which is described briefly in Section 3.4 of this DBR). In addition, the RAWP will identify ways to incorporate GSR principles into the construction process (such as minimizing transportation distances).

The remedy was selected in accordance with the ROD. The selected remedy for Parcel E-2 consists of three primary components: (1) excavation of contaminated soil, sediment, and debris; (2) containment of remaining contamination; and (3) monitoring, maintenance, and ICs to address the RAO and ARARs presented in the ROD and developed within this DBR as design criteria. The design intent at Parcel E-2 is to protect human health and the environment and to ensure the integrity of the remedy. Figure 9 provides an overview of the design components, including the limits of the Parcel E-2 Landfill (including the

existing soil cover and protective liner), location for the onsite consolidation of soil, sediment, and debris, final soil cover and protective liner, shoreline revetment, groundwater controls, LFG controls, and tidal and freshwater wetlands. This section describes each of the design components. The RA may need to be implemented in phases because of the large scope of proposed actions. To facilitate the planning process, a preliminary list of major RA construction phases is provided below.

RA Construction Phase 1

- Preliminary land surveying
- Excavation and offsite disposal of hot spots
- Construction of groundwater control systems (slurry walls)

RA Construction Phase 2

- Construction of shoreline revetment structure
- Excavation for freshwater and tidal wetlands
- Site grading and consolidation of excavated soil, sediment, and debris
- Radiological surface scanning, remediation, and clearance

RA Construction Phase 3

- Construction of protective liner, demarcation layer, and soil cover
- Installation of LFG extraction and treatment system
- Construction of surface water control features
- Soil placement (including demarcation layer) and planting for freshwater and tidal wetlands
- Installation of cover vegetation
- Installation of perimeter fence and warning signs

These preliminary construction phases will be reviewed and refined in the RAWP, as appropriate; however, potential revisions will adhere to the critical connections between RA construction phases. Most notably, the construction of the protective liner, demarcation layer, and soil cover can only occur after all tasks involving excavation and radiological remediation are completed.

This report describes one design approach proposed to address the risks present at Parcel E-2. Future redevelopment of Parcel E-2 will likely change the surface grades of the covers developed herein. Future changes to the remedy are acceptable, as long as the proposed changes are at least as protective of human health and the environment as the remedy components described in this DBR.

3.1. SITE PREPARATION

The site will require some preparation before the remedy can be constructed. Site preparation will include the following tasks:

- Securing the site with fence to prevent unauthorized access to the site during implementation of the remedy
- Performing preconstruction subsurface utility and land surface surveys to identify subsurface and surface site features and changes in site conditions that may have occurred between the development of the RD and mobilization to implement the remedy
- Performing a preconstruction biological assessment to identify species on the site that might require special protection or consideration during construction
- Implementing environmental protection measures
- Establishing radiological and nonradiological material handling and storage areas
- Identifying the extents of the existing landfill cover and protective liner
- Preserving and destroying existing groundwater monitoring wells
- Performing site demolition, clearing, and grubbing

The following sections describe the requirements for the site preparation tasks.

3.1.1. Site Security Fencing

The existing site security fence runs along the landward site boundary of Parcel E-2 and upslope from the shoreline, as shown on design drawing C3 in Appendix B. The existing fence will obstruct construction; therefore, it will need to be removed. A temporary fence, shown on design drawing C2 in Appendix B, will be erected along an alignment that provides site security and allows for implementation of the remedy. In accordance with GSR principles, the existing site control fence and materials should be reused wherever possible or recycled off site. Portions of the current site fence are located sufficiently outside of the work area and can be used during construction. Encroachment agreements will need to be established with adjoining property owners and users, such as UCSF, California Department of Parks and Recreation, and the City and County of San Francisco, to allow for a temporary fence to be constructed. Open access between the landward portion of the site and the shoreline will be necessary to construct the shoreline revetment, so temporary fencing need not be constructed along the shoreline.

The design includes the installation of a perimeter fence along the inland parcel boundary to protect the remedy after construction. A perimeter fence is not a requirement of the ROD and it may be removed or reconfigured as part of the future redevelopment of the site.

3.1.2. Preconstruction Utility and Land Surveys

Prior to conducting any subsurface activities, preconstruction utility and land surveys are required. Underground Service Alert North will be contacted at least 72 hours prior to initiating soil intrusive activities to locate publicly owned underground utilities. Geophysical surveys are also required where subsurface work will be performed. Any utility lines encountered should be assumed to be active, unless specifically determined to be inactive through consultation with the subject utility company. Active underground and aboveground utilities should be clearly marked, flagged, and protected in place. Inactive former Navy utilities, if encountered, should be removed or cut and capped in place with cement grout. Subsurface utilities should be capped in a manner to eliminate potential preferential pathways for contaminant migration (such as cement grout).

A California-licensed land surveyor should perform all land surveying work. A survey will be completed prior to start of construction to verify the locations of site features and the existing grades used as the basis for the design drawings (Appendix B). Land surveying should be conducted to an accuracy of 0.1 foot horizontally and 0.01 foot vertically. All horizontal coordinates will be based on the following surveying control datum: (basis of bearings) North American Datum (NAD) 27 Zone-III (Hunters Point West 1 PID HT0613) USFT. All vertical elevations will be based on the following surveying control datum: (benchmark) National Geodetic Vertical Datum (NGVD) 29.

3.1.3. Biological Assessment

Past biological assessments at Parcel E-2, as documented in the Final RI/FS Report (ERRG and Shaw, 2011), have identified several species of migratory birds and one special-status species (the American peregrine falcon [*Falco peregrinus*]) that are protected under pertinent ARARs (see Table 1). The past biological assessments have not identified any federal and state-listed endangered species at Parcel E-2. Pursuant to the ROD (Navy, 2012), a biological assessment will be performed prior to implementation of the remedy to address the following objectives:

- Identify potential bird species that are protected under the Migratory Bird Treaty Act (16 United States Code § 703) and California Fish and Game Code § 3511 and, if such species are present, specify reasonable measures to ensure their adequate protection during implementation of the remedy.
- Determine the extent to which the wetlands restoration at the adjacent property (Yosemite Slough Restoration Project) may have attracted endangered or fully protected bird, mammal, amphibian, or reptile species (as identified in pertinent sections of the California Fish and Game Code) to Parcel E-2 and, if such species are present, specify reasonable measures to ensure their adequate protection during implementation of the remedy.

A biologist qualified in performing field surveys for endangered or fully protected species will perform the biological assessment. The Navy will incorporate the findings of the assessment into the RAWP,

describe the substantive regulatory requirements for protecting the species identified at Parcel E-2, and specify reasonable measures to ensure their adequate protection during implementation of the remedy.

3.1.4. Environmental Protection Measures

Construction will be performed in a manner that protects the environment. Construction BMPs will be implemented to prevent offsite migration of visible and nonvisible pollutants. Construction activities will comply with the substantive requirements of:

- The California State Water Resources Control Board's National Pollutant Discharge Elimination System General Permit No. CAS000002, "Stormwater Discharges Associated With Construction And Land Disturbance Activities" Order Number 2009-0010-DWQ, as amended by 2010-0014-DWQ
- "San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)" (SFRWQCB, 2007)
- Bay Area Air Quality Management District (BAAQMD) Regulation 6, Rule 1 (BAAQMD, 2007)

The RAWP will include a CERCLA Stormwater Plan, a Dust Monitoring and Control Plan, and a San Francisco Bay Water Quality Monitoring and Protection Plan. A qualified stormwater professional (e.g., a P.E. or Qualified Stormwater Pollution Prevention Plan Developer) will design the stormwater BMPs for construction, which will be regularly inspected and maintained by qualified BMP inspectors. Upwind and downwind air monitoring will be performed every construction day in accordance with the established basewide air monitoring procedures. A silt curtain will be deployed to protect the bay during shoreline construction, and a bay water monitoring program will be developed to evaluate the effectiveness of the silt curtain and the effect of the shoreline construction on bay water quality.

3.1.5. Radiological and Nonradiological Material Handling and Storage Areas

Until the site is radiologically released, all work areas and work support areas will be defined as a radiologically controlled area (RCA). The RCA will be delineated with fence panels and appropriate signage. Radiological material storage and handling areas, including decontamination pads, large debris holding pads, debris recycling pads, radiological screening pads, and soil and debris stockpile areas, will need to be established within the RCA to support construction. Additionally, nonradiological material handling and storage areas, such as soil and debris stockpile areas and material storage areas, may need to be established outside the RCA to support construction. The material handling and storage areas will be constructed either within or adjacent to the Parcel E-2 boundary. Management of waste within or adjacent to the Parcel E-2 boundary is consistent with EPA's area of contamination (AOC) policy that is discussed in the NCP preamble (55 Federal Register § 8666 and § 8758 [08 March 1990]) and further described in a 1996 policy memorandum (EPA, 1996a). EPA's AOC policy allows for the relocation of soil and waste material within Parcel E-2 without constituting placement and the regulatory restrictions (such as land disposal restrictions specified in the Resource Conservation and Recovery Act [RCRA]) that are triggered during placement of waste outside of the AOC.

3.1.6. Existing Landfill Cover and Protective Liner

A soil cover and protective liner were installed over a portion of the landfill in response to a fire in August 2000 (Figure 9). This type of protective liner meets the requirements of the pertinent ARARs and will be incorporated to the extent practical into the final remedy. The new protective liner will be connected to the existing liner, as shown on design drawings C13 and C16 in Appendix B. The extent of the existing liner will be verified by exposing the edges of the liner. Once identified, the liner extent will be surveyed in accordance with Section 3.1.2 and will be protected from damage from construction equipment, vehicle traffic, and the elements (ultraviolet light, cold temperatures, etc.) throughout construction.

3.1.7. Existing Groundwater Monitoring Wells

Existing groundwater monitoring wells will be protected throughout construction if they are to be incorporated into the post-remedial action monitoring program. The Navy will maintain access to the wells and their function throughout construction. Wells not required for future monitoring, as specified in the RAMP included in this RD package, will be destroyed in accordance with San Francisco Health Code Article 12B and San Francisco County and State of California regulations. If necessary, wells will be destroyed and replaced if protecting the well adversely affects construction. If relocation of a well is required, the well will be installed as close to the original location as feasible and will have the same construction (inside diameter, depth, and screen interval) as the original well. New concrete pads and well boxes will be constructed flush to the completed cover surface using traffic-rated materials. Approval by the regulatory agencies will be requested prior to destroying and replacing monitoring wells.

The locations of the existing groundwater monitoring wells are provided on design drawing C3 in Appendix B. Table 5 summarizes the groundwater monitoring wells at Parcel E-2 and wells adjacent to the parcel. The table also lists which wells will be destroyed (if not specified for future monitoring), preserved, replaced, or newly constructed.

3.1.8. Site Demolition, Clearing, and Grubbing

The site will be cleared of vegetation and debris to prepare for construction. Clearing of vegetation or debris may be required in some small areas around the perimeter of the site to provide site access and allow for placement of the temporary fence. Along the shoreline of the site, boulders and concrete have been placed in areas to provide slope stability. Any rock and debris will need to be removed from the area before earthwork can be performed along the shoreline. All debris (rocks, concrete, rebar, metal debris, wood, and other refuse) will be screened for radionuclides and handled as described in Sections 3.3.5 and 3.3.6. Testing requirements for debris may vary depending on the material, but could include testing for hazardous characteristics required under RCRA or testing for requirements of the disposal facility. In addition, several existing site features, such as groundwater monitoring wells, LFG vents and extraction wells, and existing LFG system components, will be demolished to accommodate the new gas collection and control system (GCCS). As a GSR measure, the components of the existing gas control system that are not demolished will

be either integrated into the new active GCCS or stored for future use at HPNS, or similar sites. The extents of the clearing and grubbing for the site and the items to be demolished are shown on design drawing C3 in Appendix B.

Items and debris screened and cleared for radionuclides, as described in Section 3.3.6, will be considered for onsite consolidation in accordance with Section 3.3.7. As a GSR consideration, radiologically cleared natural rocks removed from the shoreline may be stockpiled for reuse as temporary armoring on other parcels at HPNS, and radiologically cleared debris that can be recycled (e.g., metal, concrete) will be transported to an offsite recycling facility.

3.2. EXCAVATION AND OFFSITE DISPOSAL OF HOT SPOTS

This section summarizes the basis for further excavation at Parcel E-2 to address nearshore and inland soil hot spots that pose a risk to humans and wildlife. In accordance with the ROD, removed soil will be disposed of at one or more approved offsite landfills, as appropriate, and excavations will be backfilled with clean soil meeting HPNS acceptance criteria.

The RI/FS Report defined five tiers of hot spot areas in Parcel E-2 that require removal, as summarized below (ERRG and Shaw, 2011).

- Tier 1 hot spots consist of nearshore locations where soil concentrations are greater than 10 times the remediation goals and corresponding groundwater concentrations in monitoring wells consistently exceed aquatic evaluation criteria. Tier 1 hot spots were identified at the shoreline portion of the PCB Hot Spot Area.
- Tier 2 hot spots consist of nearshore locations where soil concentrations are greater than 10 times the remediation goals and corresponding groundwater concentrations in temporary wells exceed aquatic evaluation criteria. Tier 2 hot spots were identified at the Metal Slag Area and northwest of the PCB Hot Spot Area.
- Tier 3 hot spots consist of inland locations where soil concentrations are greater than 100 times the remediation goals. Tier 3 hot spots were identified along the northern sidewall of the PCB Hot Spot Area excavation and in the central portion of the East Adjacent Area.
- Tier 4 hot spots consist of nearshore locations where groundwater concentrations in temporary wells exceed aquatic evaluation criteria and no corresponding soil data are available. Tier 4 hot spots were identified in the northern portion of the Panhandle Area.
- Tier 5 hot spots consist of inland locations where soil concentrations are greater than 10 times the remediation goals and corresponding groundwater concentrations in downgradient temporary wells exceed aquatic evaluation criteria. Tier 5 hot spots were identified in the southern portion of the Panhandle Area in the East Adjacent Area. An additional Tier 5 hot spot was also identified in the East Adjacent Area during a 2009 investigation (associated with a groundwater treatability study at Parcel E). The additional Tier 5 hot spot contains elevated VOC concentrations (specifically tetrachloroethene [PCE]) that are a potential source to groundwater contamination and pose a potential risk to future occupants (via the vapor intrusion pathway) in the adjoining Parcel E.

The concentrations of chemicals of concern in soil and their corresponding hot spot goals (Table 6) are the basis for the design of this remedy component. Section 3.2.1 describes the post-excavation conditions following the Phase 2 TCRA at the PCB Hot Spot Area. The subsequent sections describe the procedures for estimating the extents and volumes of excavation, collecting preexcavation samples to refine the excavation areas, excavating soil, collecting post-excavation samples to confirm contamination has been removed, backfilling the excavations, and characterizing and disposing of waste.

3.2.1. Additional Excavation in PCB Hot Spot Area

As described above, the RI/FS Report defined five tiers of hot spot areas in Parcel E-2 that require removal and were incorporated into the selected remedy. The Navy initiated a Phase 2 TCRA at the PCB Hot Spot Area to promptly address some of the contamination prior to the ROD. However, the Phase 2 TCRA at the PCB Hot Spot Area was completed after the ROD was signed. This section describes the post-excavation conditions following the Phase 2 TCRA at the PCB Hot Spot Area, based on information from the removal action completion report (Shaw, 2013b), and evaluates the extent of additional excavation required under the selected remedy. The post-excavation conditions are summarized on Figure 10. As shown on Figure 10, samples with chemical concentrations that exceed the hot spot goals (in Table 6) were collected in several excavation areas. The samples that exceed the hot spot goals and prompt further excavation, as part of the selected remedy for Parcel E-2, are discussed below.

- **Nearshore Tier 1 and Tier 2 hot spots with PCBs** – Further excavation is required at several areas under the proposed shoreline revetment because the remaining PCBs (exceeding the hot spot goals) are a potential threat to aquatic wildlife in San Francisco Bay that will not be adequately controlled by the proposed nearshore slurry wall. Further excavation is also required at an area near the Parcel E boundary (associated with sample 139-SW-2) because the PCB concentrations exceeding the hot spot goal are relatively shallow (3 feet bgs).
- **Inland Tier 3 hot spots with lead and TPH** – Further excavation is required at two areas near the Parcel E-2 Landfill because the remaining lead and TPH exceed the hot spot goals. The remaining lead (111,000 milligrams per kilogram at 2.5 feet bgs) poses a potential threat to humans. The remaining TPH is a potential source to groundwater contamination that could impact aquatic wildlife in San Francisco Bay.
- **Inland Tier 5 hot spot with PCE** – Further excavation is required at one area near the Parcel E/E-2 boundary because the remaining PCE is a potential source to groundwater contamination that could impact future occupants of adjacent Parcel E.

The samples that exceed the hot spot goals but do not require further excavation, as part of the selected remedy for Parcel E-2, are discussed below.

- **Shoreline areas located in Parcel F (below 0 feet msl) with PCBs** – Further excavation is not required at shoreline areas below 0 feet msl because, consistent with the Final ROD (Navy, 2012), the PCB contamination is similar to the offshore conditions and will be addressed by the Parcel F remedy. The samples shown in blue on Figure 10 were collected at the offshore extent of the Phase 2 TCRA excavation, but are located beyond the offshore extent of the proposed shoreline revetment[1].
- **Shoreline areas inland of the nearshore slurry wall with PCBs, lead, and TPH** – Further excavation is not required at these shoreline areas (represented by samples shown in yellow on Figure 10) because (1) the previous excavations extended to 10 feet bgs (or deeper) and (2) the remaining contamination (which could impact aquatic wildlife in San Francisco Bay) will be adequately controlled by the proposed nearshore slurry wall.
- **Shoreline areas located in Parcel E with PCBs and TPH** – Further excavation is not required at these shoreline areas (represented by samples shown in green on Figure 10) because (1) the PCB and TPH contamination is similar to conditions that extend beyond the parcel boundary and (2) the contamination will be addressed by the Parcel E remedy.

Section 3.2.2 describes the proposed extent of the additional excavation at the Tier 1, Tier 3, and Tier 5 hot spots.

3.2.2. Hot Spot Excavation Extents and Volumes

The design for the hot spot excavations was developed by evaluating existing data to estimate the extents of the hot spots, and then calculating the volume of soil to be excavated and backfilled (Figures 11 and 12; Appendix A, calculation brief A-1; and design drawing C4 in Appendix B). The hot spot excavations were generally assumed to extend no deeper than 10 feet bgs, consistent with the maximum depth evaluated in the RI/FS Report (ERRG and Shaw, 2011). However, excavations at select nearshore hot spots were assumed to extend to deeper depths to remove continuing sources to groundwater contamination. More specifically, the following decision criteria were used to delineate the extents and depths of the remaining hot spots.

1. The hot spot delineations from the RI/FS Report were used as the initial assumed areas to be excavated.
2. Areas removed successfully by previous removal actions were eliminated from the design. Successful removal was typically defined when results of confirmation samples from excavation sidewalls and bottoms met the hot spot goals. Section 3.2.1 describes the additional evaluation of post-excavation conditions following the Phase 2 TCRA at the PCB Hot Spot Area.

[1] As shown on Figure 10, the boundary between Parcels E-2 and F is defined in this RD at the offshore extent of the proposed shoreline revetment, which will correspond to a final post-construction elevation of 0 feet msl. The former boundary between Parcels E-2 and F, which defined the offshore extent of the Phase 2 TCRA excavation, was not tied to a fixed vertical elevation and in some areas extended below 0 feet msl. This change in the administrative boundary between Parcels E-2 and F was made to prevent the shoreline revetment from extending into tidal flats (defined at 0 feet msl).

3. Where post-excavation sidewall sample data from previous excavations were available, the data were used to redefine the horizontal extents of the hot spots previously delineated in the RI/FS Report. To adjust the horizontal extents of the excavations, the sidewalls were moved to a position halfway between a sample with results exceeding the hot spot goals and a sample with results meeting the hot spot goals. Two exceptions to this methodology are described below:
    a. The horizontal extent of several nearshore Tier 1 hot spots was terminated at the proposed nearshore slurry wall because this feature will adequately control contamination located further inland.
    b. The horizontal extent of several inland Tier 3 hot spots was terminated within 20 feet of the existing geosynthetic cap at the Parcel E-2 Landfill. This limitation, which is consistent with the approach used for the Phase 2 TCRA excavation, is intended to protect the existing geosynthetic cap that will be integrated into the final cover and protective liner.
4. Where post-excavation bottom sample data from previous excavations were available, the data were used to redefine the vertical extents of the hot spots previously delineated in the RI/FS Report. To adjust the vertical extents of the excavations, the bottoms were moved to a position 2.5 feet below the deepest sample with results exceeding the hot spot goals.

The results of the hot spot reevaluation, including the proposed areas remaining to be excavated and the calculated excavation volumes, based on the design criteria listed above, are shown on Figures 11 and 12, and design drawing C4 in Appendix B. Table 7 summarizes the hot spot excavation areas and volumes. It should be noted that calculated volumes for the hot spot excavations include additional excavation required for sloping and benching (required to maintain the sidewall stability of the excavation). The design estimates that approximately 22,996 cubic yards of soil (the estimated in-place volume, also referred to as "bank cubic yards") will be excavated to address the remaining soil hot spots in Parcel E-2. The lateral and vertical extent of hot spots will be refined through preexcavation characterization sampling (Section 3.2.3) to be performed during the remedy implementation, especially in areas where previous sampling has not been performed.

3.2.3. Preexcavation Characterization Sampling

Preexcavation characterization samples will be collected to better define each excavation area. Samples will be collected at a rate of one sample for every 50 feet of proposed sidewall length and one sample for every 5 feet of proposed excavation depth. In addition, one bottom sample will be collected for every 250 square feet of proposed excavation area. This sampling frequency may be re-evaluated prior to implementation of the remedy (and included in a Sampling and Analysis Plan) and reduced in areas where existing soil data or physical limits (such as the limits of the Parcel E-2 Landfill) adequately define the proposed excavation. Data will be used to confirm the excavation dimensions presented in this RD. This information is particularly critical in Tier 4 hot spot areas where soil samples have not been collected to adequately characterize subsurface conditions.

3.2.4. Excavation and Confirmation Sampling

Soil hot spots will be excavated following the preexcavation sampling event. After initial excavation, confirmation samples will be collected for analysis to verify that residual chemical concentrations are less than the hot spot goals. Post-excavation confirmation samples will be collected at the same frequency as the preexcavation characterization samples described above. An approach for evaluating confirmation sampling results and expanding the horizontal and vertical extents of a given excavation will be developed prior to implementation of the remedy (and included in a Sampling and Analysis Plan).

3.2.5. Backfilling of Hot Spot Excavations

All hot spot excavations will be backfilled with imported soil that meets the project's acceptance criteria. Backfill testing will include collection of samples for analysis of the site-specific chemicals of concern and ROCs, and other contaminants based on the nature of the fill source, in accordance with the DTSC "Information Advisory, for Clean Imported Fill Material" (DTSC, 2001). The DTSC advisory also provides the required sampling frequency for import fill (DTSC, 2001). The backfill acceptance criteria for Parcel E-2 are included in the project specifications (Appendix C, Section 31 00 00, Earthwork).

3.2.6. Waste Characterization and Disposal of Hot Spot Soil

All excavated material will be screened for radioactivity, sampled for analysis of the ROCs, and then remediated for radiological constituents, if necessary. Following radiological analysis and remediation, the remedial action contractor will characterize the hot spot soil for offsite disposal. All excavated hot spot soil will be disposed of at one or more offsite landfills, approved to accept CERCLA wastes in accordance with Title 40 Code of Federal Regulations § 300.440 (also referred to as the "CERCLA Off-Site Rule").

3.3. GRADING AND ONSITE CONSOLIDATION OF SOIL, SEDIMENT, AND DEBRIS

This section describes the basis of design for excavation and grading required to construct the shoreline revetment structure, the tidal and freshwater wetlands, and the final cover subgrade (in preparation for installation of the protective covers) developed in this RD. This section also provides details about the radiological screening requirements for soil, sediment, and debris, and the criteria that dictate how waste will be consolidated under the new protective liner at the Parcel E-2 Landfill.

3.3.1. Excavation to Construct Shoreline Revetment

The revetment structure will consist of a facing of stone armor material that is intended to protect the site shoreline from erosion. The construction of the shoreline revetment structure (described further in Section 3.6) will require excavation to achieve subgrade design elevations, in preparation for the installation of the under-layer materials and stone armor material. The shoreline slope will need to be graded to a 3H:1V slope (i.e., 1 foot of vertical rise for each 3 feet of horizontal distance) from 0 feet

above msl to a crest of 9.0 feet above msl to construct the revetment structure. This slope will be the subgrade for the revetment structure described in Section 3.6.

A significant amount of debris, including rocks, concrete, rebar, metal debris, wood, and other refuse, is present along the Parcel E-2 shoreline that will need to be removed (as described in Section 3.1.8) prior to performing the slope excavation for the revetment structure. All debris will be removed, segregated, and stockpiled prior to (or during) excavation of the shoreline slope. Excavation of the slope for the shoreline revetment areas is expected to generate approximately 9,100 cubic yards of shoreline sediment and debris (including temporary recycled concrete armoring along the former PCB Hot Spot Area and subsurface debris consisting of rocks, concrete, metal, wood, and brick debris along areas of the shoreline that have not previously been excavated; Appendix A, calculation brief A-2). Also, where the nearshore slurry wall runs parallel with the revetment along the south edge of the landfill, additional impacted soil between the slurry wall alignment and the revetment will be excavated and replaced with clean import fill that will be placed and compacted to meet the lines and grades for the revetment subgrade. This additional excavation will be performed to ensure that any potential contamination between the slurry wall and the revetment structure is removed. It is estimated that 7,700 cubic yards of soil will be generated from the excavation between the revetment and the nearshore slurry wall (Appendix A, calculation brief A-18).

All debris and sediment generated during excavation for the shoreline revetment will be screened for radionuclides and consolidated, if appropriate, under the protective liner at the Parcel E-2 Landfill as discussed in Sections 3.3.5 and 3.3.6.

3.3.2. Excavation to Construct Wetlands

The wetlands restoration area consists of two components: (1) the freshwater wetlands, which will be constructed behind the revetment at the north end of the Panhandle Area, and (2) the tidal wetlands, which will be constructed along the south and east edges of the Panhandle Area. Construction of the wetlands (described further in Section 3.9) will require excavation to achieve subgrade design elevations, in preparation for the installation of wetland soil and plants. The wetlands subgrade elevations were designed to allow for the installation of 3 feet of imported wetlands-compatible soil and a 1-foot soil bridge between the imported wetlands-compatible soil and the underlying existing soil subgrade.

The wetland subgrade elevations, which are the basis for the excavation volume calculations, were dictated by the requirement to achieve wetland finish grades between 2 and 7 feet above msl. This elevation range allows for the tidal wetlands to become inundated periodically during high tide events and for the freshwater wetlands to intercept the water table, so submerged aquatic vegetation can be planted. Approximately 16,500 cubic yards of soil will be excavated to construct the freshwater wetland, and approximately 30,300 cubic yards of soil will be excavated to construct the tidal wetlands (Appendix A, calculation brief A-2).

All soil, sediment, and debris generated from the wetlands excavations will be screened for radionuclides and consolidated, if appropriate, under the protective liner at the Parcel E-2 Landfill as discussed in Sections 3.3.5 and 3.3.6.

3.3.3. Excavation to Construct Groundwater Controls

Two slurry walls will be constructed at Parcel E-2 to passively control groundwater upgradient of the Parcel E-2 Landfill and along the Parcel E-2 shoreline (downgradient of the landfill). The construction of the slurry walls (described further in Section 3.7) will require excavation of trenches to achieve the slurry wall depths proposed in the design prior to backfilling with the specified slurry mixes. The depth of the nearshore slurry wall varies along its alignment and was dictated by the depth of the Bay Mud Aquitard into which the wall will be keyed 2 feet. The upland slurry wall depth was dictated by the need to minimize upland groundwater from contacting waste within the A-aquifer; thus, it was designed to penetrate to a depth of -10 feet msl. A subsurface drain (i.e., French drain) will be constructed with the upland slurry wall to divert groundwater. The French drain will have a level bottom at a depth of 6 feet msl. Approximately 2,700 cubic yards of soil will be excavated to construct the nearshore slurry wall, and approximately 2,200 cubic yards of soil will be excavated to construct the upland slurry wall and French drain (Appendix A, calculation brief A-19).

All sediment, soil, and debris generated from the slurry wall excavations will be screened for radionuclides and consolidated under the new multilayer geosynthetic cap as discussed in Sections 3.3.5 and 3.3.6.

3.3.4. Site Grading to Construct Final Cover Subgrade

Site grading will be performed across much of Parcel E-2, including the landfill, the site perimeter, the upland Panhandle Area, and the East Adjacent Area to establish the subgrade for the designed protective covers (described further in Section 3.5). The slopes of the final cover, and by association the subgrade, are designed to promote positive drainage and control erosion caused by high runoff velocities.

Within the Parcel E-2 Landfill, the bulk of the subgrade preparation will consist of stripping 1 foot of soil from above the existing soil cover (without damaging the existing protective liner) and performing grading along the perimeter of the landfill to transition between the landfill elevations and the surrounding elevations. Transitions from the proposed site grading to the existing grades along the perimeter will be no steeper than 3H:1V. No retaining walls or other structures will be used to transition from the cover to existing grades. Additional grading will be performed in areas designed to collect and direct surface runoff from the site.

The upland portions of the Panhandle Area will be graded to direct surface runoff to the tidal and freshwater wetland areas. Because the contiguous landfill waste does not underlie these areas, they will be graded to flatter than 3 percent slopes.

Along the north boundary, bordering the UCSF property, fill will be placed and grading will be performed on portions of the landfill that extend onto UCSF property. This grading is needed to prepare the area for the final soil cover and protective liner.

The East Adjacent Area will be graded to direct surface water runoff from the landfill down to the existing grades within adjacent Parcel E.

Design drawing C11 in Appendix B shows the extents of the grading required to prepare the subgrade of the site. Grading activities across upland areas are expected to generate approximately 39,300 cubic yards of soil (Appendix A, calculation brief A-2). All soil generated during grading activities will be screened for radionuclides as discussed in Sections 3.3.5 and 3.3.6 before being consolidated under the new protective liner in the Parcel E-2 Landfill.

3.3.5. Radiological Screening and Management of Soil and Sediment

All excavated soil from Parcel E-2 will be segregated from debris and moved to a screening pad for radiological screening. Screening pads will be constructed with sufficient slope so that all runoff is conveyed to a sump. Rock and gravel should be used to allow for decontamination water to filter through to the collection sump. The screening pad will be bermed with sandbags, and collected runoff will be pumped from the sump into a holding tank for sampling, characterization, and disposal as needed.

Radiological screening surveys will be conducted on soil using fixed contamination survey methods. A gamma walkover survey with high-density scan and systematic radiological soil sampling should be conducted in each radiological screening pad. All surveying and sampling methods should be conducted in a manner consistent with the "Multi-Agency Radiation Survey and Site Investigation Manual, NUREG-1575, Revision 1 guidance" (U.S. Department of Defense et al., 2000). Soil samples will be submitted for analysis of the ROCs.

Following radiological screening, all soil that is identified as low-level radioactive waste will be disposed of in sealable roll-off bins and transported to an appropriate offsite facility for disposal. Soil that is radiologically cleared may be stockpiled in preparation for consolidation beneath the protective liner in the Parcel E-2 Landfill.

3.3.6. Radiological Screening and Management of Debris

Debris collected from the site or generated during excavation activities will be segregated from soil and moved to a radiological screening area for debris. Debris anticipated to be encountered during implementation of the remedy includes, but is not limited to, concrete, bricks, timber, metal, and large rocks. Most debris will be radiologically screened and tested for radiological contamination. Debris will be scanned for gamma radiation, and loose surface contamination on debris will be sampled using wipe methods. Debris that is typically not cleared for radiological contamination, such as bricks or saturated

wood, will be inspected and screened for potential radioactive anomalies (such as radioluminescent devices). Following removal of potential radioactive anomalies, screened debris will be consolidated within the northwest portion of the Parcel E-2 Landfill as discussed in Section 3.3.7.

Radiologically cleared debris that is recyclable or reusable (e.g., metal, concrete, asphaltic concrete) should be recycled off site or retained for reuse on site as a GSR component of the remedy. All other radiologically cleared debris, will be consolidated within the northwest portion of the landfill as discussed in Section 3.3.7. Any radiological debris identified during the screening process will be disposed of off site at an appropriate facility. The RAWP will identify specific procedures for the radiological screening of debris prior to onsite consolidation.

3.3.7. Waste Consolidation Criteria

Waste generated during RA construction and grading activities, including soil, sediment, and non-recyclable or non-reusable debris, will be consolidated in the northwest area of the Parcel E-2 Landfill, outside the extent of the existing landfill liner (Figure 9). As described in Sections 3.3.1 through 3.3.3 (and detailed in design drawing C11 in Appendix B), most of the waste and debris will be generated during excavation to construct the shoreline revetment and wetlands and will include rocks, concrete, rebar, metal debris, wood, and other refuse. In contrast, the site grading process (described in Section 3.3.4) will involve relocation and consolidation of soil from different areas (mostly within the East Adjacent Area and existing landfill cover) with negligible amounts of debris.

Based on the foundation grading plan, the northwest area of the landfill was selected because it has the greatest capacity to receive waste (depth and area); thus, it can accommodate the largest volume of debris. Design drawing C12 in Appendix B shows the foundation grading plan. The waste consolidation area was also selected because it is not within the footprint of the existing landfill liner, which could be damaged by consolidated debris.

The following general consolidation criteria were established to guide the debris consolidation process and minimize settlement of the cover system in the future:

- Debris will be buried in soil at least 5 feet below the new protective liner. This depth results in a minimum cover thickness of 7 feet over all consolidated debris, corresponding to 3 feet of cover fill over the debris (minimum), 2 feet of foundation layer soil (minimum), and 2 feet of cover soil over the liner (minimum).
- Debris will be consolidated in a homogeneous manner to avoid clustering of similar materials in one location because that might produce differential settlement of the cover system.
- Debris should be resized and/or reshaped using breakers, mechanical shears, or other equipment to produce uniform shapes that are free of significant voids. The purpose of this criterion is to ensure that soil can be placed and compacted around consolidated debris without compromising

the project's compaction requirements, and to ensure that voids inside of debris pieces are filled or eliminated to reduce the risk of differential settlement.

- Debris may be placed within the lifts of soil being installed as the consolidation process proceeds, or debris may be placed within trenches or excavations created after the subgrade soil has been placed and compacted.
- Debris that is visibly contaminated with chemicals (as determined by visual or olfactory evidence) should not be consolidated unless it can be decontaminated or encapsulated in a manner that prevents future migration of the contamination.
- Wood debris (such as piers) that is determined to be free of radioactive anomalies should be chipped to the extent practicable and spread evenly within the consolidation area to reduce the risk of differential settlement resulting from wood decay.

3.4. ADDITIONAL RADIOLOGICAL ACTIONS

This section describes the additional radiological actions that will be performed to satisfy the RAO specified for radionuclides at Parcel E-2.

3.4.1. Additional Excavation in Ship-Shielding Area

As described in Section 2.6, the Navy completed a TCRA at the Ship-Shielding Area involving excavation and screening of 3,800 cubic yards of soil from a berm and fan-shaped testing area (Shaw, 2013a). The removal action demonstrated that the activity levels for ^{60}Co (the ROC associated the previous activities) were less than the remediation goals. The remaining radiological contamination in this area (associated with other ROCs) will be addressed during radiological screening activities, as described in Section 3.3.5 and 3.3.6. The final radiological survey of Parcel E-2 (described in Section 3.4.4) will include the Ship-Shielding Area.

3.4.2. Potential Refinement of Site-Specific Background Level for Radium-226

As shown in Table 3, the remediation goal for ^{226}Ra is 1 pCi/g above background based on agreements with EPA and established in the Action Memorandum for the basewide radiological removal action (Navy, 2006). The remediation goal is also consistent with the radiological-related remedies selected in the RODs for Parcels B, G, and D-1 and UC-1. As developed for the ongoing radiological removal actions, the background level for ^{226}Ra in surface soil is 0.633 pCi/g and the background level for ^{226}Ra in storm drain and sewer lines is 0.485 pCi/g. The background levels for ^{226}Ra, and other ROCs at Parcel E-2, may be reevaluated in the RAWP and are subject to regulatory agency approval.

3.4.3. Removal of Sanitary Sewers, Storm Drains, and Septic Sewer Lines

As shown on Figure 3, the sanitary sewer, storm drain, and septic sewer lines in Parcel E-2 are radiologically impacted. The lines that extend into the East Adjacent Area but are located outside the boundary of IR-01/21 will be removed and any radioactive contamination exceeding the remediation

goals within the trenches will also be removed. Soil and debris from these areas (an estimated 10,000 cubic yards) would be excavated and transported to a screening yard, where the material will be screened for radioactivity and properly segregated, characterized and disposed of off site. Post-excavation gamma scans will be performed, and soil samples will be collected to verify that residual radioactivity in the trenches does not exceed the remediation goals. Remaining sections of sanitary sewer, storm drain, and septic sewer lines that extend into IR-01/21 will not be removed because the potential radioactivity within these lines is similar to that potentially present in subsurface soil throughout IR-01/21, which will be contained and subject to ICs to achieve the radiological RAOs. Remaining sections of sanitary sewer, storm drain, and septic sewer lines that extend into IR-01/21 will be cut and capped (with an appropriate cement-based grout).

3.4.4. Final Radiological Survey

Concurrent with the radiological screening of material excavated during the activities described in Section 3.3, the Navy will perform a final radiological surface survey throughout Parcel E-2 to identify and remove radiological contamination to a depth of 1 foot (i.e., the maximum effective depth of the surface survey). Deeper soil will be excavated, if necessary, to ensure that residual radiological risk at the final ground surface (following installation of a demarcation layer and soil cover) is acceptable. The survey procedures will be outlined in the RAWP; however, the general approach is described in the following paragraphs.

To conduct the final radiological survey, Parcel E-2 will be divided into an appropriate number of Class 1 survey units not to exceed 1,000 square meters in area. The objective of the survey is to demonstrate that, before placement of any radiologically screened soil (as part of the site grading or cover construction), the upper 1 foot of soil does not contain radionuclides at activity levels exceeding the remediation goals (Table 3). Survey methods will include fixed static (direct) and scan measurements for gamma radiation over 100 percent of the Class 1 survey units. A number of systematic soil samples will be also collected from each of the survey units for gamma spectroscopy analysis of the ROCs (^{137}Cs, ^{226}Ra, and ^{90}Sr). In addition, biased soil samples will be collected based on the scan data results and an analysis of the spatial distribution of the data; the biased samples will also be analyzed by gamma spectroscopy for the ROCs (^{137}Cs, ^{226}Ra, and ^{90}Sr).

Following review of the results for systematic and biased soil samples, each location with radionuclide activity above the release criteria will be further characterized. The number and location of characterization samples collected will be selected, based on criteria to be specified in the RAWP, to ensure the locations of elevated activity are adequately delineated both laterally and vertically. The additional data are intended to support future risk modeling that will demonstrate the radiological risk at the final ground surface (following installation of a demarcation layer and soil cover) is within the risk management range specified in the NCP (10^{-6} to 10^{-4}).

After the areas are adequately characterized, the locations with the elevated radioactivity will be excavated to a depth of 12 inches bgs. Deeper soil will be excavated if the results of systematic or biased samples significantly exceed the remediation goals and are likely to result in a residual radiological risk at the final ground surface (following installation of a demarcation layer and soil cover) that exceeds the risk management range specified in the NCP (10^{-6} to 10^{-4}). The Navy has performed preliminary risk modeling, using procedures initially developed in the radiological addendum to the RI/FS Report (ERRG and Shaw, 2011), that indicate that an excavation depth of 1 foot combined with a two-foot-thick soil cover will provide adequate shielding against the range of residual radioactivity likely to be encountered at Parcel E-2. Appendix D presents the results of this preliminary risk modeling.

The preliminary risk modeling also indicates that the highest levels of residual radioactivity previously identified at Parcel E-2 (at surface anomalies that were subsequently removed) will not pose an unacceptable risk if present below 3 feet of soil that meets the radiological acceptance criteria. This preliminary information suggests that an upper bound of acceptable radiological contamination at depth can be established to guide future remediation activities. This preliminary information will be refined in the RAWP and provided to the regulatory agencies for review and approval prior to implementing final radiological surveys.

3.5. SOIL COVER AND PROTECTIVE LINER

This section summarizes the basis of the draft RD for the soil cover and protective liner. Following completion of the final radiological survey (as described in Section 3.4) and placement of radiologically screened material from grading operations (as described in Section 3.3), a minimum 2-foot-thick soil cover will be placed over all of Parcel E-2, including a small portion of the Parcel E-2 Landfill that extends north onto property owned by UCSF (see Figure 13). In addition, a protective liner, consisting of (at minimum) a high-density polyethylene (HDPE) geomembrane with an overlying geocomposite drainage layer, will be placed under the soil cover in all areas except the new wetlands. The protective liner will minimize water seeping into the contaminated material and serve as a visual marker for the bottom of the cover. A liner will not be used in the new wetlands, so they function more naturally. To prevent exposure to contaminated material, the soil cover in the new wetlands will be 4 feet thick. The new protective liner will be contiguous with the existing landfill cap (which includes a geosynthetic clay liner [GCL) under the HDPE geomembrane; this design element will be extended through the Parcel E-2 Landfill); however, portions of the existing landfill cap will be removed to achieve the design elevations, and a new protective liner will be constructed in these areas.

In conjunction with installation of the protective liner, a demarcation layer will be installed within radiologically impacted portions of the East Adjacent Area and throughout the Parcel E-2 Landfill, Panhandle Area, and Shoreline Area to identify remaining radiological hazardous substances at depth. The demarcation layer will consist of a permeable geosynthetic material and magnetic marking tape placed at the bottom of the soil cover. A demarcation layer will also be installed under the 4-foot-thick cover in the new

wetlands. The soil cover, protective liner, and demarcation layer, in combination with ICs that are to be implemented throughout Parcel E-2 (as described in Section 2.6), will prevent unacceptable exposure of humans or wildlife to remaining contamination that exceeds the remediation goals (see Tables 2 and 3).

Table 1 identifies pertinent landfill closure requirements at Titles 22 and 27 Cal. Code Regs. The substantive provisions of these ARARs will serve as design criteria for the soil cover and protective liner for the Parcel E-2 Landfill and adjacent non-wetland areas. These ARARs pertain to various design elements, including geotechnical considerations, components of the soil cover and protective liner, surface water drainage, and erosion control. These design elements, and the pertinent ARARs that informed their design, are discussed in the Sections 3.5.1 through 3.5.4. The design basis of the soil cover for the new wetlands is discussed in Section 3.5.5 (the restoration design for the wetlands is further detailed in Section 3.9).

Figures 13 and 14 show the extent of the different cover types and conceptual cross sections. Section 3.5.2 describes the components of the proposed cover types.

3.5.1. Geotechnical Considerations

Golder Associates, under a subcontract to ERRG, performed geotechnical analyses in support of this DBR. The geotechnical analyses, which are presented in Appendix E, consist of the following:

- A deterministic seismic hazard analysis to estimate the peak ground acceleration corresponding to the maximum credible earthquake (MCE) along the San Andreas Fault and to develop spectrally matched acceleration time histories for seismic stability analysis.
- An analysis of liquefaction potential using data collected during previous geotechnical investigations (from soil borings and cone penetrometer test [CPT] locations surrounding the Parcel E-2 Landfill).
- An analysis of cyclic softening potential of the Bay Mud using data collected during previous geotechnical investigations (from soil borings and CPT locations at the southern perimeter of the Parcel E-2 Landfill adjacent to San Francisco Bay).
- An analysis of the stability (under both static and seismic conditions) of the most critical slope of the Parcel E-2 Landfill (the southern perimeter adjacent to San Francisco Bay).

The geotechnical analyses will be refined for the Draft Final DBR to evaluate the global stability of the Parcel E-2 Landfill (under both static and seismic conditions) and the settlement potential of the landfill waste and underlying Bay Mud. These analyses were deferred until the Draft Final DBR because (1) they require additional data that will be collected as part of an upcoming investigation planned for summer 2013 (ITSI Gilbane Company, 2013) and (2) they are unlikely to significantly affect the cover design (particularly when compared to the analysis of the most critical slope along the southern perimeter of the Parcel E-2 Landfill).

The following sections briefly summarize the results of the geotechnical analyses.

3.5.1.1. Analysis of Seismic Hazards

The final cover for the Parcel E-2 Landfill is designed to withstand the MCE, which is the design requirement under Title 22 Cal. Code Regs. § 66264.310(a)(5). The MCE is defined as "the maximum earthquake that appears capable of occurring under the presently known geologic framework." For Parcel E-2, the MCE matches the maximum historical earthquake (the 1906 San Francisco Earthquake), which is a moment magnitude (M_w) 7.9 earthquake located 12 kilometers from Parcel E-2 (to be conservative, a M_w of 8.0 was used in the analysis). The promulgated design requirements for seismic slope stability do not specify the method of estimating the ground motion for the MCE event. Accordingly, ground motion for the MCE event was estimated based on the current state of practice for seismic design. Specifically, the seismic hazard analysis consisted of the following steps to estimate the ground motion for the MCE event:

- Ground motion prediction equations, which are empirical relationships developed from extensive ground motion databases for North America and other seismically active regions, were used to estimate the acceleration spectra for the MCE (damped by 5 percent).
- Ground motion prediction equations were also used to estimate the median peak ground acceleration at Parcel E-2 following the MCE (0.29 times the acceleration due to gravity).
- Four acceleration time history records for other areas that met the magnitude-distance criteria for the San Andreas Fault were reviewed and matched to the acceleration spectra for the MCE at Parcel E-2.

The results of the seismic hazard analysis are presented in Appendix E and were used in the liquefaction potential and seismic stability analyses. These analyses informed the design of the final cover for the Parcel E-2 Landfill.

3.5.1.2. Analysis of Liquefaction Potential

The Navy performed an initial analysis of liquefaction potential in 2004 (TtEMI, 2004c). This analysis, which was based on data from soil borings and CPT locations surrounding the Parcel E-2 Landfill, concluded that sandy soil below and along the perimeter of the landfill is potentially liquefiable. The report also concluded that, because of the varying thickness and types of liquefiable soil at each location, the liquefaction is likely to be non-uniform (or discontinuous) across the site, which would be less damaging than liquefaction over a large continuous area. The Navy collected additional data, in support of this DBR, from soil borings and CPT locations along the southern perimeter of the Parcel E-2 Landfill (ERRG, 2013). Data from both studies were used to refine the previous liquefaction potential analysis for this DBR. Based on the analytical results, it was concluded that:

- Sandy fill within and adjacent to the Parcel E-2 Landfill may liquefy during the MCE and affect the stability of the southern perimeter of the landfill (adjacent to San Francisco Bay).
- Lateral spreading is not considered a serious concern at this site because the potentially liquefiable zones appear to be discontinuous and isolated.
- Post-liquefaction settlement is unlikely to be critical to the overall stability of the landfill because it is estimated to be less than 10 inches.

The potential instability along the southern perimeter of the Parcel E-2 Landfill warranted an iterative slope stability analysis that is further detailed in Appendix E and briefly summarized in Section 3.5.1.4.

3.5.1.3. Analysis of Cyclic Softening of Bay Mud

Bay Mud samples were collected from soil borings along the southern perimeter of the Parcel E-2 Landfill. The samples were tested using several different methods to evaluate the strength of the Bay Mud during static and seismic (i.e., cyclic) loading conditions. Tests included constant rate of strain consolidation tests, static triaxial shear strength using consolidated undrained test conditions, a series of three cyclic triaxial shear strength tests, and post-cyclic triaxial shear strength tests (ERRG, 2013). The test results were used to analyze the potential for cyclic softening of the Bay Mud during an earthquake. The analysis showed that the Bay Mud has the potential to undergo cyclic softening during ground motion associated with the MCE. However, the post-cyclic triaxial shear strength tests on samples subjected to cyclic loading show that post-cyclic shear strength is similar to the original static shear strength. Therefore, the reduction of the strength of Bay Mud due to cyclic softening is expected to be small and potentially negligible. However, the presence of relatively soft Bay Mud, combined with the additional loading from the shoreline revetment, warranted a detailed evaluation of the stability of the southern perimeter of the landfill.

3.5.1.4. Stability Analysis of Southern Perimeter of Parcel E-2 Landfill

As described in Section 3.5.1.2, the potential exists for liquefaction of sandy fill materials underlying the perimeter of the Parcel E-2 Landfill during the MCE. Such liquefaction could affect the stability of the southern perimeter of the Parcel E-2 Landfill, including the shoreline revetment and final cover. To satisfy the requirements of Title 27 Cal. Code Regs. § 21145(a), a quantitative slope stability analysis was performed for the southern perimeter of the Parcel E-2 Landfill, which is adjacent to San Francisco Bay and represents the most critical slope of the final cover. Results of the iterative slope stability analysis, under both static and seismic conditions, determined that two layers of Tencate Miragrid® 22XT geogrid (or equivalent reinforcement with a combined long-term design tensile strength of 20,500 pounds per foot) will be required to achieve the minimum factors of safety for geotechnical practice (1.3 for short-term conditions and 1.5 for long-term conditions).

The geogrid layers will be placed on the shoreline slope directly below the revetment material and will extend horizontally to an appropriate anchor point under the protective liner. The required total length of each geogrid layer, from the base of the slope to the upland anchor point, is approximately 82 feet. The geogrid layers will be installed in segments (perpendicular to the shoreline) in the following sequence:

1. Excavate material along the shoreline slope and upland area requiring reinforcement
2. Install two geogrid layers (one directly on top of the other)
3. Place and compact soil within the upland area to properly anchor the geogrid layers
4. Install revetment material

This general construction sequence is important because the short-term slope stability analyses (see Appendix E) identified a potential slope failure if the geogrid layers are not installed and anchored before placement of the revetment material.

3.5.2. Soil Cover and Protective Liner for Parcel E-2 Landfill and Adjacent Non-Wetland Areas

The soil cover and protective liner for the Parcel E-2 Landfill and adjacent non-wetland areas were designed to meet the substantive requirements of pertinent ARARs (see Table 1). The soil cover and protective liner for the Parcel E-2 Landfill and adjacent non-wetland areas have the following components:

- A foundation soil layer that is at least 2 feet thick [in accordance with Title 27 Cal. Code Regs. § 21090(a)(1)]
- A protective liner that limits infiltration into the underlying material
- A demarcation layer to identify remaining radiological hazardous substances at depth
- A vegetative soil layer (at least 2 feet thick) that is capable of sustaining plant growth that will resist erosion [in accordance with Title 27 Cal. Code Regs. § 21090(a)(3)]

Soil cover material at depths greater than 0.5 foot below the final cover surface will be compacted to 90 percent or greater of the maximum dry density at or near optimum moisture, in accordance with ASTM International-modified proctor density testing. The upper 0.5-foot portion of the soil cover will be compacted to not greater than 85 percent of the maximum dry density. This compaction scheme is based on U.S. Army Corps of Engineers (USACE) technical guidance and optimizes slope stability with vegetative growth (U.S. Army Engineer Research and Development Center, 2001).

The following sections describe the design basis for each element of the soil cover and protective liner.

3.5.2.1. Foundation Soil Layer

The foundation soil layer will be no less than 2 feet thick and will consist of appropriate material that includes onsite soil (following radiological screening) or offsite soil (imported from a source that meets the acceptance criteria. The backfill acceptance criteria for Parcel E-2 are included in the project specifications (Appendix C, Section 31 00 00, Earthwork). Soil for the foundation layer must meet the engineering properties specified in the project specifications (Appendix C, Section 31 00 00). The foundation soil layer shall be compacted to 90 percent or greater of the maximum density obtainable at or near optimum moisture content in accordance with ASTM International-modified proctor density testing (frequency specified in the project specifications in Appendix C).

The foundation soil layer will be graded to match the slopes of the final cover. The final cover over the Parcel E-2 Landfill will have slopes of at least 3 percent to promote surface water runoff and prevent ponding in accordance with Title 27 Cal. Code Regs. § 21090(b)(1). Steeper slopes (not to exceed 1 foot of vertical rise for each 3 feet of horizontal distance [3H:1V], or about 33 percent) will be constructed in the northwest corner of the Parcel E-2 Landfill (where most of the onsite material will be consolidated prior to constructing the final cover) and along the property boundary (as a transition to match the surrounding topography). The cover slopes in the Panhandle and East Adjacent Areas are not subject to the requirements of Title 27 Cal. Code Regs. § 21090(b)(1), but will be graded to promote positive drainage into the wetland areas and other surface water drainage features

3.5.2.2. Protective Liner

The protective liner will be placed on top of the foundation soil layer and will consist of one of two configurations described below.

Multilayer Geosynthetic Liner for the Parcel E-2 Landfill

The multilayer geosynthetic liner for the Parcel E-2 Landfill consists of the following elements:

- A composite low-permeability layer that consists of an HDPE geomembrane at least 60-mil (0.06 inch) thick over a GCL (comprising bentonite clay)
- An overlying geocomposite drainage layer consisting of:
  - a nonwoven polypropylene geotextile fabric placed over the HDPE geomembrane (to cushion it from the overlying geonet)
  - a geonet comprising two bonded overlapping HDPE strands to transmit infiltrated water to drainage features at the top of the cap
  - another layer of geotextile fabric to prevent soil from clogging the underlying geonet (this fabric layer may also serve as the demarcation layer that is described in Section 3.5.2.3)

The multilayer geosynthetic liner would prevent the downward entry of water into the landfill waste in accordance with Title 22 Cal. Code Regs. § 66264.310(a)(1), which is an ARAR for the Parcel E-2 Landfill. The inclusion of the GCL in the multilayer geosynthetic liner provides extra protection and enhances LFG control. Bentonite, when hydrated, will swell into the defect in the overlying geomembrane to impede infiltration. The interaction between the two components of the composite low-permeability layer creates a self-sealing system that is extremely impermeable to infiltration. In addition, the self-sealing properties of the composite low-permeability layer will control LFG emissions in a variety of site conditions. Because of the higher volume and proportion of putrescible waste in the Parcel E-2 Landfill relative to the Panhandle, East Adjacent, and Shoreline Areas, the extra protection afforded by the composite low-permeability layer is important to the control of LFG emissions. The design of the multilayer geosynthetic liner matches the existing interim cap that is present over 14.5 acres of the Parcel E-2 Landfill (see Section 2.2).

Geosynthetic Liner for the Panhandle and East Adjacent Areas (outside of new wetlands)

The geosynthetic liner for non-wetlands portions of the Panhandle and East Adjacent Areas consists of the following elements:

- A HDPE geomembrane at least 60-mil thick
- An overlying geocomposite drainage layer (identical to that provided for the Parcel E-2 Landfill)

The geosynthetic liner for non-wetlands portions of the Panhandle and East Adjacent Areas would be connected to the multilayer geosynthetic liner for the Parcel E-2 Landfill. Although the combined liner system would be continuous across these areas and would serve a similar function (to limit infiltration into the underlying material), the design basis of the two liners are different.

The multilayer geosynthetic liner for the Parcel E-2 Landfill satisfies Title 22 Cal Code Regs. § 66264.310(a)(1), which requires that the downward entry of water into the landfill waste be prevented. However, Title 22 Cal. Code Regs. § 66264.310(a)(1) is not an ARAR for the Panhandle or East Adjacent Areas because the conditions in these areas do not match the type of site regulated by this requirement (i.e., landfill sites). Accordingly, the geosynthetic liner is specified to minimize (not prevent) water seeping into the contaminated material, thereby reducing the potential for contamination to leach to underlying groundwater.

Figures 13 and 14 show the different cover types for Parcel E-2 and the non-wetlands portions of the Panhandle and East Adjacent Areas. For brevity, these cover types are designated on Figures 13 and 14 as follows:

- Existing multilayer geosynthetic cap (for the portion of the interim cap that will be incorporated into the final cover design)
- Proposed multilayer geosynthetic cap (for the remaining portion of the Parcel E-2 Landfill that will be covered with a multilayer geosynthetic liner)
- Proposed geosynthetic cap (for the non-wetlands portions of the Panhandle and East Adjacent Areas that will be covered with a geosynthetic liner)

The estimated quantities of the geosynthetic materials are provided in Appendix A, calculation brief A-3.

3.5.2.3. Demarcation Layer

In areas that are radiologically impacted, a demarcation layer will be installed at the bottom of the soil cover to mark the presence of remaining radiologically hazardous substances at depth. The demarcation layer will consist of an orange-colored geotextile fabric and marking tape to ensure proper identification of the bottom of the soil cap. The marking tape will be printed with a warning message indicating the presence of the contaminated soil beneath. The marking tape will be placed in a 10-foot grid on top of the fabric. The marking tape will be of a material suitable to be detectable by electromagnetic geophysical equipment.

As described in Section 3.5.2.2, all non-wetland areas will be covered with a protective liner that will include a geocomposite drainage layer. In non-wetland areas that are radiologically impacted, the upper layer of geotextile fabric within the geocomposite drainage layer will also serve as the demarcation layer. That is, the upper layer of fabric will be orange-colored and overlain by magnetic marking tape, and will then be covered by 2 feet of soil.

Wetland areas, which are discussed further in Section 3.5.5, will not have a protective liner but will require a demarcation layer. In the wetland areas, the orange-colored geotextile fabric and overlying magnetic marking tape will be placed at the bottom of the 4-foot-thick soil cover.

3.5.2.4. Vegetative Soil Layer

The geosynthetic layers described in Sections 3.5.2.2 and 3.5.2.3 will be covered by a minimum 2-foot-thick vegetative soil layer capable of supporting plant growth. The plant growth will provide erosion resistance for the cover soil. The total volume of the vegetative soil layer is estimated at 124,800 cubic yards (compacted in place; see Appendix A, calculation brief A-3). The upper 0.5-foot portion of the soil cover will be compacted to not greater than 85 percent of the maximum dry density.

The final cover, excluding the tidal and fresh water wetlands, will be seeded with the following mix. The native seed mix in the table below is intended for survival without irrigation or significant maintenance after a 3-month establishment period.

Common Name	Species	Pounds per Acre
California Brome	*Bromus carinatus*	25
Meadow Barley	*Hordeum brachyantherum*	10
Small Fescue	*Vulpia microstachys*	6
Tomcat Clover	*Trifolium willdenovii*	4
California Poppy	*Eschscholzia californica*	1.5

Binders or degradable geonet will be used to minimize erosion during the 3-month establishment period for vegetation, which will be the responsibility of the construction contractor. Irrigation during the vegetation establishment period may be necessary. Additional erosion control measures will be incorporated, as appropriate, following placement of the vegetative soil layer. For example, slopes greater than 5H:1V and along the drainage swale will be further stabilized through the use of composite turf reinforced matting.

3.5.3. Surface Water Drainage and Erosion Control

The proper design of surface water drainage features and erosion control measures are required by several requirements in Title 27 Cal. Code Regs. (see Table 1). Most notably, Title 27 Cal. Code Regs. § 20365(c) requires that diversion and drainage facilities be designed and constructed to accommodate the anticipate volume of precipitation and peak flows. The surface water drainage features and erosion control measures are designed to satisfy the pertinent ARARs and are described below.

3.5.3.1. Drainage Features

Drainage channels along the perimeter of Parcel E-2 will capture most surface water (see Figure 9). Drainage channels along the northwestern and southwestern perimeter of the Parcel E-2 Landfill will receive surface runoff from the west and central portions of landfill and will convey the surface water into the freshwater wetlands. Drainage channels along the northeastern and southeastern parcel boundary will receive surface runoff from the east side of the Parcel E-2 Landfill and most of the East Adjacent Area and will convey the surface water to an outfall structure that will discharge into San Francisco Bay. A culvert pipe will be used to carry the flow under the site entrance road along the eastern parcel boundary. The remainder of the surface water runoff will be conveyed as follows (see Figure 9 and design drawing C19 in Appendix B):

- Runoff from the southeast corner of Parcel E-2 (including portions of the Parcel E-2 Landfill and East Adjacent Area) will sheet flow across the shoreline revetment to San Francisco Bay.
- Runoff from the south-central portion of the Parcel E-2 Landfill will flow into a subsurface structure that will convey the surface water into the freshwater wetlands.

- Runoff from the northeastern portion of the Panhandle Area will sheet flow into the freshwater wetlands.
- Runoff from the southwestern portion of the Panhandle Area will sheet flow into the tidal wetlands.

The existing topography of the area surrounding Parcel E-2 is relatively flat and does not direct significant surface water onto Parcel E-2.

The proposed drainage channels, culvert, and outfall structures were designed to accommodate the peak flows from a 24-hour storm event totaling 7.5 inches of rainfall (with an estimated return period of 1,000 years). In addition, a 1-hour storm event totaling 1.62 inches (with an estimated return period of 1,000 years) was used to evaluate the scour potential within the channels. Rainfall totals for the 1,000-year design storm were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 6 Version 2 Precipitation Frequency Data Server[2]. For the drainage design calculations (see Appendix A, calculation briefs A-4 and A-5), the site was divided into 13 drainage subareas and peak flows were analyzed using the Rational Method for flow in small watersheds.

The following criteria were used to design the drainage channels:

- Peak flow rate of 3.4 cubic feet per second associated with the 24-hour design storm must be controlled.
- Velocities of intermittent flow in grass-lined reinforced channels cannot exceed 4 feet per second without armoring or other considerations to dissipate energy.
- The base and side slopes along the drainage route will be a 2-foot-wide base with a 2H:1V side slopes up to finish grade.
- The minimum slope along the channel water course is 0.5 percent.

Using these criteria, grass-lined drainage channels with a minimum depth of 1 foot are sufficient to control surface water. The drainage channel along the eastern perimeter of Parcel E-2 will be increased to 1.5-feet deep to control the peak flow. Grass-lined channels were specified because the highest velocity along the drainage channels is approximately 3.9 feet per second.

Although the drainage features for Parcel E-2 are designed as a long-term remedy, it is anticipated that site conditions may change following redevelopment. Future modifications to the soil cover resulting in a change in the surface water drainage features should be consistent with the design basis provided in this DBR.

[2] http://www.nws.noaa.gov/oh/hdsc/index.html

3.5.3.2. Erosion Control

Erosion of the soil cover by wind and water was estimated and is provided in Appendix A, calculation brief A-6. The erosion calculations were completed for two likely scenarios: (1) the period just after the cover is seeded and before the grasses are established, which is considered the establishment period, and (2) the period after the grasses become established over the cover, which is considered the long-term cover scenario. These two scenarios were compared with the maximum acceptable soil loss value of 2 tons per acre per year that was suggested at the American Society of Civil Engineers short course titled, "Design of Waste Containment Liner and Final Closure Systems" (Richardson, 1997).

For the first scenario, it was assumed that the ground cover would be completely bare and fully exposed to wind and water erosion without protection for the period just after the grasses are planted over the soil cover. Under this scenario, total erosion losses over the cover would be anticipated to be approximately 31 tons per acre per year, or a loss of 0.17 inches of soil per year. This rate is considerably greater than the acceptable loss of 2 tons per acre per year; thus, vegetation is needed over the cover for erosion control and temporary erosion control measures are needed during the establishment period. As described in Section 3.5.2.4, binders or degradable geonet will be used on the cover to minimize erosion during the 3-month establishment period for vegetation, In addition, slopes greater than 5H:1V and along the drainage swale will be further stabilized through the use of composite turf reinforced matting.

For the second long-term scenario, it was assumed that the vegetative coverage would be 90 percent. Under this scenario, total erosion losses over the cover are anticipated to be approximately 0.10 ton per acre per year, or a loss of less than 0.0006 inch of soil per year. This rate is considerably less than the acceptable loss of 2 tons per acre per year, and the recommended vegetative cover will be sufficient to control erosion over the site. Practices for controlling erosion and maintaining the vegetative cover are included in the OMP. In addition, stormwater discharges to San Francisco Bay and the wetlands will be subject to periodic inspections and monitoring, as described in the RAMP.

3.5.4. Other Design Considerations for Soil Cover and Protective Liner

The elevation of the final cover over the site will be surveyed after construction is complete to document the final cover elevations. Permanent survey monuments will be installed on the cover and periodically surveyed to assess future settlement. The OMP includes specific procedures for future inspections to assess future settlement.

A fence will be constructed around the site perimeter (except along the shoreline) to help the Navy protect the constructed remedy. Fencing is meant to restrict access to the site and to prevent damage that might occur under Navy ownership. The OMP includes specific procedures for future inspections of the fence and other security features.

Burrowing animal activity can be expected on the soil cover and, if the burrows extend deep enough, such activity could be indicative of potential damage to the protective liner. The potential for burrowing animals to penetrate an HDPE geomembrane is generally considered low by experts in the waste containment industry (Sharma and Lewis, 1992; Karr et al., 1992; Gee and Ward, 1997; Air Force Center for Environmental Excellence, 1999). However, the potential cannot be entirely dismissed and some landfill closures specify a biotic barrier (to supplement postclosure inspection, maintenance, and animal control measures). For example, a geocomposite drainage layer has been specified to serve as a biotic barrier at several landfill sites in the San Francisco Bay area (TtEMI, 2005b; IT, 2000; U.S. Department of Energy, 1997). The soil cover and protective liner at Parcel E-2 include a 2-foot-thick vegetative soil layer [12 inches thicker than the minimum requirement under Title 27 Cal. Code Regs. § 21090(a)(3)] and a geocomposite drainage layer (consisting of three separate geosynthetic materials) that would deter burrowing animals from penetrating the HDPE geomembrane.

The soil cover will be regularly inspected for evidence of burrowing animals. Specific inspection procedures for burrowing animal activity are included in the OMP. If burrowing animal activity is observed, maintenance actions will include prompt repair of any damage to the soil cover (or underlying protective liner) and may involve the use of animal control measures. The OMP describes the corrective measures and adaptive management that will be used to control burrowing animal activity, if necessary, to limit erosion of the soil cover or ensure the integrity of the protective liner. Low-impact control measures, such as the installation of raptor perches, are preferable as opposed to higher impact control measures, such as the use of poisons, to control burrowing animals at Parcel E-2.

3.5.5. Soil Cover and Demarcation Layer for Wetland Areas

The freshwater and tidal wetlands are being constructed to offset the loss of wetlands at Parcel E-2 and other areas at HPNS, in accordance with the substantive requirements of the federal Clean Water Act and the state of California's McAteer-Petris Act (see Table 1). A liner will not be used in the new wetlands, so they function more naturally. To prevent exposure to contaminated material, the soil cover in the new wetlands will be 4 feet thick and will consist of 3 feet of hydric soil underlain by a demarcation layer (see Section 3.5.2.3) and a 1-foot-thick soil bridge (consisting of clean imported soil). Section 3.9 provides further information on the wetlands design basis.

3.6. SHORELINE REVETMENT

This section summarizes the basis of the draft RD for the shoreline revetment. The design criteria for the shoreline revetment along the boundary of Parcels E-2 and F include the RAOs and ARARs that pertain to soil and sediment, surface water, and groundwater presented in the ROD (Navy, 2012). The revetment design will prevent unacceptable exposure to humans and wildlife from contaminants in shoreline sediment. The design requires the development of a San Francisco Bay Water Quality Monitoring and Protection Plan that specifies the monitoring requirements for nearshore excavations and revetment

construction and BMPs that will control the discharge of contaminants into the bay. The plan will incorporate appropriate steps to comply with the specified discharge restrictions and minimize adverse impacts to waters of the bay. The design basis for the revetment adheres to standard practice for coastal engineering design, including pertinent USACE guidance (USACE, 2006), and address potential constructability issues and environmental controls for shoreline excavation.

A revetment is a facing of armor material, such as stone or concrete, that is intended to protect a shoreline from erosion. The primary physical design components of the revetment are the armoring material, the toe, the crest, and the filter layer. The armoring material is selected and sized based on the forces that will act on the structure, such as water currents, wave action, and gravity. The extent of the revetment, or the elevations of the toe and crest, is based on the expected high and low water conditions, significant wave heights, and wave runup on the structure. The filter layer is set between the armoring material and the underlying soil or engineered fill and is intended to allow water to pass while supporting the structure and preventing erosion of the underlying soil and sediment.

The design of the revetment for Parcel E-2 differs slightly from traditional revetment designs. These differences are related to its additional function to contain contaminated soil at Parcel E-2 and protect humans and wildlife. The following list summarizes the primary design basis elements that were used in developing the revetment design:

- The impact of anticipated maximum wave energy.
- The geotechnical stability of the revetment structure and shoreline slope.
- Water levels from tidal fluctuations and potential sea level rise.
- Prevention of human contact with potentially contaminated soil beneath the revetment.
- The need to minimize filling the tidal flats (present below 0 feet msl) with riprap.
- The future use of the area as open public space, and the possibility for foot traffic and vandalism along the revetment.
- Minimize negative impacts to the bay during construction.

The revetment will improve the shoreline of Parcel E-2 by replacing the existing shoreline with an armored, engineered revetment, meeting USACE design criteria (USACE, 2006). The revetment will prevent migration of contaminated sediment along the current shoreline and will integrate with the soil cover at the onshore portions of Parcel E-2. Sections 3.6.1 through 3.6.9 discuss the specific design basis elements and construction considerations.

The shoreline was inspected as part of the revetment design. The existing shoreline is partially armored with an unsupported revetment that maintains the shoreline in a relatively stable condition.

The revetment would be installed along approximately 1,800 feet of shoreline where Parcel E-2 meets Parcel F. The revetment will be approximately 35 feet wide[3], and the crest elevation will be approximately +9 feet msl. In addition, a 3-foot-high concrete seawall will be incorporated into the crest of the revetment to accommodate wave runup. The sea wall was designed as an alternative to placing additional soil and armor rock to reach the design elevation (+12 feet msl), thereby providing an acceptable level of protection while minimizing the fill volume and associated weight of the shoreline revetment. This is an important consideration because, as discussed in Section 3.5.1, the relatively soft Bay Mud along the shoreline, combined with the additional loading from the shoreline revetment, affects the slope stability along the southern perimeter of the Parcel E-2 Landfill. The seawall would also act as a protective barrier along the shoreline walking path and act to hold back material that might erode from the upland soil cover.

A conservative approach for design of the revetment was taken to maximize its ability to prevent contaminated soil from migrating to the bay while remaining protective of humans and wildlife, considering the future use of the area. The long-term ongoing remedy developed in this DBR consists primarily of a soil cover and shoreline revetment over the site, which has been assessed for susceptibility to damage from seismic activity (see Section 3.5.1). The following sections and procedures for the revetment design are based on the USACE "Design of Coastal Revetments, Seawalls, and Bulkheads" and "Coastal Engineering Manual, Parts I through VI" (USACE, 1995 and 2006). Figure 13 shows the proposed location of the shoreline revetment; Figure 15 provides a conceptual cross section of the revetment; and design drawings C8, C9, and C10 in Appendix B provide the detailed cross sections along the revetment. The following sections summarize development of the revetment design.

3.6.1. Water-Level Ranges

The tidal ranges for Parcel E-2 were estimated from data published by the NOAA and the National Geodetic Survey (NOAA, 2009; National Geodetic Survey, 2012). Tidal data serve as the basis for design of a revetment as a primary component in calculating the crest elevation and the extent of the structure. All data were corrected to NGVD 1929, the universal vertical datum selected for this design package.

The tidal range between the mean higher high water (MHHW) and the mean lower low water (MLLW) was approximately 6.73 feet for the tidal epochs of 1960 through 1978 (NOAA Hunters Point Tidal Benchmark and Datum). The MHHW and MLLW are defined as the mean of the higher high water height and the lower low water height of each tidal day observed over the tidal datum epoch. When adjusted for msl based on NGVD 1929, the MHHW is +3.61 feet above msl and the MLLW is -3.12 feet

[3] The width of the shoreline revetment adjacent to the proposed tidal wetlands appears narrower than 35 feet; however, as shown in design drawing C15 (specifically Section K) in Appendix B, clean soil within the tidal wetlands will be placed on top of the lower half of the revetment.

below msl. Tidal ranges are generally referenced to MLLW; however, elevations are referenced to msl in this design to remain consistent with overall site elevations and the surveys completed.

Also of significance for the revetment design is the determination of the highest water levels expected. Tidal data were obtained to assess the extreme high and low water events for the tidal epochs described above. An extreme high tide of 6.7 feet above msl can be expected for the project location and is associated with a 100-year return period (USACE, 1984). Appendix A, calculation brief A-7, includes the tidal range calculations and adjustment factors. Table 8 summarizes the primary tidal data elevations used for the revetment design and calculations.

The potential for an increase in the sea level elevation as a result of atmospheric warming has been considered in the design of the revetment. The paragraphs below briefly summarize information on potential increases in the global sea level over the next 100 years.

The Intergovernmental Panel on Climate Change (IPCC) estimated potential increases in the global sea level over the next 100 years. The following excerpt from Church et al. (2008) summarizes the most recent IPCC estimates of global sea level rise (which range from 0.3 feet to 2.9 feet): "The IPCC provides the most authoritative information on projected sea-level change. The IPCC Third Assessment Report of 2001 (Church et al., 2001) projected a global-averaged sea-level rise of between 20 and 70 centimeters (cm) between 1990 and 2100 using the full range of IPCC greenhouse gas scenarios and a range of climate models. When an additional uncertainty for land-ice changes was included, the full range of projected sea-level rise was 9–88 cm. For the IPCC's Fourth Assessment Report (Meehl et al., 2007), the range of sea-level projections, using a larger range of models, is 18–59 cm (90% confidence limits) over the period from 1980–1999 to 2090–2099 (Meehl et al., 2007)."

The estimates from the IPCC's Fourth Assessment Report used data published in 2005 or earlier and, because of uncertainty in the available information, did not account for potential increases in sea level due to changes in ice sheet dynamics (i.e., rapid loss of ice sheets that could contribute to sea level rise). More recent research has yielded a wide range of estimated sea level rise over the next 100 years (between 1.8 to 6.5 feet) that accounts for changes in ice sheet dynamics but reflects the significant uncertainty in such projections (National Research Council, 2010).

Based on the information summarized above, a contingency of up to a 3-foot increase in sea level was considered in designing the crest elevation, which is discussed in Section 3.6.6.

3.6.2. Wind and Wave Dynamics

Wave height is an element of the revetment design basis that depends largely on the velocity of wind over the water, the duration of the sustained wind, and the available wind fetch (i.e., the uninterrupted over-water distance where wind can affect the water surface). The greatest 2-minute sustained peak wind

speeds that might affect generation of waves for the site are anticipated to be from a direction of 160 degrees (clockwise) from north at 49 mph and have been estimated to have a 100-year return period. Unsustained wind gusts of short duration do not significantly affect the formation of waves. Appendix A, calculation brief A-8, summarizes the determination of the wind dynamics for the design.

The proposed revetment area is directly exposed to waves generated by winds blowing from between 143 degrees (clockwise) from north and 176 degrees from north as shown in the fetch distance and wind parameters calculation brief (A-8). Fetch distances in the other cardinal directions are restricted by significant landmasses. The design wind speed should be appropriate to the design fetch distance. The fetch for winds blowing from 160 degrees (clockwise) from the north extends from Coyote Point, which is over 10 kilometers (6.2 miles) from the Parcel E-2 shoreline. However, not all of these distances are available at all points along the shoreline. Appendix A, calculation brief A-8, summarizes the available fetch distances for Parcel E-2.

A series of deep-water wave heights can be calculated for given wind and fetch parameters available for a location. Appendix A, calculation brief A-9, summarizes the anticipated wave heights by appropriate cardinal direction for the site. The highest calculated wave height is considered the significant wave and is used in the design of a revetment or other coastal structures. The highest calculated significant wave height anticipated for the site would be from 160 degrees (from the north), at a wind speed of 41 mph, with a height of 4.1 feet associated with the 100-year return period winds. This maximum anticipated significant wave of 4.1 feet serves as the design wave in calculations throughout the design.

The design wave, as summarized above, is an open water wave that would break before it reached the shoreline and the revetment. It is used in this design and provides a conservative estimate of the wave that can be expected to affect the revetment. Generally, a wave will break when it reaches a water depth equal to or less than approximately 128 percent of its height (USACE, 2006). Based on this ratio of wave height to depth, the design wave will break in 5.3 feet of water (see Appendix A, calculation brief A-13). The open water wave has been used in this design because it is conservative; however, most waves will break before they reach the revetment, so the actual wave energy along the revetment will be less.

3.6.3. Selection of Armor Material

The revetment can be constructed from a wide variety of materials, including stone, concrete, or prefabricated mats and blocks. Potential materials were screened and selected based on strength, availability, cost, and constructability. Special consideration was also given to the future use of the area in selecting the material. It was determined that the bulk of the revetment structure should be constructed using stone, as it will appear more natural, and because stone-based options are flexible and are able to withstand minor damage without compromising strength and function. Revetments constructed from stone can also be repaired more easily than can structures made from prefabricated materials. As

described previously, a concrete seawall will be incorporated into the crest of the revetment to accommodate wave runup.

Three options are available for the primary natural stone: (1) multiple layers of angular uniform-sized rock (quarrystone), (2) graded rock of sizes between upper and lower limits (riprap), and (3) layers of subrounded to rounded boulders (field stone). The primary disadvantage to revetments constructed of fieldstone is that they have considerably less strength than revetments constructed of more angular quarrystone or riprap material of the same weight. Obtaining larger fieldstone needed for a revetment could be difficult, and placement of this material is costly. For this reason, fieldstone was not considered.

When comparing the strengths of randomly placed quarrystone versus randomly placed riprap, a greater thickness of quarrystone is needed to achieve the strength of a thinner layer of riprap. The quarrystone option would likely have a greater cost than riprap for a comparable strength. For this reason, uniform quarrystone was not considered suitable. Additionally, it has significant void space between rocks, which could pose a trip hazard to potential foot traffic given the anticipated future use of the site as a park.

Riprap is not recommended for revetments with sustained exposure to waves larger than 5 feet. The significant wave for this design was estimated at 4.1 feet, and a natural riprap material was deemed the most appropriate option. This design incorporates a randomly placed natural riprap, which is typically composed of two layers of the selected median size armor stone.

3.6.4. Revetment Slope Selection

For Parcel E-2, the two primary considerations in selecting the revetment slope are (1) the geotechnical stability of the revetment structure and shoreline slope, and (2) the need to integrate the revetment structure with the surface elevations of the proposed final cover (which, as described in Sections 3.3 and 3.4, will include onsite consolidation of more than 117,000 cubic yards of material before placement of the final 2-foot-thick soil cover). A uniform revetment slope of 3H:1V will be stable under the seismic design conditions (summarized in Section 3.5.1 and detailed in Appendix E), and integrates with the proposed elevations of the final cover. The proposed 3H:1V slope is also similar to the conditions along the Parcel E-2 shoreline prior to the Phase 2 TCRA at the PCB Hot Spot Area; which, as described in Section 2.6, removed significant volumes of contaminated soil and debris and resulted in more gradual shoreline slopes.

A secondary consideration in selection of the slope is the assessment of the existing shoreline slope and the amount of soil and sediment that would need to be excavated or filled to achieve the prescribed slope. The existing slope along the extent of the proposed revetment (which was substantially reduced following removal of contaminated soil and debris during the Phase 2 TCRA at the PCB Hot Spot Area) varies between about 20H:1V and 10H:1V, depending on location, with the average slope being about 14H:1V.

A uniform revetment slope of 3H:1V increases the existing slope along the shoreline, which reduces the total amount of excavation necessary along the revetment.

In addition, a uniform slope along the revetment is desirable for ease in construction and to maintain uniform rock gradation throughout the structure. More steeply sloped riprap revetments are inherently less stable, and larger rock sizes are needed to achieve the same strength as less steeply sloped structures. If varying slopes are used along the revetment, varying riprap sizes are needed to maintain the stability, which can increase the risk of failure and can complicate operations and maintenance of the structure. Therefore, a uniform slope has been used in this design basis.

Figures 13 and 14 show a plan view and details of the revetment extents and final grade. Figure 15 shows a typical cross section of the revetment.

The shoreline will be excavated for construction of the revetment, and most of the revetment will be placed on Bay Mud or clean import fill. Approximately 4,900 bank cubic yards of soil and sediment will be excavated along the shoreline to achieve the prescribed slopes for the revetment (Appendix A, calculation brief A-17). Excavated sediment may be consolidated on site following radiological screening, as described in Sections 3.3.5 and 3.3.7.

3.6.5. Armor Unit Sizing

Armor unit sizing for revetments depends on five primary physical design criteria: (1) wave height, (2) the slope of the structure, (3) the type of material used, (4) the configuration of the revetment, and (5) the degree of access by the public.

Future use of the site was considered in determining the size of the armor unit. Issues such as vandalism, theft, and inadvertent movement of the rocks caused by foot traffic needs to be considered in the design because of the potential future public access to the area. Generally, rocks that weigh between 400 to 500 pounds are of sufficient size to withstand vandalism, theft, and inadvertent movement (USACE, 1985).

The median rock size (W_{50}) of the riprap was calculated using the Hudson formula (see Appendix A, calculation brief A-10). The calculation is based on a revetment slope of 3H:1V, revetment material consisting of randomly placed riprap, and a design wave height of 4.1 feet. Using this formula yields a W_{50} of approximately 437 pounds, which corresponds to a spherical shape with a diameter of 1.7 feet and a cubical shape with a dimension of 1.4 feet.

The median weight calculated using the Hudson formula is considerably less than the recommended weight for projects with a high degree of public access as described above. Therefore, a stone weight of 450 pounds was selected as the median stone weight for the revetment design.

The layer thickness of graded riprap measured perpendicular to the slope is calculated based on both the W_{50} rock size and the largest rocks obtained (W_{100}). Based on the W_{50} of 450 pounds, the upper rock size of the gradation is 900 pounds, with a minimum weight of 75 pounds. This gradation is similar to a "1/4-ton riprap," as defined by the California Department of Transportation,[4] and is readily available in the San Francisco Bay area. Based on this gradation, the revetment will be 2.8 feet thick, or two times the diameter of the W_{50} rock. Appendix A, calculation brief A-11, provides the calculation of the armor thickness.

3.6.6. Crest Elevation

Similar to the selection of the revetment slope, the two primary considerations in selecting the crest elevation for the Parcel E-2 revetment are (1) the geotechnical stability of the revetment structure and shoreline slope, and (2) the need to integrate the revetment structure with the surface elevations of the proposed final cover (which, as described in Sections 3.3 and 3.4, will include onsite consolidation of more than 117,000 cubic yards of material before placement of the final 2-foot-thick soil cover). A secondary consideration is the placement of the top of the revetment or the crest design element at a sufficient height above the water level to prevent overtopping of water (from wave action). Design criteria, including the maximum water levels, wave heights, contingencies, and potential wave runup, are considered for selection of the crest elevation. Runup is defined as the vertical height above the still water level where the uprush from a wave will rise on a structure. The wave runup onto a revetment is based on the design wave, the design wave period, the depth of water on the revetment, and the slope of the revetment. The wave runup is calculated using the Ahrens and Heimbaugh formula, which is provided in Appendix A, calculation brief A-12.

Two wave runup conditions were calculated to evaluate the potential for water to overtop the revetment crest: (1) wave runup condition based on an extreme tide (100-year return period), and (2) wave runup condition based on MHHW that also accounts for 3 feet of sea level rise (the contingency described in Section 3.6.1). The Ahrens and Heimbaugh formula and the conditions based on an extreme tide (100-year return period) yield the higher estimated wave runup elevation (approximately 10.84 feet). This estimated wave runup elevation assumes that the 100-year return interval wave would occur during the 100-year high water event and is an inherently conservative estimate for the crest elevation. Both the extreme high tide and the wind conditions capable of producing the design wave are events with a return interval of 100 years (U.S. Army Corps of Engineers, 1984); therefore, the probability that either event occurs in any one year is 0.01. The probability that both occur in the same year is $0.01 \times 0.01 = 0.0001$, or 1 in 10,000. The likelihood of occurrence of 1 in 10,000 is interpreted as highly unlikely.

[4] California Department of Transportation Standard Specifications Section 72, Method B table, Available Online at: <http://www.dot.ca.gov/hq/LandArch/ec/steep_slopes/StdSpecs_Section_72.pdf>.

A revetment crest elevation of approximately +9 feet msl will integrate with the proposed elevations of the final cover, and will be stable under the seismic design conditions (summarized in Section 3.5.1 and detailed in Appendix E). An increase to the revetment crest elevation would increase the loading of the relatively soft Bay Mud along the shoreline and would result in an unstable slope along the southern perimeter of the Parcel E-2 Landfill. A 3-foot-high concrete seawall will be incorporated into the crest of the revetment to achieve a final design elevation of +12 feet msl, thereby providing an acceptable level of wave runup protection while minimizing the fill volume and associated weight of the shoreline revetment. The final design elevation of +12 feet msl would accommodate wave runup from two future scenarios and provide an additional 1 foot of freeboard during these two scenarios (more than 7 feet of freeboard would be provided at MHHW under normal wind and wave conditions). The 3-foot-tall seawall will also be protective of the durable cover over the landward portion of the site, and will not restrict sight lines to the bay. Figures 13 and 14 show the extents of the revetment, and Figure 15 provides a conceptual cross section of the revetment. Appendix A, calculation brief A-14 provides the design criteria for the seawall, and calculation brief A-15 includes the structural calculations for the seawall.

The revetment design will allow the revetment height to be increased in the future if the need arises because of increases in sea level elevation. The revetment could be extended as currently designed or constructed using a benched configuration if shoreline stability concerns remain in the future. A benched configuration would reduce the load at the top of the revetment slope by moving the revetment crest landward. However, revetment foundation soil is expected to gain strength over time as pore water in clay is gradually expelled and the revetment will strengthen over time as the angular revetment materials further interlock. The geotechnical parameters selected for the stability evaluation were chosen conservatively, and observation of the performance of the constructed revetment will allow further qualitative evaluation of the strength of the shoreline profile to inform future decisions to raise the crest. A thorough geotechnical evaluation should be performed if any changes to the revetment are envisioned.

3.6.7. Filter and Underlayers

A filter layer is needed between the armor rock and the underlying soil to ensure that the revetment is supported. The design criteria for the filter layer is that it has a transmissivity of at least the surrounding sediment and soil, allowing water to pass (both groundwater and surface water) while maintaining the stability of the soil. A geotechnical filter fabric intended for ocean shoreline and revetment applications is placed onto the base of the excavation in overlapping lateral sections and extends beyond the toe and crest sections to minimize sinking or moving the entire structure as a result of soil erosion. A layer of crushed filter rock is spread over the filter fabric to protect it from the armoring and distribute the load of the rock. This filter rock layer also contributes to the interlocking and securing the armor material. Figure 15 provides the typical cross section of the revetment and the filter layer and its location relative to the armor layer.

The filter fabric will run under the entire length of the revetment and will be tied into the armor layer at both the toe and the crest (see Figure 15). Securing the filter fabric into the revetment will secure the material in place even if the revetment material settles over time.

Given the site-specific conditions and the construction of the revetment, filter fabric sections should overlap by at least 2 feet to ensure continuity of the fabric material when the weight of the armor layer is added and during any shift of the revetment that may occur over time. Additionally, a 19-inch layer of crushed filter rock of 6.25 inches in diameter will be sufficient to protect the geotechnical filter fabric from the weight of the armor layer. Appendix A, calculation brief A-16, provides the filter stone size calculation.

3.6.8. Materials Quantities

Calculation of materials quantities for the revetment is an element of the design that determines the amounts of riprap, crushed rock, and filter fabric material that would be needed for the project. These calculations are provided as Appendix A, calculation brief A-17, and estimates are summarized below.

- Riprap rock – 5,915 tons
- Crushed rock – 3,602 tons
- Filter fabric – 15,730 square yards

The calculations assume 30 percent porosity for the crushed rock and riprap, 2 feet of overlap between filter fabric sections, and 12-foot fabric sections.

3.6.9. Other Design Considerations – Revetment

The following subsections describe other revetment design considerations, including construction, final survey, sediment deposition, and impacts to San Francisco Bay.

3.6.9.1. Construction

It is anticipated that the construction contractor will excavate and construct the revetment in complete sections and progress along the shoreline as sections are completed. Construction will be scheduled with consideration of the tidal cycle. Construction of the toe and lower portions of the revetment will be completed during low tides when the revetment area will not be exposed to seawater to minimize contact between seawater and potentially contaminated soil and sediment along the shoreline. Constructing the revetment using these methods will minimize the amount of bay water that will be in direct contact with potentially contaminated soil and sediment during construction. It also will ensure that erosion of the shoreline material will be minimal during construction because excavations will be open only during the workday. Erosion control and soil stabilization practices such as silt fencing and hay bales will be used as necessary to ensure that erosion is prevented. In addition, Section 3.5.1.4 specifies installation of two

layers of geogrid reinforcement under the shoreline revetment, and describes a general construction sequence that must be followed to ensure the short-term slope stability during construction. Specific construction methods will be included in the RAWP.

The revetment will be constructed above the 0 feet msl elevation from the shore without the use of barges or other provisions for construction from offshore. All construction will control the discharge of contaminants into San Francisco Bay. The revetment is being constructed to replace the existing shoreline armoring, and tidal flats will not be affected.

Prior to full construction of the revetment, the construction contractor will be required to demonstrate their capability of grading, placing the required materials, and other procedures, including environmental controls within specified tolerances. This demonstration section of the revetment will be 100 feet in length along the shoreline and construction of the remaining portion of the revetment will not begin without approval of the demonstration section from the Contracting Officer.

3.6.9.2. Final Survey

After construction of the revetment is complete, the structure will be surveyed to document the final elevations. These final elevations will be used for assessing the movement of the structure over time. Some movement and settlement of the structure are expected.

3.6.9.3. Sediment Deposition

Studies completed for the HPNS peninsula (Battelle and Woods Hole Group, 2001) indicate that the nearshore area in the vicinity of the site is generally depositional, and it is expected that, over time, the toe portions of the revetment will fill with sediment. The extent of deposition is not known but could reach to the MHHW elevation (+3.6 feet msl). This deposition will enhance the stability of the revetment to some degree through further stabilization of the toe. The revetment is being designed not to extend farther into San Francisco Bay than the existing shoreline armoring, and offshore erosion and deposition and nearshore wave dynamics are not anticipated to be affected by the revetment construction. The lateral extents of the revetment along the existing shoreline, or where the revetment meets Parcels E and F, will be below the existing grade for the toe and the lower portions of the revetment. Sediment will fill in above the revetment toe and lower portions over time to meet the existing grade. The crest portion of the revetment at the lateral extents will be above the existing adjacent site grade and will slope on site to meet the existing grade of the adjacent site, while maintaining the 4.4-foot thickness of the revetment materials.

3.6.9.4. Impacts to the San Francisco Bay

The revetment has been designed to minimize any negative impact to San Francisco Bay and follow the substantive provisions of the federal Coastal Zone Management Act and the State of California McAteer-Petris Act. Table 1 summarizes the specific requirements of these regulations and how the revetment

design elements address these requirements. The revetment will contain and stabilize contaminated sediment along the shoreline of the site and prevent future migration of contaminated sediment to the bay.

3.7. GROUNDWATER CONTROLS

This section describes the design basis and proposed design elements for the groundwater controls to be implemented at Parcel E-2. The ROD specifies that groundwater at Parcel E-2 will be controlled through the installation of two belowground barriers (Navy, 2012). Controlling groundwater at Parcel E-2 will specifically address the groundwater RAOs for the protection of wildlife specified in the ROD:

- Prevent or minimize migration of chemicals of potential ecological concern (in A-aquifer groundwater) to prevent discharges (to surface water [i.e., the San Francisco Bay]) that would result in concentrations greater than the corresponding surface water quality criteria for aquatic wildlife.
- Prevent or minimize migration of A-aquifer groundwater containing total petroleum hydrocarbons (TPH) concentrations greater than the remediation goal (see Table 4) (where commingled with CERCLA substances) into San Francisco Bay.

The first groundwater barrier, hereafter referred to as the "upland slurry wall," will be installed along the western boundary of the landfill, in the northern Panhandle Area. The goals of the upland slurry wall and associated subsurface drain (i.e., French drain) are (1) to divert a portion of the groundwater that would flow through the landfill waste, thus reducing the rate of leachate generation, and (2) to redirect a portion of the groundwater diverted by the barrier to a drain pipe that flows to the freshwater wetlands (discussed further in Section 3.9). The ARARs, provided in Table 1, include the surface water quality objectives that will apply to groundwater that is redirected to the freshwater wetlands through the subsurface drain.

The second groundwater barrier, hereafter referred to as the "nearshore slurry wall," will be installed near the shoreline adjacent to the Parcel E-2 Landfill and East Adjacent Area. The goal of the nearshore slurry wall is to maximize the travel time of groundwater between areas upgradient of the barrier and the San Francisco Bay, thus extending the natural attenuation period for contaminants in groundwater that might be discharged to the bay. The nearshore slurry wall will be supplemented by an upgradient well network to support monitoring and, if necessary, leachate extraction.

In accordance with the ARARs (Table 1), future leachate mitigation, monitoring, and control must be incorporated into the remedy. The upgradient slurry wall (and drain) and the nearshore slurry wall (and extraction wells) were designed to adequately control generation and migration of leachate. In addition, the design includes the installation of a monitoring well network to support future assessment of the performance of the slurry wall and leachate controls.

The design of the slurry walls was prepared in general accordance with USACE and EPA standard practices for design of slurry walls (USACE, 1986; EPA, 1984).

3.7.1. Slurry Wall Alignments

The alignments of the proposed slurry walls were dictated by the presence of physical features and parcel boundaries, as well as the predominant directions of A-aquifer groundwater flow at Parcel E-2. The specified alignments of the slurry walls are generally the same as the alignments presented in the ROD (Navy, 2012).

The upland slurry wall is positioned between the western property boundary and the western extent of landfill waste (Figure 9). It is aligned perpendicular to the direction of groundwater flow in the western portion of the site to divert upgradient offsite groundwater away from groundwater that contacts landfill waste. The upland slurry wall extends from the northern parcel boundary to the southern extent of the landfill waste in the western portion of Parcel E-2 (Appendix B, design drawing C5).

The nearshore slurry wall is positioned between the southern extent of the landfill waste (and remaining contamination in the East Adjacent Area) and the proposed crest of the shoreline revetment (described in Section 3.6 and shown on Figure 15). It is aligned with the shape of the Parcel E-2 shoreline to prevent groundwater located bayward of the landfill waste from contacting surface water in San Francisco Bay. The alignment of the nearshore slurry wall will divert most nearshore groundwater flow to the east toward adjacent Parcel E.

3.7.2. Slurry Wall Dimensions

The following subsections describe the design basis for the lengths, depths, and thicknesses of the proposed slurry walls.

3.7.2.1. Wall Lengths

The lengths of the slurry walls are generally aligned with the adjacent lengths of the extent of landfill waste. As stated above, the upland slurry wall extends from the northern parcel boundary to the southern extent of the landfill waste (Figure 9 and design drawing C5 in Appendix B). The upland slurry wall is approximately 571 feet long.

The nearshore slurry wall extends from the western edge of the landfill waste (near the shoreline) to the boundary of Parcels E-2 and E in the east (Figure 9 and design drawing C5 in Appendix B). The nearshore slurry wall is approximately 1,237 feet long. The extension of the nearshore slurry wall to the Parcel E-2/E boundary was based on the following factors:

- Although previous and future hot spot excavations have or will address the most significant sources of groundwater contamination, residual contamination that remains may be a continuing source to groundwater in the area for a period of time following construction of the remedy.
- An evaluation of recent groundwater data collected under the basewide groundwater monitoring program (through February 2012) shows that the data collected to date cannot be used to definitively demonstrate that contaminant concentrations in groundwater are attenuating. Moderate detections of PCBs and TPH in groundwater indicate that contamination may not have attenuated yet.
- An evaluation of recent groundwater data also revealed that metals (copper, lead, nickel, and zinc) are present in groundwater immediately to the southeast of the Parcel E-2 boundary (in Parcel E). These metals are present at concentrations that may pose a potential risk to aquatic wildlife in the bay. Although groundwater generally flows away from the southeast corner of the Parcel E-2 boundary in this area, shifts in groundwater flow directions may route contaminated groundwater to Parcel E-2 from the western edge of Parcel E.
- Although not yet finalized, the ROD for Parcel E will likely propose construction of a similar groundwater barrier in the northwestern corner of Parcel E (adjacent to Parcel E-2) that would complement the nearshore slurry wall in Parcel E-2, if they were extended to connect at the boundary between the parcels.

Groundwater modeling was performed to estimate the approximate travel time of groundwater from various locations behind the slurry wall to San Francisco Bay (Appendix F). Travel times were increased by up to 4 years because of the presence of the slurry wall, providing a significant increase in natural attenuation periods for groundwater chemicals.

3.7.2.2. Wall Depths

Geologic data collected within the vicinity of the slurry wall alignments were used as the basis for the slurry wall depths. Stratigraphic information from soil borings (shown on design drawing C6 in Appendix B) was compiled and plotted on cross sections. The boring logs used to develop the cross sections were provided in the RI/FS Report (ERRG and Shaw, 2011) and the technical memorandum for the geotechnical investigation of Parcel E-2 (ERRG, 2013). Slurry wall profiles were developed based on the stratigraphic interpretations developed from the boring logs (design drawing C6 in Appendix B). The slurry wall profiles show the approximate design depths and elevations of each alignment.

The nearshore slurry wall profile also shows the bottom of the wall relative to the approximate elevation of the underlying Bay Mud Aquitard. The nearshore slurry wall will be keyed a minimum of 2 feet into the aquitard and will extend up to the designed finish grade. The bottom elevation of the nearshore slurry wall varies between –6 and –20 feet below msl. Given the importance of the keying of the wall into the Bay Mud, the project specifications (Appendix C, Specification 03 35 27) require that the depth of the Bay Mud be verified along the entire alignment of the nearshore slurry wall during construction (at a specified minimum interval of 20 feet).

Slurry walls are commonly designed to limit groundwater flow beyond a specified boundary by virtue of being keyed into a confining layer (e.g., the Bay Mud); however, the upland slurry wall will deviate from this convention. The upland slurry wall is considered a "hanging" slurry wall because it will not key into an aquitard. The Bay Mud unit is discontinuous and generally absent in the northwestern portion of the site. The upland slurry wall will be installed from the designed finish grade, down through a thin noncontiguous lens of Bay Mud (identified in the boring logs as clay with shell fragments), to an elevation of approximately -10 feet below msl. Some groundwater will flow under the upland slurry wall, but groundwater modeling predictions indicate that upgradient flow will mostly be diverted around the wall or diverted to the freshwater wetland via the French drain installed on the upgradient side of the upland slurry wall. Appendix F includes a discussion of the groundwater modeling results.

3.7.2.3. Wall Thickness

The selected thickness of the slurry walls was specified to be 2 feet (minimum). Groundwater modeling was performed to evaluate the anticipated mound heights and hydraulic gradients associated with the walls under typical groundwater conditions. The highest upgradient mound height (3 feet) and hydraulic gradient across the walls (6 feet) were associated with nearshore slurry wall. In accordance with Chapter 9 of USACE Engineer Manual 1110-2-1901 (USACE, 1986), a wall thickness of 1 foot is required per 10 feet of differential head for typical soil-bentonite slurry walls. Assuming a safety factor of 2 to account for groundwater modeling uncertainty and extreme tides, blowout risk can be alleviated by making the slurry walls 2 feet thick (i.e., allowing for 20 feet of differential head across the wall). Also, the wall thickness must be at least 2 feet thick because the equipment (i.e., an excavator) required to construct the walls will be equipped with a bucket that is 2 feet wide or more (typically). Excavation of a wall narrower than 2 feet would not be practical with conventional construction equipment.

3.7.3. Slurry Wall Mix

The following criteria dictate the basis of design for the material mixes used to construct slurry walls: (1) geotechnical constraints, (2) compatibility of backfill mix with the subsurface environment (i.e., chemical compatibility), and (3) material availability. Slurry walls typically consist of a soil–bentonite (SB) or soil-cement-bentonite (SCB) mixture that has been designed for specific site conditions to achieve the strength and permeability requirements for the site.

The mix design selected for the upland slurry wall is an SB mix. SB mixes comprise bentonite, clean well-graded soil, and potable water, all of which can be readily procured for this site. The upland slurry wall will be located far enough inland that it will not compromise the strength of the soil around it, so no geotechnical issues must be considered when determining the appropriate backfill mix. The upgradient slurry wall will only be subjected to clean groundwater (i.e., fresh water without significant chemical contamination), which allows for the use of a standard SB mix.

Given that the particular soil and the specific bentonite (or clay alternative) to be used during construction of the slurry wall cannot be specified in the RD, the design specifies a target permeability that must be achieved to meet the project goals. The target permeability for the SB mix is 10^{-6} centimeters per second (maximum). This permeability target is readily achievable with mixes developed using available fill sources and bentonite, which typically achieve permeabilities within a range of 10^{-6} to 10^{-8} centimeters per second (EPA, 1984). To ensure that the maximum permeability of 10^{-6} is achieved, the construction contractor will perform compatibility testing on the selected mix design, in accordance with the project specifications (Appendix C, Section 02 35 27). The laboratory compatibility testing will be required to demonstrate the suitability of the slurry mix to withstand the environmental and chemicals conditions acting on the slurry wall, and its ability to retain its relative impermeability under site-specific environmental conditions. The project specifications also require a field quality control testing program to ensure that the slurry wall is constructed in a manner that achieves the project requirements for its performance.

An SCB mix will be used for the nearshore slurry wall. SCB mixes comprise bentonite, cement, clean well-graded soil, and potable water, all of which can be readily procured for this site. The nearshore slurry wall will be located within 100 feet of the shoreline revetment structure and the bayward edge of the landfill waste. Based on the results of the geotechnical study performed to evaluate the stability of the shoreline (Appendix E), the strength of the slurry mix for the nearshore slurry wall must not compromise the strength of the soil along the shoreline. Therefore, the target compressive strength of the nearshore slurry wall is 30 pounds per square inch (minimum). This strength specification will ensure that the slurry wall is at least as strong as the soil adjacent to it; therefore, it will not reduce the stability of the shoreline slope. The target compressive strength of 30 pounds per square inch is readily achievable by including cement in the design mix (EPA, 1984).

As with the design of the upland slurry wall mix, the particular SCB mix to be used during construction cannot be specified in the RD, so a target permeability of 10^{-5} centimeters per second (maximum) is specified. This permeability target is readily achievable with mixes developed using available fill sources, bentonite, and cement, which typically achieve permeabilities within a range of 10^{-5} to 10^{-7} centimeters per second (EPA, 1984). The nearshore slurry wall will be subjected to saline groundwater containing low-level contamination, which may compromise its long-term permeability performance. Compatibility testing will be a critical component in developing the mix to ensure that its design is appropriate for the site-specific environmental conditions. To ensure that the compressive strength, maximum permeability, and environmental compatibility of the selected mix are achieved, the construction contractor will perform compatibility testing on the selected mix, in accordance with the project specifications (Appendix C, Section 02 35 27).

Both slurry walls were designed to include surface completions (design drawing C6 in Appendix B). The surface completions will be installed after the walls have been allowed to settle and cure, as detailed in the project specifications (Appendix C, Section 02 35 27). Both surface completions will be constructed using the approved SCB mix used to construct the nearshore slurry wall. The SCB mix will provide adequate strength to dissipate loads applied to the finish grade surface above the walls, thus minimizing the risk of differential settlement of the walls (USACE, 1986).

3.7.4. Constructability Considerations

Installation of the slurry walls may be impacted by site conditions identified during previous removal actions, including the presence of large debris (which would make excavation difficult) and the presence of irregular debris and subsurface voids (which could result in slurry loss during construction). However, site conditions will not preclude construction of a slurry wall and can be mitigated by over-excavating to remove obstructions or by realigning the walls to avoid obstructions. The project specifications in Appendix C describe the limitations and preapproval requirements associated with any proposed realignment of a slurry wall.

Construction of the slurry walls will require significant amounts of potable water to be delivered to the site. Temporary storage tanks or a temporary pond may be constructed to store large amounts of water, if an active water supply is not readily available at the time the remedy is implemented. Any temporary storage structures will be confined to areas outside the footprint of the existing landfill soil cover and protective liner to prevent damage to the liner.

3.7.5. French Drain for Upland Slurry Wall

The French drain associated with the upland slurry wall will consist of a buried perforated pipe embedded within a trench filled with gravel. The drain will be installed along the upgradient side of the upland slurry wall alignment (design drawings C5 and C6 in Appendix B). The French drain has the following design constraints: (1) setting the drain elevation to a level that will not conflict with the constraints of the topographic design of the freshwater wetlands, yet will allow intercepted groundwater to flow to the freshwater wetlands; (2) adequately sizing the pipe to accommodate the anticipated flow range; and (3) adequately sizing the pipe to allow for future maintenance.

Based on the design constraints for the freshwater wetlands, the lowest allowable elevation for the drain pipe is 6 feet msl. This elevation corresponds to the required wetland crest elevation. Therefore, the drain pipe was set at an elevation of 6 feet msl at a 0 percent slope to maximize the amount of water to be intercepted by the drain.

Groundwater modeling was performed to estimate the average flow that would be produced, given the proposed characteristics of the slurry wall and drain elevation. The modeling results estimate that, under average conditions, flow from the drain will be between 3 and 4 gallons per minute. The flow would vary

seasonally, as the groundwater table rises and falls. Given the anticipated flow rate is small, even if magnified to account for peak conditions, the overriding basis for pipe sizing is the need to allow for future pipe maintenance. Therefore, the design specifies a 4-inch drainpipe, which allows for flows up to 50 gallons per minute and for maintenance to be performed using conventional pipe cleaning equipment. Pipe cleanouts will be included approximately every 200 feet along the alignment of the pipe to facilitate future maintenance. The design also specifies that the drainpipe and the gravel backfill around the pipe be wrapped with geotextile to filter out sediment from incoming water and minimize the need to perform frequent maintenance to address drain clogging.

3.7.6. Monitoring/Extraction Wells and Piezometers for Nearshore Slurry Wall

The design of the nearshore slurry wall includes the monitoring wells and piezometers to measure groundwater levels and the hydraulic gradient across the slurry wall (see Figure 9). The existing groundwater monitoring wells in the area of the nearshore slurry wall are located along the inland side of the slurry wall and will be paired with four new piezometers located on the bay side of the slurry wall. The primary purpose of these piezometers will be for collecting depth-to-water measurements; however, the piezometers will be constructed in a manner that will allow for collection of groundwater samples if deemed necessary based upon monitoring results. The RAMP further describes the data evaluation methodology for nearshore groundwater wells.

If results of the data evaluations indicate that surface water quality may have been impacted, then further analysis, including modeling, will be performed to more accurately predict contaminant fate and transportation in the mixing zone. If results of additional modeling indicate that surface water quality has been impacted, then a contingency action, including groundwater extraction and treatment if necessary, will be implemented. To support this contingency action, 26 6-inch-diameter leachate monitoring/extraction wells will be installed every 50 feet along the nearshore slurry wall alignment (see Figure 9 and design drawings C5 and C6 in Appendix B). The leachate monitoring/extraction wells can be equipped with submersible pumps to allow for groundwater extraction. Groundwater modeling was performed to evaluate the required flow rate at the designed spacing that would achieve measurable drawdown of the water table behind the slurry wall (Appendix F). The results of the modeling estimate that an extraction rate of 1.2 gallons per minute (per well) would be required to hydraulically contain groundwater behind the nearshore slurry wall (in a manner that prevents discharge of groundwater contamination that impacts surface water quality)..

3.7.7. Materials Quantities

This section summarizes the results of the material quantity calculations performed for the designed slurry walls (as shown on design drawing C7 in Appendix B). The supporting calculations are provided in Appendix A, calculation brief A-19.

- Upland slurry wall excavation volume – 1,350 cubic yards
- Nearshore slurry wall excavation volume – 2,718 cubic yards
- Upland slurry wall fill volume (SB mix) – 1,350 cubic yards
- Nearshore slurry wall fill volume(SCB mix) – 2,718 cubic yards
- Upland French drain excavation volume – 811 cubic yards
- Drain rock volume for upland French drain – 347 cubic yards
- Upland French drain soil backfill volume – 179 cubic yards
- Non-woven geotextile fabric for French drain – 11, 098 square feet
- Western boundary slurry wall surface completion volume (SCB mix) – 340 cubic yards
- Nearshore slurry wall surface completion volume (SCB mix) – 733 cubic yards

The calculations include a 30 percent bulking factor for excavated material and a compaction volume of 10 percent for clean imported soil.

3.8. LANDFILL GAS CONTROLS

This section summarizes the basis of design for the GCCS for Parcel E-2. The RAOs for the GCCS are:

- Control methane concentrations to 5 percent (by volume in air) or less at subsurface points of compliance.
- Control methane concentrations to 1.25 percent (by volume in air) or less in onsite structures ("on site" is defined as any area within the subsurface points of compliance for LFG [i.e., Building 830 crawlspace and subsurface structures such as catch basins and utility vaults]).
- Prevent exposure to NMOCs at concentrations greater than 500 parts per million by volume (ppmv) at the subsurface points of compliance.
- Prevent exposure to NMOCs at concentrations greater than 5 ppmv above background levels in the breathing zone of onsite workers and visitors.

The basis for the design of LFG controls is information provided in the RI/FS Report (ERRG and Shaw, 2011), the Removal Action Closeout Report (TtEMI, 2004a), and the data collected as part of the LFG monitoring program. However, the Navy is currently performing a soil gas survey that includes the following primary objectives:

1. Conduct a soil gas survey in the Panhandle, East Adjacent, and Shoreline Areas of Parcel E-2 (areas adjacent to the Parcel E-2 Landfill) to evaluate whether soil gas mitigation will be necessary in conjunction with installation of a soil cover and protective liner in select portions of these areas.
2. Conduct a LFG generation study to estimate the gas generation rates from the Parcel E-2 landfill, determine the content of the LFG (to refine the design of the LFG treatment system), and estimate the radius of influence of future gas extraction wells.

The Navy prepared a draft work plan for the LFG survey (ITSI Gilbane Company, 2013), and fieldwork is planned for summer 2013. The results of the soil gas survey will be integrated into the design evaluation of the GCCS in the Draft Final RD, which may result in changes to the currently proposed design.

GCCSs must comply with the ARARs that specify LFG performance standards (Table 1). A detailed review of the ARARs was included in the development of the design to ensure that the proposed GCCS meets all the legal requirements established in the ROD.

The following subsections discuss the primary elements of the LFG control design, which include integrating or decommissioning the existing system, installing a collection and control system, installing extraction wells, construction of a treatment facility, management of condensate, and monitoring of the system.

3.8.1. Existing System

The components of the existing LFG control system and GMPs (Table 9) at the UCSF compound will be either integrated into the active GCCS or decommissioned and removed from the site after initial startup and operation of the GCCS. The preliminary anticipated status of the components of the existing LFG control system is summarized below.

- HDPE barrier wall (Gundwall) and gas collection trench will be retained. The gas collection trench consists of a horizontal perforated pipe (wrapped with geotextile and buried in sand or gravel), eight vertical riser pipes, and a 2-foot-thick bentonite seal. Five of the vertical riser pipes terminate above the ground surface and are used for either passive venting or active extraction of LFG. The vertical riser pipes that terminate above the ground surface are referred to as trench vents PV-01 through PV-05. The remaining three vertical risers terminate at the ground surface and are not used for monitoring or LFG venting. The vertical riser pipes that terminate at the ground surface are referred to as trench risers.
- Three of the five existing trench vents (PV-01, PV-02, and PV-04) contain methane and NMOCs at concentrations that warrant collection and will therefore be connected to the final GCCS. PV-03 and PV-05 do not contain significant methane and NMOCs, thus they should be sealed to minimize the potential for excessive infiltration of air into the waste.
- The three existing trench risers will be sealed to minimize potential air infiltration, unless monitoring results indicate significant methane or NMOCs concentrations are present.
- The soil vapor extraction wells (EX1 through EX10) are not required to extract LFG from the UCSF facility, thus they will be destroyed using approved well destruction procedures (see design drawing C3 in Appendix B). However, the Draft Final DBR will evaluate the need for potential LFG extraction at one localized area within the UCSF facility (GMP-24), where periodic exceedances of trigger levels have prompted LFG extraction.

- The redundant GMPs, where the regulatory agencies approve monitoring may be discontinued, will be decommissioned using approved well destruction procedures.
- Monitoring at the GMPs along Crisp Road is recommended to be discontinued, but the GMPs will be retained for monitoring if LFG should migrate in the future.
- The remaining GMPs in the UCSF compound and along the HDPE barrier wall will be retained and integrated into the final GCCS.
- The remaining capacity and life of the six active adsorption vessels (four granular activated carbon [GAC] and two Hydrosil) will be assessed for their usability in the GCCS based on empirical LFG flow and NMOC concentrations obtained during extraction testing as part of the upcoming LFG survey (ITSI Gilbane Company, 2013).
- As a GSR measure, existing system piping and hoses will be salvaged for use with the GCCS pretreatment vessels, as applicable.
- As a GSR measure, existing equipment (e.g., blowers, motor controls, knock-outs, trailers, etc.) will be salvaged for reuse or recycled. (Note: the blowers may be assessed for their usability in the GCCS, but are not likely to have suitable operating characteristics.)

3.8.2. Gas Collection and Control System

Migration and emissions of LFG can be controlled using two general approaches. The first method, referred to as "passive venting." Passive venting consists of providing highly permeable pathways through or around the waste (the vent trench), which allow LFG to flow to multiple passive vents under natural pressure gradients, where it is either vented directly to the atmosphere or treated to mitigate emissions. Passive venting is currently applied along the northern edge of Parcel E-2. Passive venting alone has not sufficiently controlled the lateral migration of LFG across the northern parcel boundary.

The second control method is referred to as "active extraction." Active extraction of LFG is achieved by using a gas blower to apply a partial vacuum to perforated collection pipes installed within the waste. The applied vacuum induces LFG to flow from the waste through the collector to a main header pipe, which conveys the LFG to a central facility for treatment.

The development of the design considered the fact that the new system must accommodate a larger landfill footprint than the existing LFG system. The performance of the existing LFG system and the potential for changing site conditions that could potentially exacerbate LFG migration were also considered. Based on the aforementioned evaluations, the proposed GCCS was designed as an active system. The GCCS includes the following features to increase and maintain effective extraction of LFG over the entire site in the future:

- In total, 50 extraction wells from 5 to 20 feet deep to remove LFG from the landfill waste and minimize the potential for LFG emissions from under the final cover cap.
- Underground LFG piping to convey LFG from the extraction wells to a single centralized treatment facility.
- Centralized treatment facility, including vacuum exhausters, pretreatment adsorption filters, and enclosed ground flare (i.e., low-profile clean emission burner [CEB]).
- Condensate collection and storage system for removal and offsite discharge of LFG condensate.
- In total, 39 GMPs for monitoring the effectiveness of the system to control the migration of LFG along the parcel boundary. The proposed GMP network (see Figure 16) will be reevaluated in the Draft Final RD based on the results of the upcoming LFG survey (ITSI Gilbane Company, 2013).

The following sections describe the various components that comprise the proposed GCCS.

3.8.2.1. Extraction Wells

Figure 16 and design drawings C28 through C31 in Appendix B present the piping layout and details for the extraction wells designed to capture LFG from below the cap, minimize migration of LFG along the site perimeter, and maintain regulatory compliance at the current locations with known LFG impacts. A network of 50 vertical extraction wells is proposed to efficiently extract the relatively low flow of LFG anticipated to be produced by the shallow, aged waste. If higher LFG flows are projected based on the results of upcoming field extraction tests (ITSI Gilbane Company, 2013), the RD could be revised to include a sub-geomembrane collection layer or venting strips to reduce the potential for gas surface emissions or buildup of LFG below the cap.

The extraction wells will draw LFG out of the waste and away from the landfill perimeter to control its migration. The network of vertical extraction wells will be spaced sufficiently close together to facilitate capture of LFG from all solid waste areas, especially near the landfill perimeter. The vertical extraction wells will be connected with laterals to a header pipe. The header pipe will be installed underground, and all extraction wells will be terminated flush with the ground and have vaults with lockable covers at the surface to discourage vandalism. A blower assembly will be used to create a vacuum in the header pipe that will draw LFG to the treatment facility located in the southeast corner of the landfill. The collected gas will then be conveyed through the treatment facility, where methane and NMOCs in LFG will be treated. Figure 16 shows the conveyance piping alignments leading to the treatment facility.

Although LFG is not expected to be generated in the Panhandle Area or the East Adjacent Area to a degree that requires collection, a LFG survey is currently being performed to evaluate soil gas in those areas to determine whether gas collection and control (such as passive subsurface venting) are required (ITSI Gilbane Company, 2013). If gas collection and control are required in areas adjacent to the landfill, then vents will be incorporated into the design to address those areas.

The following subsections summarize the calculation of the radius of influence for and the construction of the extraction wells.

LFG Extraction Well Radius of Influence

The theoretical radii of influence were calculated for vertical extraction wells drilled through waste ranging from 5 to 20 feet deep using EPA's New Source Performance Standards calculation model and the more conservative EMCON model (to be included in the Draft Final DBR). Assuming the generation rate for LFG estimated in the RI/FS Report of 30 standard cubic feet per minute (scfm) (ERRG and Shaw, 2011) and a dilution factor of 2 (to 60 scfm), to account for perimeter air intrusion and/or intermittent operation, the resultant radii of influence ranged from 59 feet for the shallowest wells to 118 feet for the wells in waste at a depth of 20 feet. These radii of influence equate to dense-packed well spacings ranging from 102 to 204 feet. Given the size of the treatment area, 50 LFG extraction wells are required to provide an adequate area of influence.

The empirical radii of influence estimated during operation of the LFG extraction system at the UCSF compound extended to approximately 200 feet during overlapping extraction well operations (TtEMI, 2004a). The extractions wells were 10 feet deep, and the extraction flows varied from 20 to 50 scfm. The large radii of influence were caused by the relatively high vacuums and resulting flows applied to the extraction wells. Such vacuums and resulting flows could not be applied to extraction wells in the landfill waste because of the potential for excessive air intrusion into the waste, which increases the risk of subsurface landfill fires.

LFG Extraction Wells Construction

Vertical extraction wells will be constructed of HDPE or polyvinyl chloride pipe casings, 3 to 4 inches in diameter. The lower section of the well casing will be perforated to allow LFG to be extracted from the waste. The perforated length of pipe will typically be from 1/3 to 3/4 of the overall casing length (5 to 15 feet), depending on the depth of the well bore and the thickness of waste encountered. The remaining length of the well casing will be constructed of non-perforated pipe to reduce the potential for intrusion of air into the waste and the well. The well casings will be installed in borings ranging from 18 to 24 inches in diameter and backfilled with coarse gravel around the perforated section of pipe and a bentonite seal around the solid section of pipe. An HDPE well boot will be used to seal the pipe casing with the cap geomembrane. A wellhead with a flow control valve will be installed in a below-grade vault at the top of each casing to monitor gas and adjust flow. The spacing and radius of influence calculations will be provided in Appendix A of the Draft Final DBR.

3.8.2.2. Conveyance Piping

Conveyance piping refers to the lateral piping and main header piping that transport the LFG flow from the extraction components (vertical wells, vents, and trenches) to the treatment facility. LFG conveyance pipes will be constructed and buried in trenches in the vegetative soil above the geomembrane layer of the final cap. The LFG pipes will be constructed of HDPE, a very durable material for conveying LFG. Design drawing C30 in Appendix B shows the typical LFG conveyance piping details.

Laterals refer to smaller diameter pipes (2-, 3-, and 4-inch nominal pipe size) that convey LFG from each of the extraction components to the main LFG pipe (i.e., the header). LFG lateral pipes will be constructed of HDPE and will be buried above the geomembrane layer of the cap to facilitate operator access (to condensate sumps associated with the header pipe network). The laterals are sloped away from the extraction components and toward the main headers to facilitate the removal of LFG condensate from the waste and drainage toward the condensate collection sumps. To account for landfill settlement, laterals located over waste will be constructed with a minimum 3 percent slope.

LFG headers refer to the larger diameter pipe (6-inch nominal pipe size) that will convey the LFG from multiple LFG collector laterals to the treatment facility. LFG header pipes will be constructed of HDPE and will be buried mostly around the perimeter of the landfill to maximize use of final grade contours to promote condensate drainage. Header piping will be aligned to maintain positive drainage toward four low points, thereby reducing the required number of condensate storage sumps. Headers located on waste will have a minimum 3 percent slope to account for settlement. Headers located on native soil should have a minimum 0.5 percent slope. HDPE condensate pipes and compressed air supply lines for condensate sump pumps will be installed in a joint trench with the LFG header pipe: Detailed LFG piping criteria are provided in the project specifications (Appendix C, Section 31 21 00).

3.8.2.3. Treatment Facility

The Navy is proposing to use a three-stage treatment process consisting of GAC adsorption, followed by potassium permanganate adsorption, followed by thermal oxidation in an enclosed flare. Use of adsorptive medial (GAC and potassium permanganate) is proposed to remove NMOCs (most notably chlorinated VOCs potentially present in the LFG) prior to thermal oxidation. The three-stage treatment process would address stakeholder concerns regarding the potentially unknown health impacts of trace emissions of compounds of concern (such as dioxins) following thermal oxidation. An evaluation of LFG collected from the landfill to support the selection of the proposed treatment technology is currently underway (ITSI Gilbane Company, 2013). The Navy is performing the survey in summer 2013, and results will be evaluated in the Draft Final RD.

Design drawing M2 in Appendix B shows the preliminary plan layout of the LFG treatment facility. Design drawing M4 in Appendix B shows the treatment equipment plans and elevations. Design drawings M1 and M3 in Appendix B contain the process and instrumentation diagram and the component identification legends.

A blower assembly will create a vacuum in the header pipe that will draw LFG to the treatment facility. The collected LFG will then be conveyed through the three-stage treatment process (GAC, potassium permanganate, and enclosed flare) for adsorption and destruction of methane and NMOCs. The area around the treatment facility will be fenced to restrict public access. In the future, the treatment facility may require additional security to prevent unauthorized access and vandalism, and to minimize potential public exposure to NMOCs or methane hazards.

The LFG treatment facility is proposed to be located on the southeast side of Parcel E-2, farthest from people working and living in existing building and residences on the western and northern sides of the parcel. Data on LFG flow and methane and NMOC concentrations obtained from the LFG survey and extraction testing will be used to run conservative emission air dispersion and health risk models. The results of the models will be used to estimate worst-case air quality and health risk impacts caused by LFG destruction at the treatment facility. These results will be compared with the site action levels specified in the RAOs.

LFG Pretreatment

Based on data from the Removal Action Closeout Report (TtEMI, 2004a) and the LFG monitoring program, the use of GAC and Hydrosil adsorption units as part of the UCSF extraction system has effectively removed NMOCs from LFG. Between 2008 and 2012, typically 95 percent of LFG was removed at PV-01 and PV-2. Influent NMOC concentrations ranged from 0 to 120 ppmv and averaged 7 ppmv as measured with calibrated field photoionization detection instruments. Effluent NMOC concentrations were generally not detectable and averaged less than 0.5 ppmv over all reported events, substantially less than the current action level of 5 ppmv.

To maximize the removal efficiencies under a wider range of initial operating conditions, two GAC and two Hydrosil adsorption units will be installed within the treatment facility. The four units will be installed in series (with bypass connections), providing the operator maximum flexibility for directing LFG from one to four units, independently or in combination, depending on the measured influent NMOC concentrations and resultant effluent NMOC concentrations. The production and concentrations of NMOCs and methane typically decrease with the aging of landfills and the ongoing operation of environmental control systems. Thus, cleanup levels and emission standards should be more easily achieved with reduced level of complexity and effort. The Navy will perform annual (or more frequent) assessments of the performance of the GCCS (e.g., NMOC removal) to evaluate whether any of the

processing stages can be eliminated or reduced over time, while always maintaining continuous and comprehensive protection of public health and the environment.

Treatment by adsorption will be designed to ensure that NMOC concentrations discharged to the flare will not exceed 5 ppm above background levels. This threshold is significantly lower than the BAAQMD and federal regulatory standards for NMOC concentrations in flare exhaust, which are 30 and 20 ppmv, respectively. Adsorption will not remove flammable methane, thus the enclosed flare is required for the combustion of methane. The flare will be designed to ensure adequate dispersion of the treated exhaust.

A moisture separator (i.e., knock-out pot) with demister pad will be installed immediately upstream of the blowers to remove excessive moisture and particulate matter from the LFG. Removal of moisture and particulates will protect the downstream equipment, as well as remove solid and soluble contaminants from the LFG flow.

To provide maximum available removal efficiency of potential NMOCs prior to thermal oxidation, the treatment facility will include the following two adsorption units ahead of the LFG flare inlet: a GAC filter bed and a Hydrosil filter bed. Similar adsorption units are being used to remove NMOCs from the LFG extraction system—consisting of a Carbonair Model GPC3 carbon vessel with 200 pounds of carbon and one Hydrosil HS-600 vessel with 400 pounds of potassium permanganate zeolite—in the UCSF compound. These units provided the following average removal efficiencies for NMOCs calculated based on results of LFG monitoring from 2008 through 2012:

- Average single pass GAC vessel NMOC effluent removal efficiency 88%
- Average single pass Hydrosil vessel NMOC effluent removal efficiency 60%
- Combined GAC Hydrosil NMOC effluent removal efficiency 95%

The adsorption units for the existing LFG system were sufficiently sized to effectively remove NMOCs to less than actions levels (NMOC concentrations up to 120 ppmv) for the reported extraction flow rates (up to 50 scfm) from the perimeter trench vents. The sizing of the adsorption units for the final RD is contingent on the flow rates at the extraction wells and NMOC concentrations obtained during the LFG extraction field testing performed as part of the upcoming LFG survey. The LFG flow and NMOC concentrations to be treated from the entire landfill could increase by more than an order of magnitude above that currently observed in the northern area alone.

LFG Treatment by Thermal Oxidation

Thermal oxidation using conventional enclosed flares readily destroys more than 98 percent of the methane and NMOCs in the LFG. The primary byproducts from flare combustion are carbon dioxide and water vapor. Secondary emissions are nitrogen oxide and carbon monoxide. As in all combustion devices (e.g., burners and engines), these byproducts are minimized by controlling combustion

temperatures and flame characteristics. State and federal requirements for methane and NMOCs at most active landfills are a destruction efficiency of 99 percent and 98 percent, respectively (Title 17 Cal. Code Regs. § 95464(b)(2)(A)1; BAAQMD Rule 34; EPA, 1999). The destruction efficiencies of properly designed and operated conventional ground flares are typically 99 percent or better for methane and NMOCs. EPA recognizes this treatment technology as the best demonstrated available technology for LFG (EPA, 1999), and the technology has been approved by the BAAQMD, as shown by implementation of flares at many municipal landfills in the San Francisco Bay area.

A CEB flare will be used in accordance with GSR principles. The proposed CEB is an enclosed flare, which has a higher destruction efficiency than an open flare. Additionally, the enclosed flare stack will be 11 feet tall to address potential aesthetic concerns of future site occupants; typical flare stacks are 15 to 20 feet tall.

Several project stakeholders have expressed concern about the potential creation of dioxins as a byproduct of flare combustion. To address this concern, the design incorporates (1) adsorptive media (GAC and potassium permanganate) to remove NMOCs (most notably chlorinated VOCs potentially present in the LFG) prior to flare combustion, and (2) an enclosed flare with controlled conditions to reduce the creation of dioxins. The following three conditions can result in the creation of dioxins during flare combustion: the presence of organic compounds, temperatures in the 400°F to 800ºF range, and minimal combustion durations. Conventional enclosed flares use automated controls to (1) maintain temperatures in the 1,400 to 1,800ºF range (well above the 400 to 800°F range) and (2) have longer combustion durations (i.e., extended residence time in the stack). The CEB flare will use automated temperature controls, a fuel air mixer (to allow for mixing LFG with combustion air to ensure combustion efficiency is maximized), and a mesh knit burner to maintain a very uniform flame front and temperatures in the 2,000°F to 2,200ºF range over a shorter stack height. These operating conditions reduce the possibility for dioxins to form by (1) promoting the complete oxidation of organic compounds (destruction efficiency of 99.99 percent total hydrocarbons) and (2) operating at temperatures above those that will allow dioxins to form followed by rapid quenching to temperatures below 400ºF at the stack discharge. Operation of the enclosed flare at Parcel E-2 will be subject to the same rigorous BAAQMD regulations applicable to landfills with 100 times more waste and 100 times higher NMOC concentrations.

The LFG flare will be designed to efficiently combust the maximum flow of LFG and NMOC concentrations to be collected from the extraction wells based on the results of ongoing LFG extraction field tests. The flare size will also be selected to operate efficiently over the lower end of the anticipated extraction flow range. The operating range of a flare is stated in terms of "turndown ratio." The turndown ratio is the ratio of a flare's maximum thermal capacity to its minimum thermal capacity. It summarizes the effective and compliant operating range of the flare. Flares with large turndown ratios are more flexible. Standard enclosed flares are typically specified with turndown ratios of 6 to 1. The CEB flare can be specified to provide practical turndown ratios of 10 to 1 because of the more precise

control of the fuel air mixture and flame characteristics. The CEB flare can be sized to accommodate variable LFG generation rates. The more precise control of the turndown ratios available with the CEB flare can treat the current higher generation rates for LFG estimated using the EPA LandGEM model and effectively treat substantially lower LFG generation rates anticipated in the long-term.

Because of the air fuel premix, the CEB flare is also able to safely and efficiently combust more dilute methane concentrations, down to 15 percent methane by volume, than conventional enclosed flares. The use of air fuel premix may be of great benefit if LFG is as diluted or depleted as shown by historical data for some of the existing passive vent wells. The CEB flare's more advanced burner and flame characteristics (i.e., mesh knit burner with flat flame bed) also eliminate delayed ignition and greatly reduce the flame height and the corresponding stack height. Table 10 shows the ranges of CEB flare capacities based on the current estimates of LFG generation in the RI/FS Report (ERRG and Shaw, 2011). Detailed LFG flare criteria in the project specifications (Appendix C, Section 11 10 00).

Based on the very low emissions and higher flow range flexibility, this RD specifies the CEB flare for final treatment of LFG at the Parcel E-2 Landfill.

Additional Treatment Calculations

Additional analyses and calculations will be prepared for final selection, sizing, and specifications of the GCCS components (i.e., adsorption filter units, CEB flare, and condensate pretreatment). These analyses will be based on the pending field testing results and will be included in the Draft Final RD:

- Characterizing LFG and condensate influent VOC streams
- Estimating LFG VOC adsorption isotherms and sizing GAC and Hydrosil adsorption units
- Sizing the CEB flare
- Preparing the landfill and LFG treatment emissions inventory and dispersion modeling
- Defining the condensate pretreatment requirements and specifying the unit processes
- Specifying facility foundation subgrade requirements and designing equipment foundations
- Designing electrical power requirements
- Estimating the landfill void volume (i.e., LFG storage capacity) and durations of available system downtime
- Optimizing the operation schedule of the GCCS
- Estimating engineering life cycle and equipment phase-out and replacement schedule

Detailed pretreatment system criteria are provided on the design drawings (Appendix B) and in the project specifications (Appendix C). Detailed descriptions of the pretreatment function and control requirements are provided in the RAMP.

LFG Treatment Blower

Blowers provide the differential pressure (vacuum) required to move LFG out of the waste, through the piping system, and through the treatment system to exhaust out the flare. A centrifugal blower is specified because of their high operating efficiency, reliability, and compatibility with pressure requirements of the GCCS. The blower capacity is selected to best accommodate the expected range of operating flows and pressures (Table 11). Table 12 shows the preliminary estimates of LFG flows that are likely to be extracted from the landfill. The calculation of vacuum and pressure requirements for the blower and piping system will be provided in Appendix A (to be provided in the Draft Final DBR).

Many manufacturers of centrifugal blowers have LFG-compatible models. LFG blowers are provided with housing and bearing gas seals to prevent gas leakage and fugitive emissions. Manufacturers provide many blower housing and impeller configurations (i.e., the shape of the blower blades) to handle the wide range of site-specific flows and pressures. Typically, multistage blowers are used to provide the higher inlet pressures required to feed the air fuel mixing chamber of the CEB flare. Variable speed motor drives will be included to increase the energy efficiency of the blower at non-peak loads and to achieve higher turndown ratios to accommodate a wider range of lower flows, down to 30 percent of peak flow.

Because consistent and continuous control of LFG may be required to minimize migration and potential cap emissions in the future public use areas, a 100-percent-capacity standby blower will be provided on site for contingency backup operations. The primary and standby blowers will be connected to common inlet and discharge manifolds in a parallel configuration. This configuration allows one blower to operate while the other is idle for maintenance or repairs.

Other Treatment Facility Components

In addition to the major equipment components such as the blowers and the flare, the treatment facility will be equipped with basic operational, safety, and monitoring equipment as required by the ARARs and current industry practice. The treatment control subcomponents are shown on design drawing M3 in Appendix B. Some of the major subcomponents include blower status monitoring systems, flare flame and temperature controls, LFG flow metering and recording, automatic LFG shutoff valves, and pilot and supplemental fuel gas systems.

The treatment facility will be sited as follows:

- Available facility plot location: West side of future road adjacent to Parcel E-2
- Distance to Parcel E-2 boundary: ~25 feet
- Site elevation: 10 feet above mean sea level (msl)
- Groundwater elevation: 1 feet msl (winter)
- Site grade relative to access road: +12 to +18 inches

The final treatment facility is designed to include:

- Concrete foundation pads designed for the manufacturer-specified equipment loads.
- Eight-foot-high chain link fence with wind and visibility screen and barbwire.
- Walk-in gates and vehicle gates for equipment maintenance.
- Driveway and walkway accessibility for operators, contractors, and monitoring security.
- Close proximity to existing and future utility connections:
  - Power supply: To be determined
  - Sanitary sewer discharge: To be determined
  - Distance to nearest fire hydrant: To be determined
  - Phone: Cellular service
- A low profile stack to reduce public visibility.
- Minimum 10-meter (30-foot) horizontal clearance from flare stack outlet to adjacent flammable materials and 25-meter (75-foot) radial clearance to overhanging flammable objects, such as power poles, cables, tall trees, etc.

The Draft Final RD will include dispersion modeling of the exhaust plume based on prevailing wind data.

3.8.2.4. Condensate Management

Condensate forms within the collection piping as fully saturated LFG cools from waste temperatures (80°F to 110°F) to ambient or ground temperature. Condensate is removed continuously by pumping from low elevation sump locations in the collection piping to prevent accumulation and pipe blockages. Table 13 provides estimates of the potential quantities of condensate that will be generated. Depending on the quantity of LFG extracted and the ambient temperatures, the generation of condensate from Parcel E-2 may range between 10 and 15 gallons per day. The generation of condensate will decrease in proportion to the decrease in LFG extraction. LFG condensate is typically a dilute aqueous solution of trace volatile organics and hydrocarbon compounds co-extracted from waste with the LFG. LFG condensate is generally acidic due to the reducing nature of the waste and the presence of carbon dioxide, sulfides, chlorides, and carbon dioxide.

Condensate Collection System

LFG condensate will be generated and accumulated in the conveyance piping as a result of LFG cooling. The condensate will drain by gravity and be collected at in-line condensate sumps located at low elevation points in the header piping. In-line sumps are integral with the header pipe to simplify the requirements for geomembrane cap penetrations. Typical condensate sump details are shown on design drawing C31 in Appendix B. Submersible pneumatic pumps will pump the collected condensate via a condensate force main to an interim storage tank at the treatment facility. Capital costs for pneumatic pumping systems are

lower than electrical pumping systems. Pneumatic pumps are also simpler to maintain than electric pumps, but less energy efficient due to air leakage and conveyance losses.

LFG condensate will also be generated and accumulated in the treatment facility as a result of LFG cooling in the treatment units. The treatment units drain condensate by gravity back into the condensate sump at the treatment facility inlet. The LFG condensate is pumped from the sump into an interim aboveground double-contained storage tank. The condensate will be characterized for discharge to an appropriate permitted liquid waste disposal facility, as discussed below under "Liquid Waste Management."

Condensate Generation Rates

Theoretically calculated estimates of condensate generation from LFG extracted from Parcel E-2 Landfill are provided in Appendix A (to be provided in the Draft Final DBR). Based on estimates of LFG generation provided in the Final RI/FS Report (ERRG and Shaw, 2011), the normal generation rate of condensate is expected to range from 10 to 15 gallons per day, with peak flows not expected to exceed 20 gallons per day. Detailed condensate conveyance and storage design criteria are provided on the design drawings (Appendix B) and in the project specifications (Appendix C). Detailed descriptions of the condensate collection system function and control requirements are provided in the RAMP.

Liquid Waste Management

Condensate characterization, handling, and disposal procedures during implementation of the remedy will follow the current site methods implemented for management and disposal of solid and liquid waste from the UCSF extraction and treatment system.

All liquid waste will be temporarily stored in an onsite selected staging area and labeled as nonhazardous waste for waste characterization, profiling, and final offsite disposal. Liquid waste from any well or source that has a history of high concentrations of contamination will be segregated, characterized, and profiled separately. Liquid waste may be discharged to a publicly owned treatment waste facility under a "batch discharge" permit if the liquid waste is suitable for discharge to the sanitary sewer. If the segregated liquid waste has a history of high concentrations of contamination and is classified as hazardous, the Navy will provide the appropriate EPA identification number, sign the required documentation, and perform other related functions required of a hazardous waste generator. Regardless of its classification, every effort will be made to characterize, profile, and remove solid and liquid waste from the site within 90 days of completion of the sampling event during which it is generated.

The following practices will be implemented during management and disposal of LFG condensate during initial startup of the GCCS and pending characterization for designation of pretreatment and final discharge:

- LFG condensate will be assumed to be contaminated, thus it will be segregated from water and liquid solid and liquid waste from other wells and sources.
- U.S. Department of Transportation-approved drums containing LFG condensate will be temporarily labeled as nonhazardous waste and stored on site pending waste characterization, profiling, and final offsite disposal.
- The generation, management, characterization, and disposal of LFG condensate will be documented.

The following disposal options for LFG condensate are available:

- Discharge (with or without pretreatment) to the sanitary sewer and city's wastewater treatment plant.
- Periodic truck transport to a commercial industrial wastewater treatment facility.

The selection of a disposal option is typically based on condensate quality, process costs, and regulatory constraints. Depending on the characterization of the LFG condensate, it may be pretreated within the LFG treatment facility and discharged to a publicly owned sanitary sewer connection or transported offsite by a licensed liquid waste transporter for final treatment and disposal at a permitted industrial treatment facility.

During the LFG survey in summer 2013, a sample will be collected from an LFG extraction well to preliminarily characterize LFG condensate at Parcel E-2. The condensate sample will be analyzed for constituents listed in the batch discharge permit requirements for the city's wastewater treatment plant. Typically, LFG condensate is acidic and may require neutralization before discharge. If confirmed to be acceptable for discharge, the condensate may be transported either by hauling or via an existing sanitary sewer connection.

The Navy will construct an interim storage tank for collecting LFG condensate from the GCCS at Parcel E-2. If the LFG condensate contains a significant quantity of VOCs or NMOCs, the condensate storage tank and other components may require closed-loop venting of the off-gas back to the LFG collection system.

The San Francisco Public Utilities Commission (SFPUC) enforces a Pretreatment Program regulating discharges from nondomestic sources into the city's sewerage system. Regulations governing these discharges are contained in the city's sewer use ordinance (Article 4.1, Chapter X, Part II of the San Francisco Municipal Code). Additional wastewater pollutant limitations are contained in Department of Public Works Order No. 158170. In San Francisco, SFPUC issues Industrial User Permits to "industrial users" for regular or continuous discharges that result from commercial or industrial operations. SFPUC also issues Batch Wastewater Discharge permits for nonroutine, episodic, or other temporary discharges. The discharge of pre-treated LFG condensate will require prior permit application and issuance. The

permits specify the conditions under which wastewater may be discharged into the sewer system. Permits are issued for a specified duration and are tailored to each user. The SFPUC Industrial Waste Discharge Pretreatment Limits will be summarized in an attachment with the Draft Final DBR.

In addition to the specific limits, all dischargers shall comply with all requirements set forth in federal Categorical Pretreatment Standards and other applicable federal regulatory standards, and applicable state orders and water quality control regulations, permits, and orders.

3.8.2.5. GMP System

Monitoring of LFG is required to meet the RAOs and to demonstrate compliance with Title 27 Cal. Code Regs. § 20917 through § 20934, "Gas Monitoring and Control at Active and Closed Disposal Sites." The gas monitoring system will be designed to account for:

- Local soil, rock, and hydrogeological conditions
- Locations of buildings and structures relative to the waste disposal area
- Adjacent land use and inhabitable structures within 1,000 feet of the landfill
- Manmade underground structures, such as vaults
- The nature and age of waste and its potential to generate LFG

Several general assumptions were made to develop the RD and costs for the LFG monitoring component. LFG will not migrate below the groundwater table, which is between 6 and 20 feet bgs, so GMPs will not be screened below the water table. Rather, GMPs will be screened from approximately 5 feet bgs (above the historical high groundwater elevation at Parcel E-2) to the historical low groundwater elevation, which varies across Parcel E-2 to a maximum depth of 16 feet bgs (north of the landfill). Existing GMPs are located approximately 150 feet apart on the Parcel E-2 boundary north of the landfill, and this spacing will continue to be used to complete the compliance monitoring boundary on the western and eastern sides of Parcel E-2.

This RD proposes installation of 13 additional permanent GMPs to complete the perimeter compliance monitoring boundary along the eastern and western edges of Parcel E-2. GMPs will not be installed along the southern (bayside) edge of Parcel E-2 because San Francisco Bay serves as a hydraulic barrier. Additional GMPs will be installed at 150-foot intervals along the western Parcel E-2 boundary and along the eastern edge of the existing multilayer geosynthetic cap. Figure 16 shows the proposed locations of the additional GMPs. The proposed GMP network will be reevaluated in the Draft Final RD based on the results of the upcoming LFG survey (ITSI Gilbane Company, 2013).

3.9. TIDAL AND FRESHWATER WETLANDS

This section describes the basis of the wetlands mitigation design. The primary design basis element used to develop the future wetlands in Parcel E-2 is the Navy's wetlands mitigation and monitoring plan (WMMP) (Shaw, 2009). The WMMP, which previously presented the key design concepts reflected in this DBR, incorporated input from various state, federal, and local regulatory agencies. The wetlands mitigation will be performed as part of the final remedy for Parcel E-2, pursuant to the ROD (Navy, 2012) and in accordance with the substantive requirements of the federal Clean Water Act and the state of California's McAteer-Petris Act (see Table 1).

The wetlands were delineated and their functional value was assessed in 2001 and 2002 (TtEMI, 2003). Table 14 provides the size of each of wetland area, and Figure 17 shows the locations of tidal and freshwater wetland areas at HPNS.

Previously completed cleanup actions at Parcels B, E, and E-2 have impacted approximately 1.574 acres of tidal wetlands and 0.458 acres of freshwater wetlands. Future remedial actions in Parcels E and E-2 will impact approximately 1.592 acres of tidal wetlands and 0.815 acres of freshwater wetlands. As a result, the total area of wetlands requiring mitigation at HPNS is approximately 3.166 acres of tidal wetlands and 1.273 acres of freshwater wetlands. Table 15 summarizes the wetland losses to date from previous remedial activities and the anticipated wetland losses from future remedial activities.

The RD has identified the Panhandle Area within Parcel E-2 as an appropriate location to construct new tidal and freshwater wetlands to mitigate the impacts of onsite remedial actions based on the WMMP (Shaw, 2009). The design includes restoration and creation of approximately 3.242 acres of tidal wetlands and approximately 1.59 acres of freshwater wetlands in the Panhandle Area (see Figure 9 and Table 15). The new tidal and freshwater wetlands will fully mitigate the impacts of past and future remedial actions and will result in a compensation ratio for restoration of wetland habitat of 1:1. The Navy and the San Francisco Bay Conservation Development Commission agreed upon the 1:1 mitigation ratio prior to the start of previous cleanup actions, and the mitigation ratio was also documented in the Final WMMP (Shaw, 2009) and Final ROD (Navy, 2012). This mitigation ratio will result in no net loss of wetland habitat at HPNS. In addition, contiguous, more highly functioning tidal and freshwater wetlands will be of greater value as compared with the small, individual, isolated patches of wetlands that were lost.

Eight design objectives have been developed to meet the mitigation goal (i.e., no net loss of habitat). The design objectives will ensure that wetland impacts are fully mitigated after removal and remedial actions at HPNS are completed. Wetland design objectives for HPNS have been tailored for site-specific conditions associated with Parcels B, E, and E-2 and take into consideration the constraints associated with restoration of wetlands at Parcel E-2. The eight design objectives are as follows:

1. Provide a setting for the natural evolution of wetland functions to establish an ecological continuity with the adjacent California Department of Parks and Recreation's Yosemite Slough Restoration Project.
2. Mitigate the loss of approximately 3.17 acres of regularly inundated tidal wetlands at an elevation of approximately +3.0 feet msl, grading to a transition zone at the foot of the slope protecting the pedestrian path.
3. Mitigate the loss of approximately 1.27 acres of seasonally inundated freshwater wetlands in an excavated basin at the approximate elevation of existing seasonal freshwater wetlands.
4. Prevent communication with subsurface residual chemicals of concern, such as heavy metals and PCBs.
5. Provide protection of the mitigation areas and landfill from high-energy waves.
6. Enhance invertebrate and native vertebrate habitat.
7. Improve surface and bay water quality by reducing non-point-source pollution into San Francisco Bay.
8. Prevent reestablishment of invasive, nonnative species.

The following additional restoration activities will also be performed:

- Increase stormwater retention capacity to create approximately 0.3 acres of additional seasonal freshwater wetland in Parcel E-2.
- Remove nonnative species in the wetland areas and adjoining upland areas.

A baseline survey will be conducted following completion of the wetlands restoration. Subsequently, the restored areas will be monitored twice annually (spring and fall) for a period of 5 years following construction of the wetland mitigation areas. The RAMP provides further information on future monitoring at the restored wetlands, including potential establishment of a reference site to provide an indication of species richness and coverage attainable in the Parcel E-2 mitigation area. Details on the baseline survey and monitoring requirements are discussed in the RAMP. In addition, the OMP outlines inspection and maintenance activities and presents adaptive management strategies to attain performance standards.

The following sections summarize the development of the wetland design.

3.9.1. Water-Level Ranges

The tidal wetland design identifies specific planting zones that are based on elevation ranges that are regularly inundated during high tide. Table 8 presents the tidal datum elevations used in the design, and Table 16 identifies the design elevations for the different wetland planting zones (see Figure 18). Water depths within the restored tidal wetlands at high tide could be approximately 2.7 feet deep in places.

The freshwater wetlands will not be inundated during high tides, but will receive surface water runoff from most of the Parcel E-2 Landfill during storms (see Section 3.5.3). In addition, the freshwater wetland will receive groundwater flow from a subsurface drain (i.e., French drain) installed along the northwestern property boundary. The freshwater wetland will be ponded from approximately +4.0 feet msl to a maximum of +6.0 feet msl. The final grade of the high marsh area will be from +6 feet msl and +7 feet msl for the developed planting zones (see Table 16). During seasonal rainfall events, inundation to a high elevation of +7.0 feet msl could be expected in the freshwater wetland but should recede gradually as ponded water drains into the bay.

A predictive groundwater modeling simulation (Appendix F) was run to show the influence of surface water infiltration from the freshwater wetlands to the underlying aquifer. The influx of surface water creates a local groundwater mound beneath the wetland. The local groundwater mound represents downward and outward flow gradients in the aquifer beneath the freshwater wetland, thus limiting the possibility of potentially contaminated groundwater upwelling into the wetlands.

3.9.2. Wind and Wave Dynamics

The tidal wetland is located on a gradually sloping bench in a protected area of San Francisco Bay referred to as "South Basin." During the winter, currents and waves in the inner reaches of the South Basin are relatively small compared with other areas of the bay shoreline (Battelle and Woods Hole Group, 2001). Wind rose data from San Francisco International Airport, approximately 8 miles to the south, indicate that the predominant wind pattern is from the west northwest, which means that winds generally blow in an offshore direction from the tidal wetland (Agency for Toxic Substances and Disease Registry, 2009). However, a shift in winds from the east–southeast can occur and may create conditions in which the tidal wetland could be subject to relatively high wind-generated waves because of the long distance (or fetch) over which the wind blows over bay water (Appendix A, calculation brief A-8). However, the erosion potential from such wind-generated waves will be reduced by the shallow, gradually sloping bench and the establishment of wetland vegetation. In addition, past studies of offshore dynamics near Parcel E-2 show that South Basin is a net depositional environment (Battelle and Woods Hole Group, 2001). Accordingly, natural estuarine accretion is expected to raise the elevations within the tidal wetlands to compensate for potential shoreline erosion during winter storms. This natural accretion should maintain the appropriate natural colonization ranges for native salt and brackish water marsh plants. However, if noticeable erosion is observed, appropriate adaptive management and/or contingency measures will be implemented, as presented in the OMP.

The freshwater wetland will be separated from San Francisco Bay by the shoreline revetment (Figure 9). As described in Section 3.6, the shoreline revetment is designed to resist erosion from offshore wind and waves. The potential for saltwater intrusion into the freshwater wetland will be minimized for many years through proper monitoring and maintenance, as described in the RAMP and OMP.

3.9.3. Hydric Soil

Once excavation has been completed and the site has been graded to the required subgrade elevations, the surface will be prepared by removing any large rocks or other harmful materials and compacting the surface as specified in the project specifications (Appendix C). As described in Section 3.5.5, the soil cover in the new wetlands will be 4 feet thick and will consist of 3 feet of hydric soil underlain by a demarcation layer (see Section 3.5.2.3) and a 1-foot-thick bridge soil layer (consisting of clean imported soil). The criteria for imported soil are described in the project specifications (Appendix C). A liner will not be used in the new wetlands, so that they function more naturally.

Soil that meets the definition of "hydric soil" is formed under conditions of saturation, flooding, or ponding for periods long enough to develop anaerobic conditions in the upper part of the soil during the growing season (USDA Natural Resources Conservation Service, 2013). Field indicators of hydric soil are morphological properties associated with their formation and are important to recognize because, once formed, they will persist under both wet and dry seasonal periods (USDA Natural Resources Conservation Service, 2009). Some of these indicators are the accumulation of organic matter and/or reduction, translocation, or accumulation of iron, manganese, and other reducible elements. A qualified wetlands scientist will use the field criteria to verify that appropriate soil fill materials are used to construct and restore the tidal and freshwater wetland areas. The composition and texture of the imported hydric soil fill material will be similar to the natural hydric soil in the reference site. Project specifications for all of the fill materials to be used in the wetland mitigation area are provided in Appendix C.

The 3-foot-thick hydric soil layer will support the wetland plants and, when combined with the underlying demarcation layer and 1-foot-thick bridge soil layer, will prevent exposure to remaining contaminants left in place. The 3-foot-thick hydric soil layer will be placed in 1-foot lifts, with top lifts compacted to not more than 85 percent of the maximum dry density to allow for good plant growth; lower lifts and bridge soil will be compacted to at least 90 percent of the maximum dry density to support the overlying soil layers.

3.9.4. Elevations and Planting Zones

Proper grading to the design elevations and slopes is important for the successful reestablishment of tidal wetland vegetation and to provide adequate drainage control for the freshwater wetland. Design drawing C13 in Appendix B presents the grading plan for the wetland mitigation areas.

The design elevations align with specific planting zones that are intended to provide a diverse habitat and be generally consistent with the characteristics of the previous tidal and freshwater wetlands at HPNS. Table 16 summarizes the areas and elevations of each planting zone.

The tidal wetland will be constructed with the following five planting zones: (1) low marsh zone, (2) middle marsh zone, (3) high marsh zone, (4) transition zone, and (5) upland zone. Within the high marsh zone, the grades will extend from +5 feet msl to +3.61 feet msl at a slope of approximately 1.5 percent, except for a small portion of this zone (about 10 percent) that will be graded flat to diversify the high marsh habitat. The freshwater wetland will consist of the following four planting zones: (1) low marsh zone, (2) middle marsh zone, (3) high marsh zone, and (4) upland zone. For both the tidal and freshwater wetlands, the slope between the high marsh zone and upland zones will be no steeper than 5H:1V to provide stability and prevent soil erosion.

The specific plant species recommended for revegetating the tidal wetland, freshwater wetland, and upland areas were selected based on vegetation community descriptions in previous surveys of the HPNS wetlands and a potential reference site in India Basin, along with review of pertinent guidance documents (Philip Williams & Associates, Ltd., and P.M. Faber 2004). Design drawing C24 in Appendix B provides a detailed planting list. The specified plant species will provide good diversity within each zone and include native plants, which is important for the long-term stability of the ecosystem. The native perennials selected for the site inhabit coastal environments, but can survive only within a narrow range of elevation. They tolerate full sun and are good for stabilizing disturbed and degraded areas (CalFlora, 2000; USDA Natural Resource Conservation Service, 2006).

The planting list identifies a range of container plants for the wetlands. Hydroseeding with mulch and native seed (per the mix identified on design drawing C24 in Appendix B) will also be performed to provide supplemental vegetation within the wetlands. Planting and hydroseeding procedures are provided in the project specifications (Appendix C, Section 32 92 19).

The seeded areas may require protection with erosion control fabric. For example, tidal wetland areas below +5 feet msl should be protected to prevent erosion of the seed during high tides. Erosion fabric, if used in wetland areas, should be anchored with tapered, non-pressure-treated wood stakes. Plantings will be performed after installation of the erosion control fabric and by creating small openings stretched or cut in the fabric. The following additional guidelines will be followed during wetlands planting:

- Planting will be supervised by a qualified professional with experience in wetland restoration and knowledge of native plants.
- Container plants will be temporarily anchored with steel soil staples hammered through their rootballs.
- Planting locations will be marked with pinflags prior to installation to confirm spacing and quantities.
- Foil number tags (or similar identification devices) will be placed at designated plants within each planting zone for future monitoring purposes.

The planting list may be refined in the Draft Final RD based on regulatory agency input, which may affect the recommended plant spacing. Accordingly, the final plant spacing requirements will be provided in the Draft Final RD once the planting list is finalized.

3.9.5. Inlet Structure to Freshwater Wetlands from Subsurface Drain

The freshwater wetlands will receive groundwater from the upgradient offsite property via a groundwater diversion system, consisting of an upland slurry wall and subsurface diversion (i.e., French) drain. Given the topographic constraints at the site, the subsurface drain (i.e., French drain) will be set at a uniform elevation of +6 feet msl, with flow driven by hydrostatic pressure when the water table rises above this elevation. Section 3.7.5 describes the design of the groundwater diversion system.

Recent groundwater sampling data from wells located upgradient of the site indicated that groundwater flowing onto the site has elevated concentrations of the anions un-ionized ammonia and sulfide. Un-ionized ammonia and sulfide are generated during decomposition of organic matter (both naturally occurring and anthropogenic) in reducing environments, and is readily transformed to non-toxic anions upon discharge to oxygenated surface water. To facilitate the anion oxidation process, groundwater diverted by the slurry wall will be aerated prior to entering the freshwater wetland. Aeration will be achieved by installing a concrete aeration apron (design drawing C21 in Appendix B). Maintenance and monitoring requirements for the inlet structure at the freshwater wetlands are discussed in the OMP and RAMP, respectively.

3.9.6. Outlet Structure from Freshwater Wetlands to Bay

A pipe and tidal valve will be installed at an elevation of approximately +6.0 feet msl to allow discharge into San Francisco Bay during peak flow conditions. This discharge structure will prevent flooding of the adjoining property. During seasonal rainfall events, inundation to a high elevation of +7.0 feet msl could be expected in the freshwater wetland but should recede gradually as ponded water drains into the bay. The discharge structure, which is shown on design drawing C23 in Appendix B, was located at the opposite end of the freshwater wetlands from the inlet structure. This alignment should provide adequate water circulation within the wetland and minimize potential stagnant zones. The tidal valve will open and close with hydrostatic pressure and will prevent bay water from entering the wetland. The recommended tidal valve (Tideflex Duckbill Check Valve, or equivalent) uses flexible material that offers improved reliability and performance compared to traditional steel flap gates. The flexible material allows the valve to compress around trapped solids, thereby providing a better seal than flap gates. Additionally, the valve is made out of a rubber matrix, which will not corrode in saltwater.

Flow from the freshwater wetlands into San Francisco Bay will discharge through a solid-wall HDPE pipe. A headwall will be constructed at the upstream end of this pipe where water enters it from the freshwater wetlands (referred to as the “Freshwater Wetland Outlet Headwall” on design drawing C22 in

Appendix B). The headwall is required so that adequate cover can be placed over the pipe near the inlet without steepening the surrounding slopes.

A second headwall will be constructed at the downstream end of this pipe where water discharges into the San Francisco Bay (referred to as the "Freshwater Wetland Outlet Headwall" on design drawing C22 in Appendix B). The headwall is required so that adequate cover can be placed over the pipe near the outfall without steepening the surrounding slopes, and to connect into a cutoff wall that will prevent undercutting below the downstream face of the headwall footing due to scour.

Appendix A presents the design calculations for the discharge pipe and headwall structures.

3.10. MONITORING, MAINTENANCE, AND INSTITUTIONAL CONTROLS

As described in the ROD (Navy, 2012), the selected remedy includes the following monitoring and maintenance activities that will be performed as long as necessary to protect human health and the environment and to comply with the substantive provisions of pertinent state and federal ARARs.

- The cover will be inspected and maintained to ensure its integrity as required under Title 27 Cal. Code Regs. § 21180(a).
- Groundwater monitoring will be performed, consistent with the requirements of Title 22 Cal. Code Regs. § 66264.100(d) and § 66264.310(b)(3), to verify that chemical concentrations in groundwater do not exceed concentrations designated by the RAOs at the point of compliance.
- LFG monitoring will be performed to meet the RAOs and to demonstrate compliance with Title 27 Cal. Code Regs. § 20917 through § 20934.
- Stormwater and erosion controls will be installed and maintained as required under Title 27 Cal. Code Regs. § 20365(c) and (d), and stormwater discharges will be monitored as required under Title 22 Cal. Code Regs. § 66264.97(c)(1) and (c)(2)(B).
- The wetlands will be monitored and maintained in accordance with the substantive provisions of the federal Clean Water Act at Title 40 Code of Federal Regulations Part 230 and the San Francisco Bay Plan at Title 14 Cal. Code Regs. § 10110 through § 11990.

The long-term monitoring requirements for the final remedy at Parcel E-2 are described in the RAMP, which is also a component of the RD. The inspection, maintenance, and repair of the constructed remedy at Parcel E-2 are provided in the OMP, which is also a component of the RD.

Also, as described in Section 2.7, the ROD requires implementation of ICs that will restrict the development, land use, and activities on Parcel E-2 for the continued protection of human health and the environment. Figure 19 presents the area requiring ICs (ARIC) for nonradioactive chemicals, which comprises all of Parcel E-2, including a small portion of the Parcel E-2 Landfill that extends north onto property owned by UCSF (see Figure 2). Figure 19 also identifies the ARIC for radionuclides (green pattern on Figure 19; also referred to as the radiological ARIC), which consists of all of Parcel E-2 except

for portions of the East Adjacent Area located outside of the IR-01/21 boundary (see Figure 3). Outside of the radiological ARIC, potential radioactive contamination exceeding the remediation goals would be removed, thus these areas would not require ICs regarding exposure to radioactivity. The implementation of ICs, including inspection and reporting requirements, are described in the LUC RD, which is a component of this RD.

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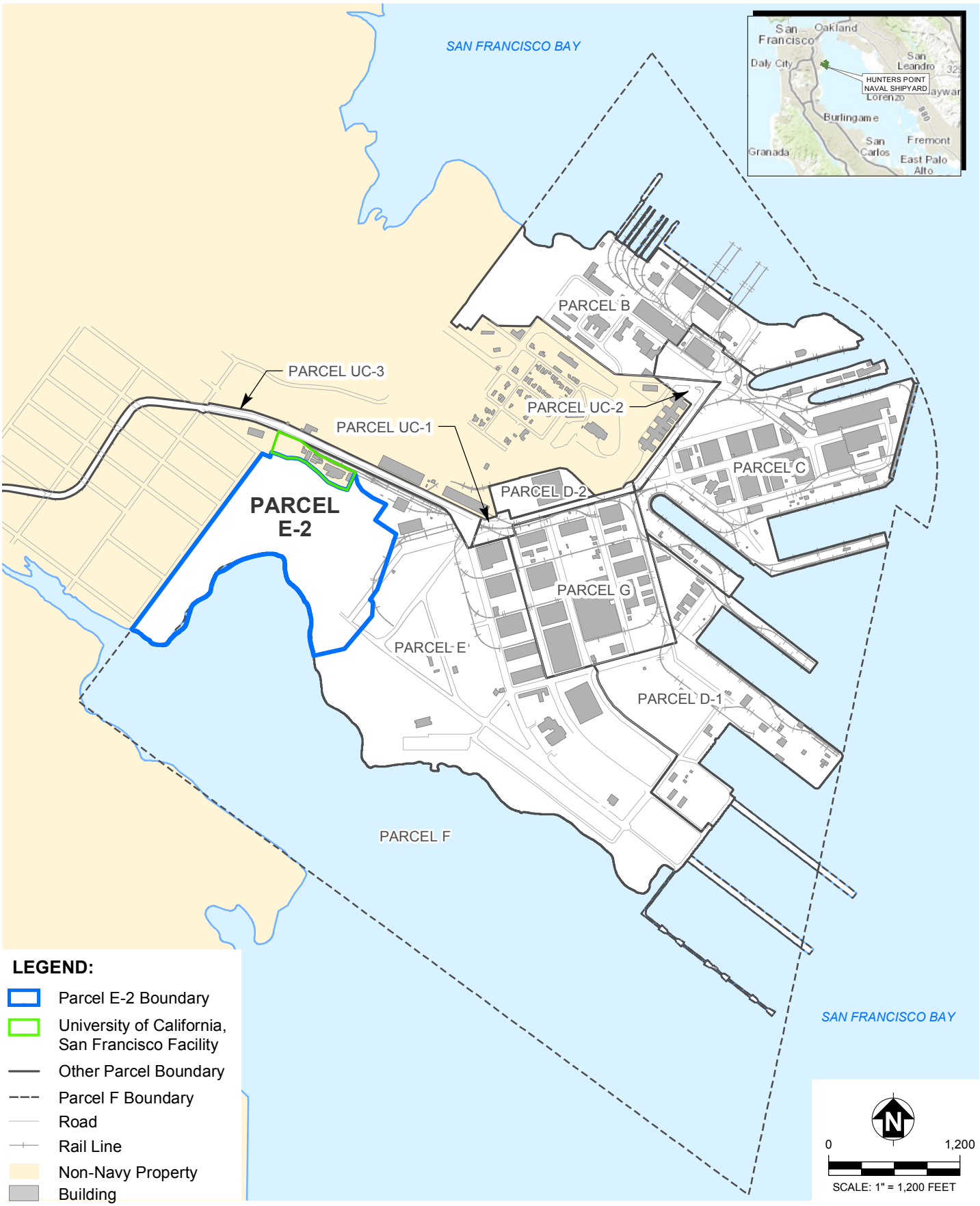
Figures



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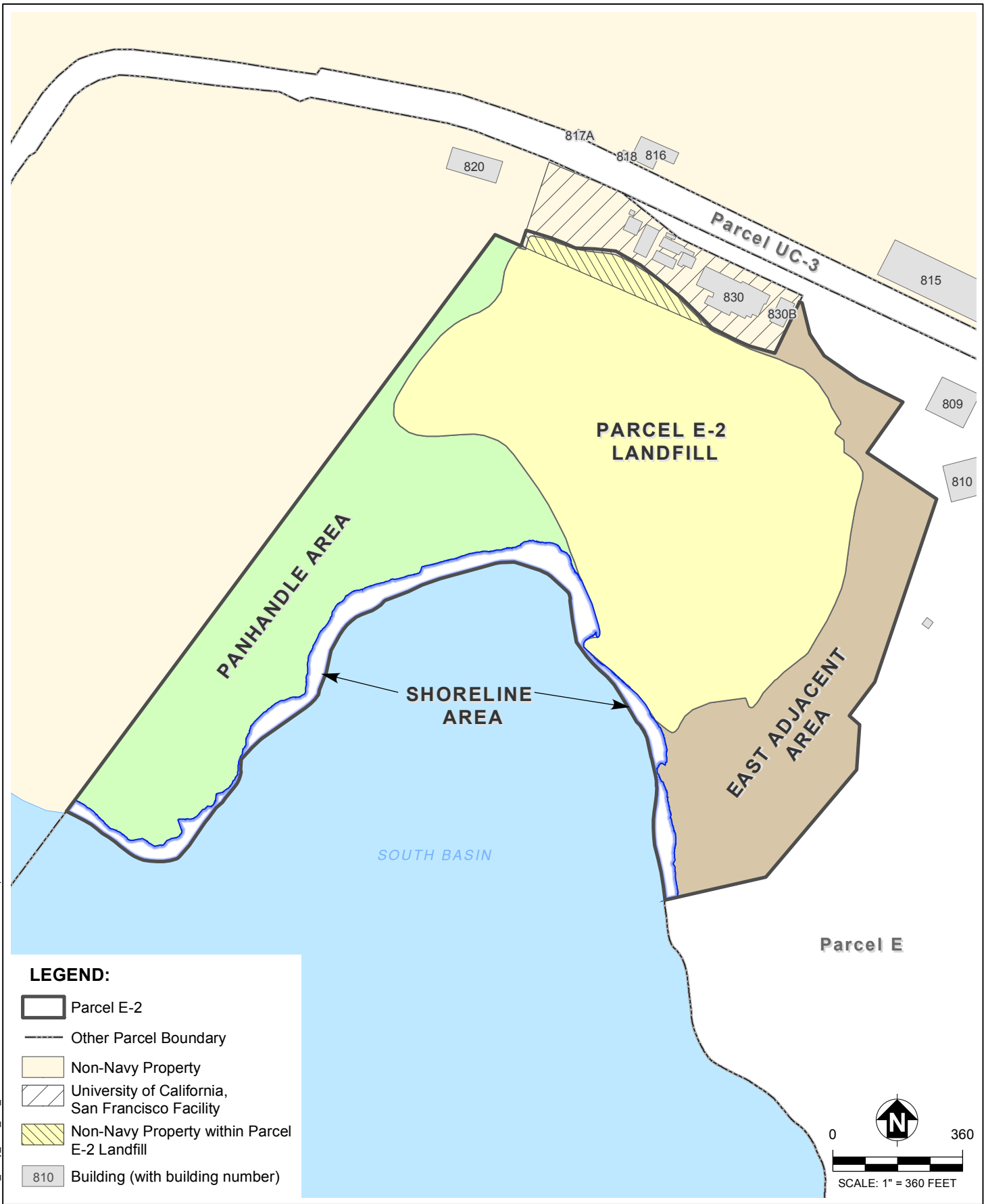
ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	SITE VICINITY MAP			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 1



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	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 2

Notes:

Impacted sites are sites that have known radiological contamination or where site history indicates that radiological contamination may be present.

Impacted sites based on Historical Radiological Assessment (Naval Sea Systems Command, 2004).

For planning purposes, all storm drains and sanitary sewers should be considered impacted.

Storm drain and sanitary sewer line locations are based on data from the Navy's Caretaker Site Office and the Historical Radiological Assessment; locations will be verified in the field. Construction documentation for septic sewer lines does not exist. Potential septic sewer lines, if found to originate from radiologically impacted buildings near Parcel E-2 (Building 810), would be considered impacted.

N

0 200

SCALE: 1" = 200 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	RADIOLOGICALLY IMPACTED AREAS		
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	DB 02/20/13	25-049	3

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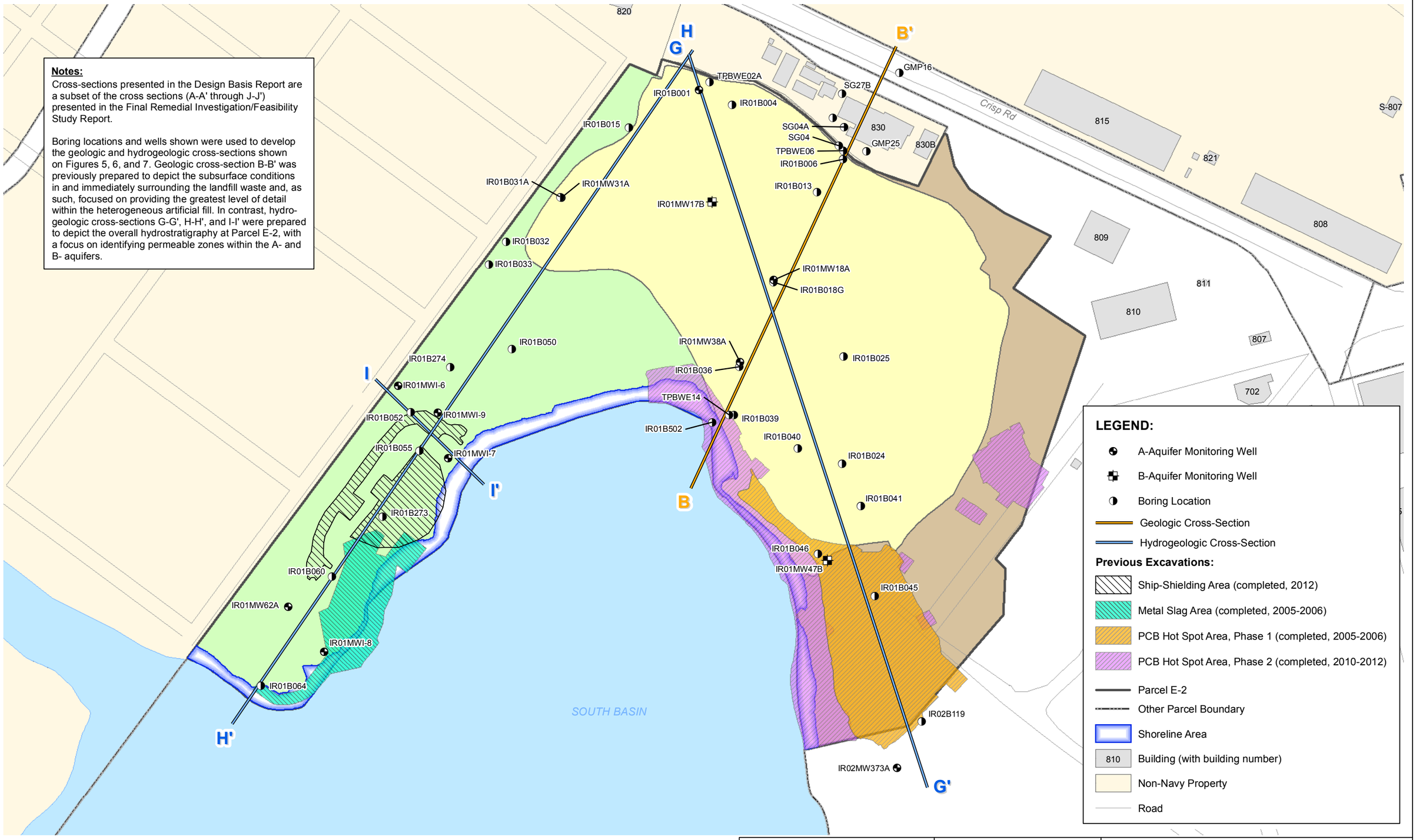
Notes:
Cross-sections presented in the Design Basis Report are a subset of the cross sections (A-A' through J-J') presented in the Final Remedial Investigation/Feasibility Study Report.

Boring locations and wells shown were used to develop the geologic and hydrogeologic cross-sections shown on Figures 5, 6, and 7. Geologic cross-section B-B' was previously prepared to depict the subsurface conditions in and immediately surrounding the landfill waste and, as such, focused on providing the greatest level of detail within the heterogeneous artificial fill. In contrast, hydro-geologic cross-sections G-G', H-H', and I-I' were prepared to depict the overall hydrostratigraphy at Parcel E-2, with a focus on identifying permeable zones within the A- and B- aquifers.



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CLIENT:	PARCEL E-2 CROSS-SECTION LOCATIONS			
DEPARTMENT OF THE NAVY, BRAC PMO WEST				
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 03/28/13	DB 03/28/13	25-049	4

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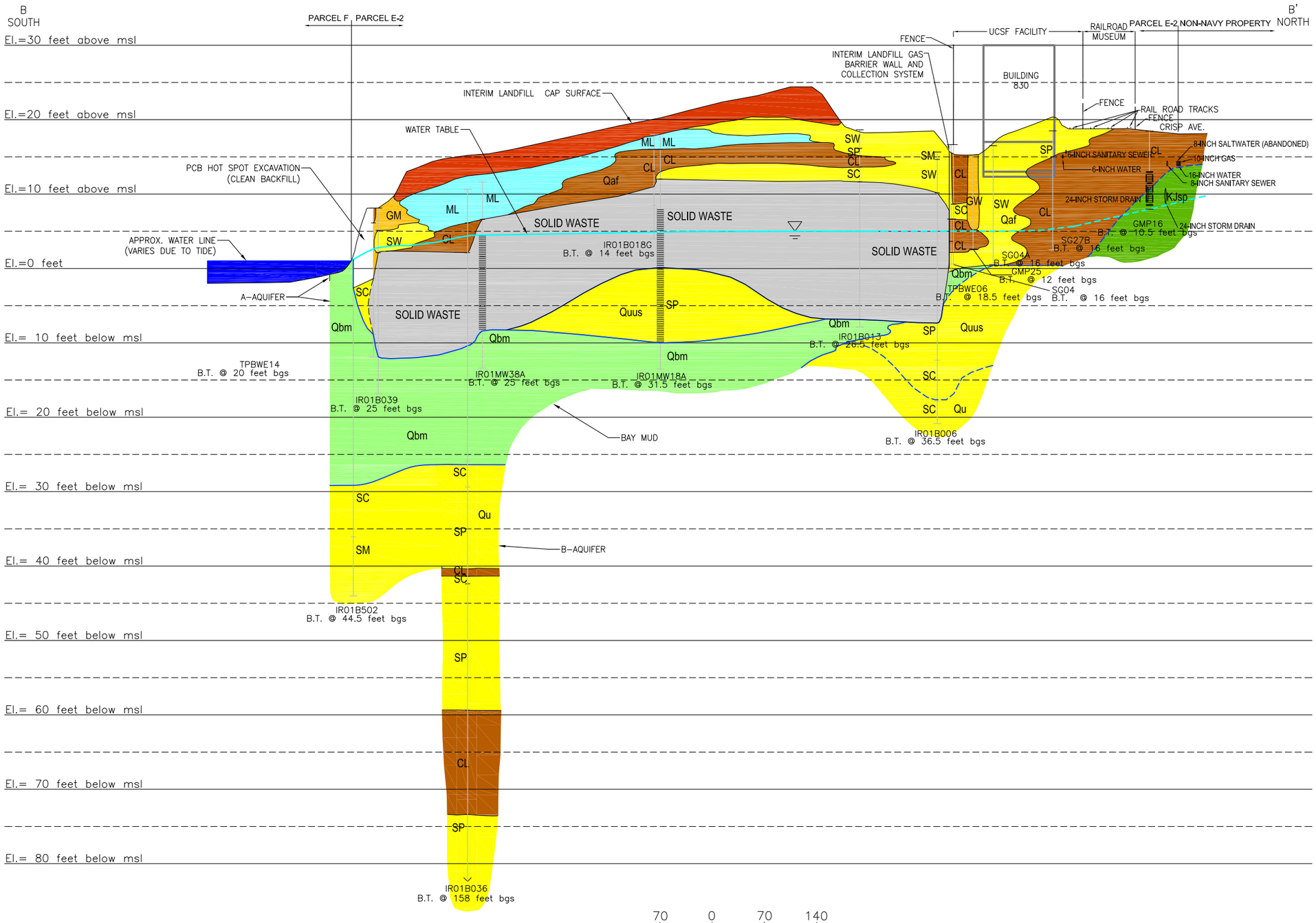

Water Table Measurement on February 14, 2012; Water Level Shown is A-aquifer (dashed where inferred)

Lithologic or Waste Boundary (dashed where inferred)

Formation Boundary (dashed where inferred)

IR01B006 Boring Location (tic marks represent change in lithology)

GMP16 Screened Area

C-C' Intersection Location of Cross Sections

- Cap
- Sand
- Clay
- Silt
- Gravel
- Bay Mud (clay)
- Solid Waste
- Bedrock
- Tidal Reference

Notes:

bgs	below ground surface
B.T.	borehole termination
CL	clay
El.	elevation
GM	silty gravel
GMP	gas monitoring probe
GP	poorly graded gravel
GW	well graded gravel
KJsp	Serpentine Bedrock
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
Quus	Undifferentiated Upper Sand Deposits
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand
UCSF	University of California, San Francisco

70 0 70 140
Horizontal Scale in Feet

7 0 7 14
Vertical Scale in Feet

Geologic interpretations originally presented in:
Tetra Tech EM Inc. 2004. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

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115 Sansome St., Suite 200
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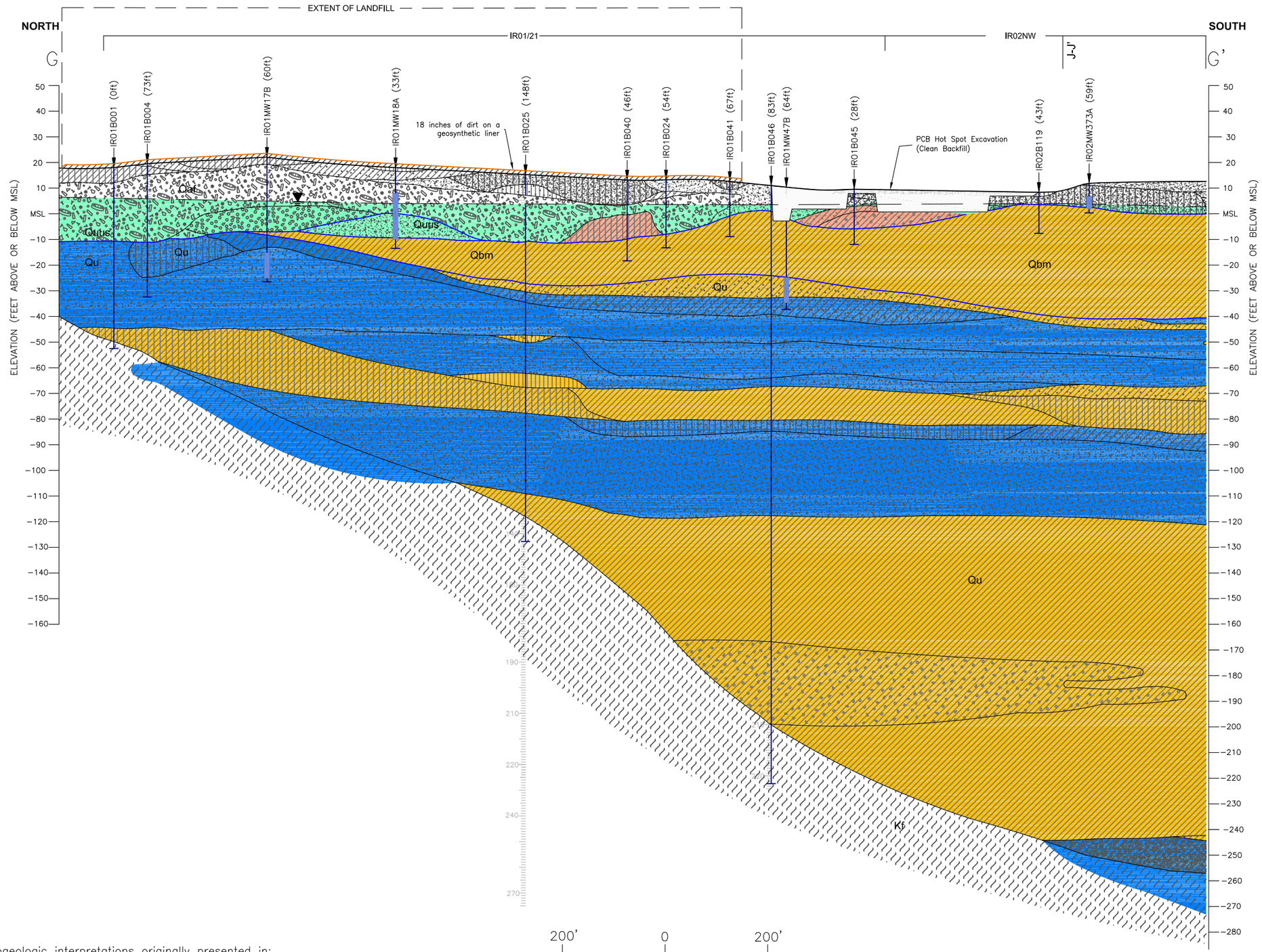
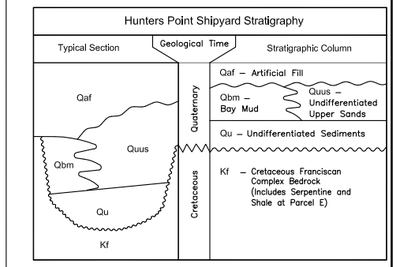
(415) 395-9974

CLIENT:	Department of the Navy BRAC PMO West	CROSS-SECTION B-B'			
LOCATION:	Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 03/22/13	CHECKED BY: PL 03/22/13	PROJECT NO. 25-049	FIG NO. 5

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\5_rev1.dwg LAYOUT NAME: 4 PLOTTED: Wednesday, June 05, 2013 - 3:57pm





LEGEND:

- Formation Contact (dashed where inferred)
- Lithological Contact (dashed where inferred)
- Ground Surface
- Landfill Cap
- MSL Mean Sea Level
- (Disatance Projected to Cross Section) Monitoring Well/Soil Boring Location.
- Well Screen
- A–Aquifer Zone Water Table February 2012
- IR Boundary
- Intersection location of cross sections
- A–Aquifer Zone
- B–Aquifer Zone
- Aquitard Zone
- Qaf Low Permeable Zone based on Lithology

Gravel	Gravelly Silt
Clayey Gravel	Clay
Silty Gravel	Silty Clay
Sandy Gravel	Sandy Clay
Sand	Gravelly Clay
Clayey Sand	Sand/Gravel/Clay Mixture
Silty Sand	Boulder Fill
Gravelly Sand	Weathered Bedrock
Silt	Bedrock
Clayey Silt	Concrete
Sandy Silt	Debris

NOTES:

1. These cross–sections represent one interpretation of the shallow subsurface along the corresponding line: alternate interpretations are possible.
2. Borings have been projected onto the lines of section. The projection of borings' lithologies may cause graphical distortions of geological features.
3. Bedrock and sediment contact is based on lithological logs and a bedrock surface map.

ft feet
Kf Franciscan Complex Bedrock
MSL mean sea level
Qaf Artificial Fill
Qbm Bay Mud
Qu Undifferentiated Sediments
Quus Undifferentiated Sediments Upper Sand Deposits

Hydrogeologic interpretations originally presented in:
Tetra Tech EM Inc. 2004. "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." May.

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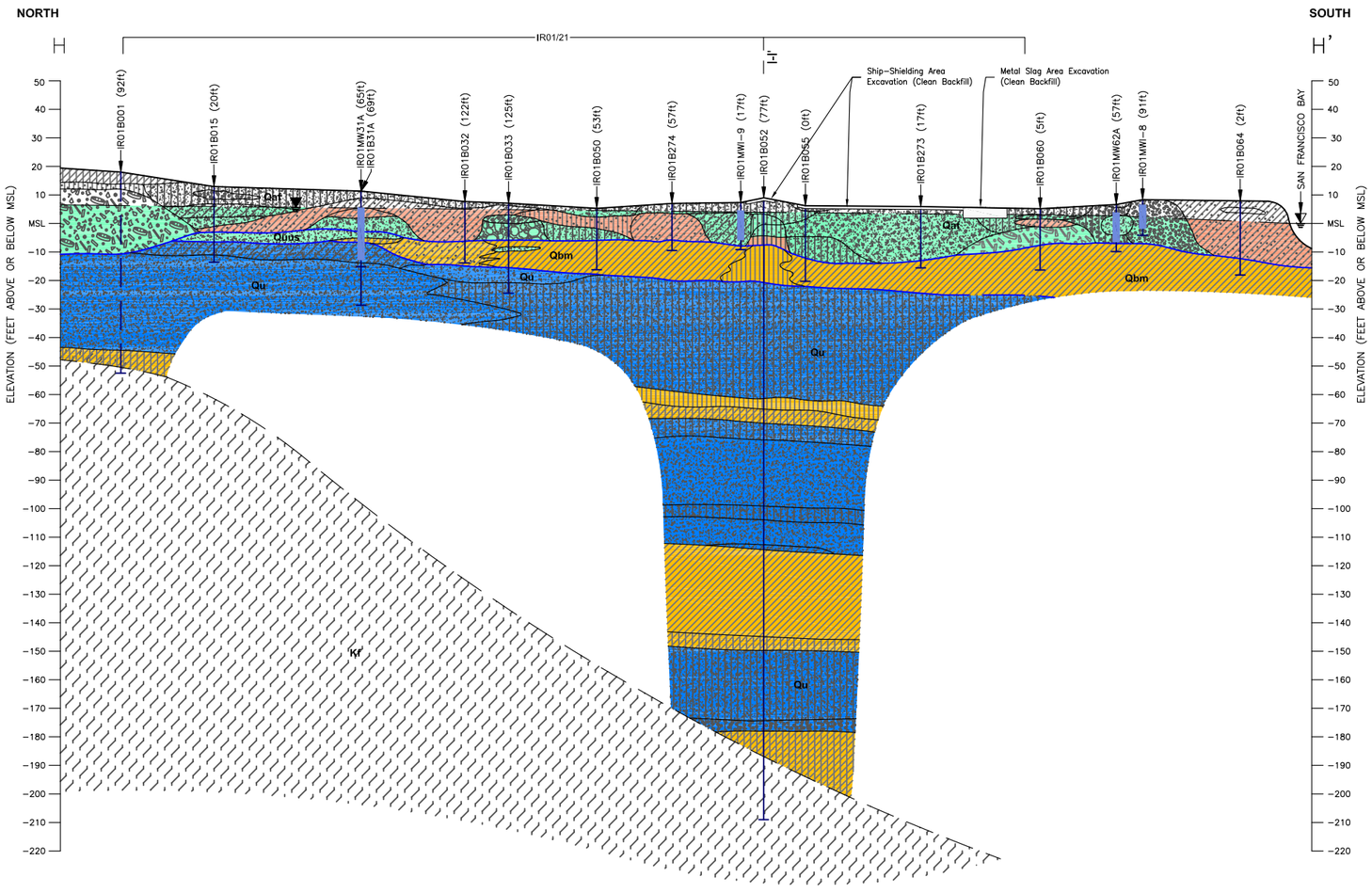
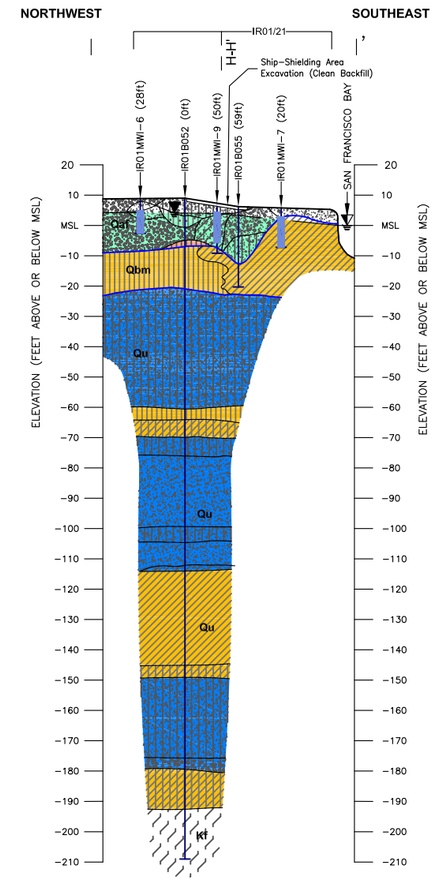
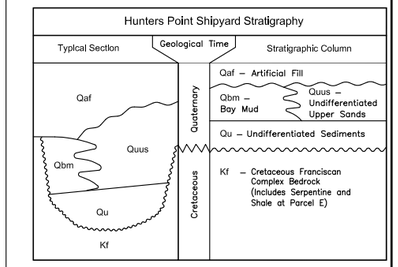
CLIENT:	Department of the Navy BRAC PMO West	CROSS–SECTION G–G'			
LOCATION:	Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 03/22/13	CHECKED BY: PL 03/22/13	PROJECT NO. 25–049	FIG NO. 6

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\6-7.dwg LAYOUT NAME: 6 PLOTTED: Wednesday, June 05, 2013 – 3:58pm







LEGEND:

- Formation Contact (dashed where inferred)
- Lithological Contact (dashed where inferred)
- Ground Surface
- Landfill Cap
- MSL Mean Sea Level
- (Disatance Projected to Cross Section)
- Monitoring Well/Soil Boring Location.
- Well Screen
- A–Aquifer Zone Water Table February 2012
- IR Boundary
- Intersection location of cross sections
- A–Aquifer Zone
- B–Aquifer Zone
- Aquitard Zone
- Qaf Low Permeable Zone based on Lithology

- Gravel
- Clayey Gravel
- Silty Gravel
- Sandy Gravel
- Sand
- Clayey Sand
- Silty Sand
- Gravelly Sand
- Silt
- Clayey Silt
- Sandy Silt
- Gravelly Silt
- Clay
- Silty Clay
- Sandy Clay
- Gravelly Clay
- Sand/Gravel/Clay Mixture
- Boulder Fill
- Weathered Bedrock
- Bedrock
- Concrete
- Debris

Notes:

1. These cross–sections represent one interpretation of the shallow subsurface along the corresponding line: alternate interpretations are possible.
2. Borings have been projected onto the lines of section. The projection of borings' lithologies may cause graphical distortions of geological features.
3. Bedrock and sediment contact is based on lithological logs and a bedrock surface map.

ft feet
Kf Franciscan Complex Bedrock
MSL mean sea level
Qaf Artificial Fill
Qbm Bay Mud
Qu Undifferentiated Sediments
Quus Undifferentiated Sediments Upper Sand Deposits

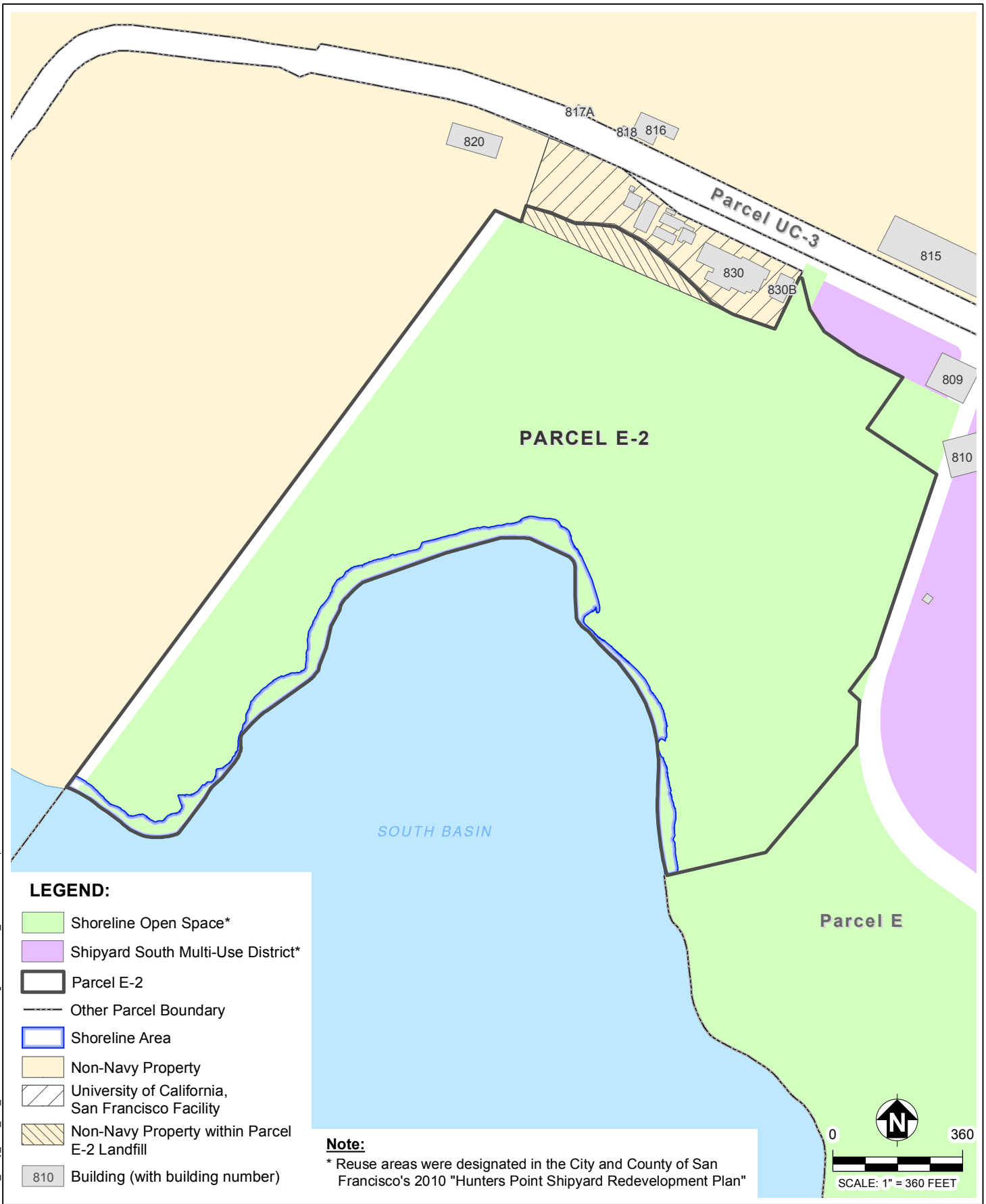
Hydrogeologic interpretations originally presented in:
Tetra Tech EM Inc. 2004. "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." May.

250' 0 250'

HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 5X

ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome St., Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: Department of the Navy BRAC PMO West	CROSS–SECTION H–H' AND I–I'			
	LOCATION: Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 03/22/13	CHECKED BY: PL 03/22/13	PROJECT NO. 25–049	FIG NO. 7

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\6-7.dwg LAYOUT NAME: 7 PLOTTED: Wednesday, June 05, 2013 – 3:59pm



N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\Designated Reuse_rev.mxd Last updated: 5/23/2013 at 4:27:20 PM

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115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:	DESIGNATED REUSE AREAS AT PARCEL E-2			
DEPARTMENT OF THE NAVY, BRAC PMO WEST				
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	DB 02/20/13	25-049	8

LEGEND:

- PARCEL E-2 BOUNDARY
- PARCEL BOUNDARY OTHER
- FENCE
- SLURRY WALL
- LEACHATE EXTRACTION CONDUIT TRENCH
- GROUNDWATER DIVERSION DRAIN
- LIMIT OF LANDFILL WASTE
- APPROXIMATE LIMIT OF FINAL COVER
- APPROXIMATE LIMIT OF EXISTING GEOSYNTHETIC CAP
- PERIMETER DRAINAGE CHANNEL
- FINAL COVER
- WASTE CONSOLIDATION AREA
- FRESHWATER WETLAND (NO GEOSYNTHETIC CAP)
- TIDAL WETLANDS
- SERVICE ROAD
- RIPRAP REVETMENT SLOPE PROTECTION
- 5 4 FINISH GRADE TOPOGRAPHIC CONTOUR LINE
- 1 0 EXISTING TOPOGRAPHIC CONTOUR LINE
- EXISTING GROUNDWATER MONITORING WELL (TO REMAIN)
- EXISTING GAS MONITORING PROBE
- EXISTING LFG VENT
- EXISTING LFG VENT (TO BE DECOMMISSIONED)
- NEW PIEZOMETER
- NEW GAS MONITORING PROBE
- NEW GROUNDWATER MONITORING WELL
- NEW LANDFILL GAS EXTRACTION WELL
- NEW LEACHATE MONITORING/EXTRACTION WELL
- NEW SURVEY MONUMENT
- DRAIN INLET

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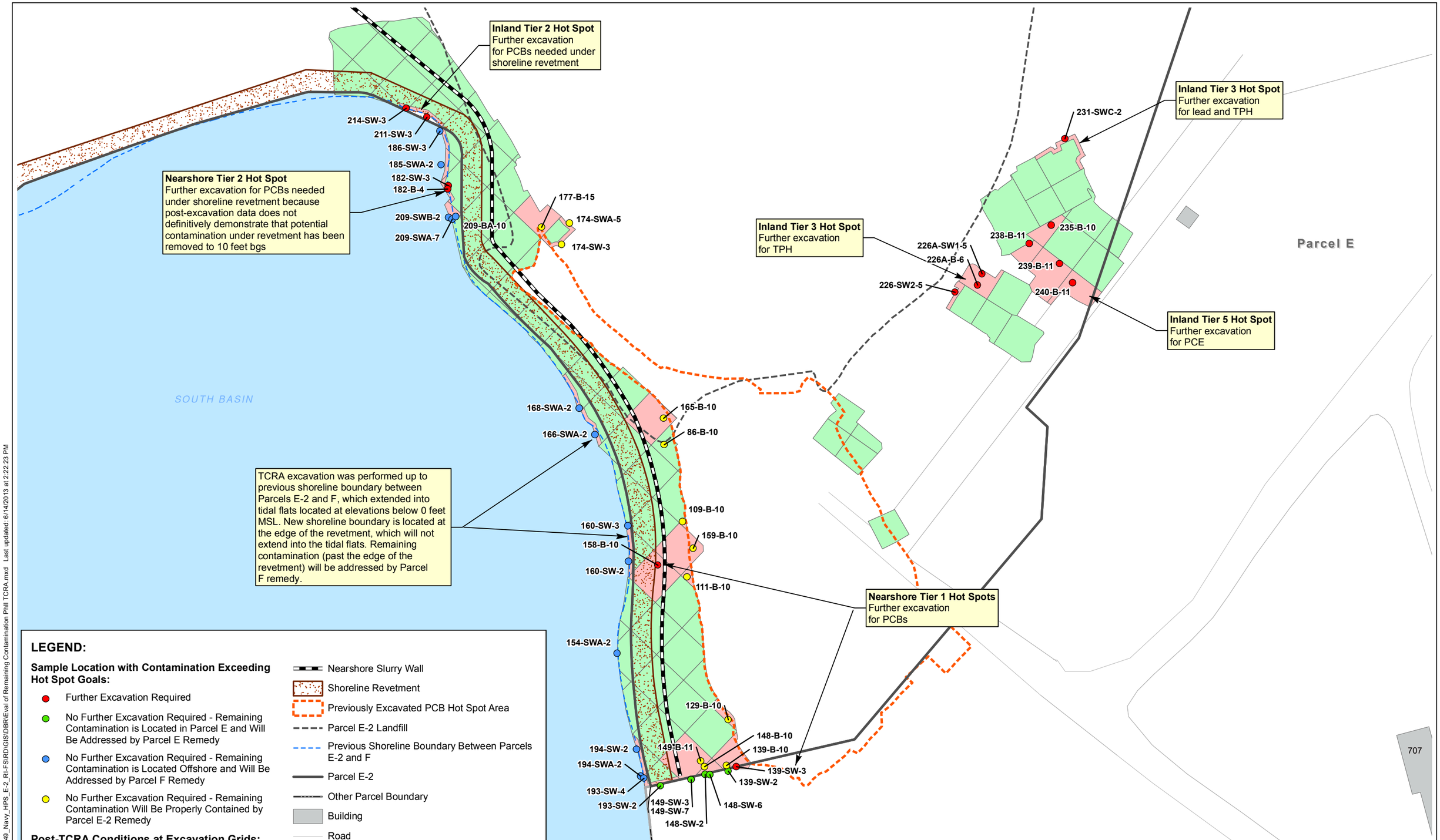
San Francisco, California 94104
(415) 395-9974

CLIENT:	Department of the Navy BRAC PMO West	DESIGN OVERVIEW			
LOCATION:	Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 05/23/13	CHECKED BY: PL 05/23/13	PROJECT NO. 25-049	FIG NO. 9

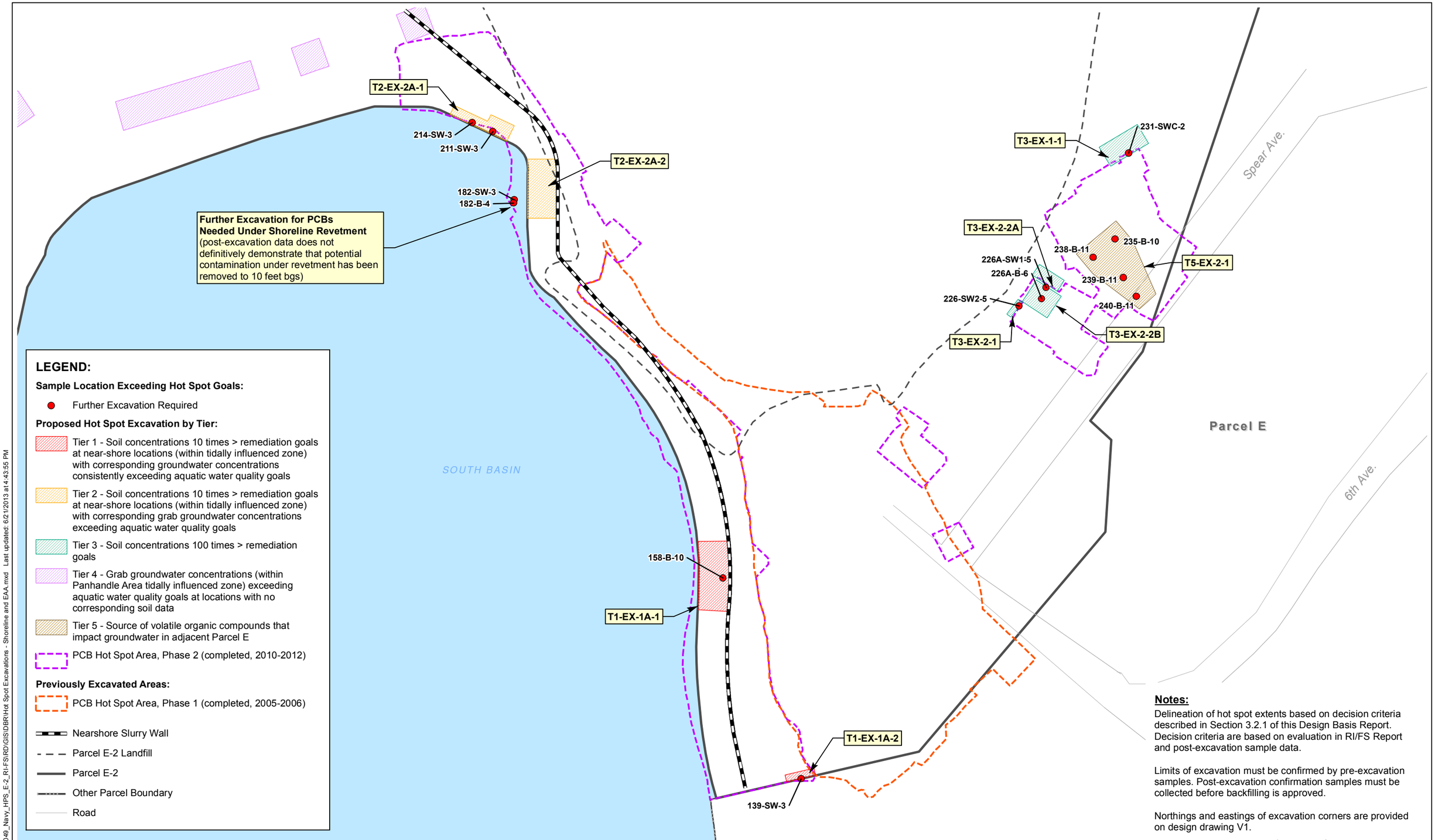
FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\9D.dwg LAYOUT NAME: 9 PLOTTED: Tuesday, June 25, 2013 - 11:00am



ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	EVALUATION OF REMAINING CONTAMINATION AFTER PHASE 2 TCRA AT PCB HOT SPOT AREA			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 05/17/13	CHECKED BY: DB 05/17/13	PROJECT NO. 25-049	FIG NO. 10

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\Eval of Remaining Contamination PhII TCRA.mxd Last updated: 6/14/2013 at 2:22:23 PM



Notes:

Delineation of hot spot extents based on decision criteria described in Section 3.2.1 of this Design Basis Report. Decision criteria are based on evaluation in RI/FS Report and post-excavation sample data.

Limits of excavation must be confirmed by pre-excavation samples. Post-excavation confirmation samples must be collected before backfilling is approved.

Northings and eastings of excavation corners are provided on design drawing V1.

N

0 120

SCALE: 1" = 120 FEET

ERRG Engineering/Remediation Resources Group, Inc.
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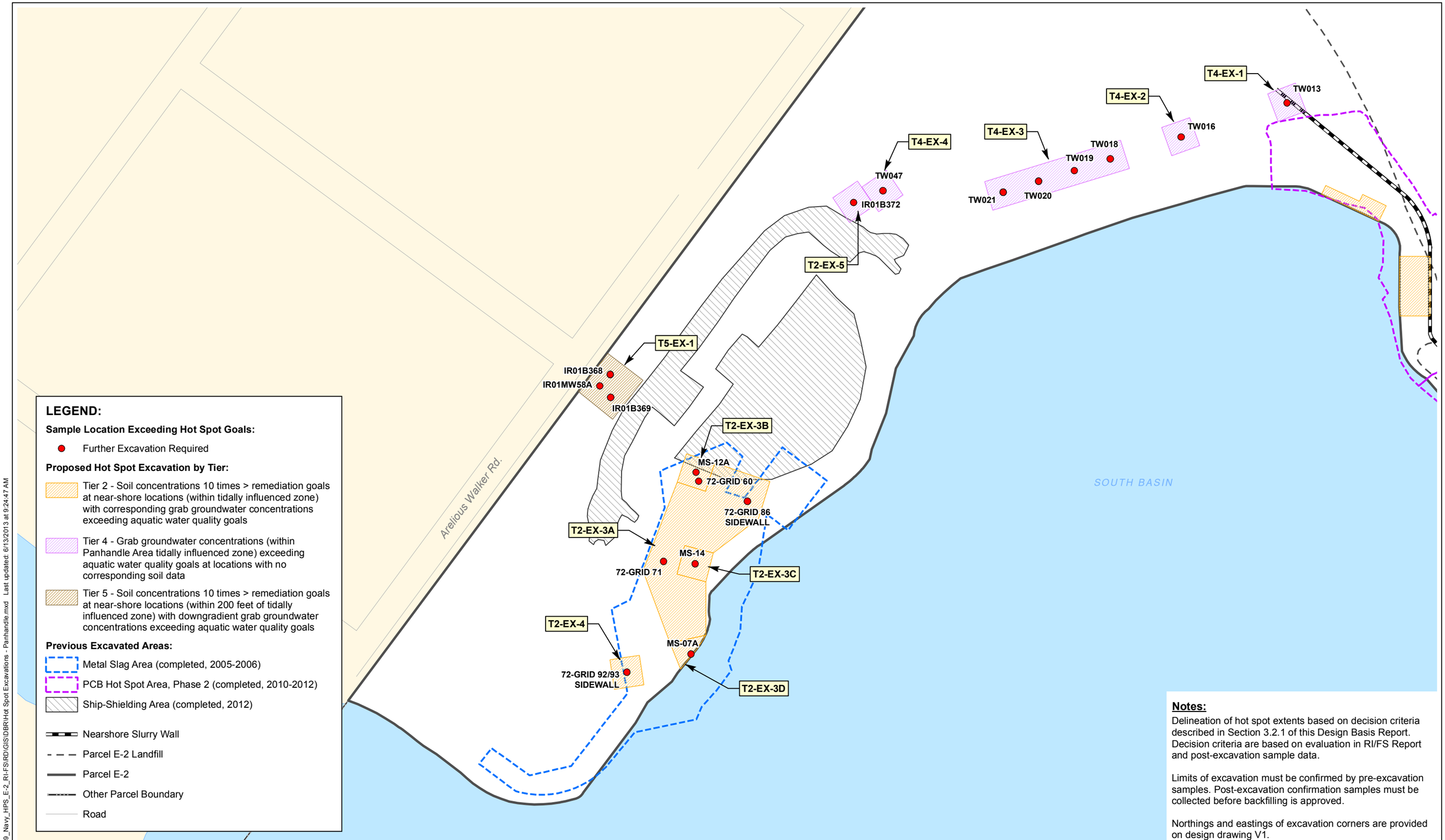
San Francisco, California 94104
(415) 395-9974

CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	HOT SPOT EXCAVATIONS IN SHORELINE AND EAST ADJACENT AREAS		
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 05/17/13	CHECKED BY: DB 05/21/13	PROJECT NO. 25-049 / FIG NO. 11

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\Hot Spot Excavations - Shoreline and EAA.mxd Last updated: 6/21/2013 at 14:43:55 PM



LEGEND:

Sample Location Exceeding Hot Spot Goals:

- Further Excavation Required

Proposed Hot Spot Excavation by Tier:

- Tier 2 - Soil concentrations 10 times > remediation goals at near-shore locations (within tidally influenced zone) with corresponding grab groundwater concentrations exceeding aquatic water quality goals
- Tier 4 - Grab groundwater concentrations (within Panhandle Area tidally influenced zone) exceeding aquatic water quality goals at locations with no corresponding soil data
- Tier 5 - Soil concentrations 10 times > remediation goals at near-shore locations (within 200 feet of tidally influenced zone) with downgradient grab groundwater concentrations exceeding aquatic water quality goals

Previous Excavated Areas:

- Metal Slag Area (completed, 2005-2006)
- PCB Hot Spot Area, Phase 2 (completed, 2010-2012)
- Ship-Shielding Area (completed, 2012)
- Nearshore Slurry Wall
- Parcel E-2 Landfill
- Parcel E-2
- Other Parcel Boundary
- Road

Notes:

Delineation of hot spot extents based on decision criteria described in Section 3.2.1 of this Design Basis Report. Decision criteria are based on evaluation in RI/FS Report and post-excavation sample data.

Limits of excavation must be confirmed by pre-excavation samples. Post-excavation confirmation samples must be collected before backfilling is approved.

Northings and eastings of excavation corners are provided on design drawing V1.

N

0 120

SCALE: 1" = 120 FEET

ERRG Engineering/Remediation Resources Group, Inc.
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CLIENT:	HOT SPOT EXCAVATIONS IN PANHANDLE AREA			
DEPARTMENT OF THE NAVY, BRAC PMO WEST				
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 05/17/13	DB 05/21/13	25-049	12

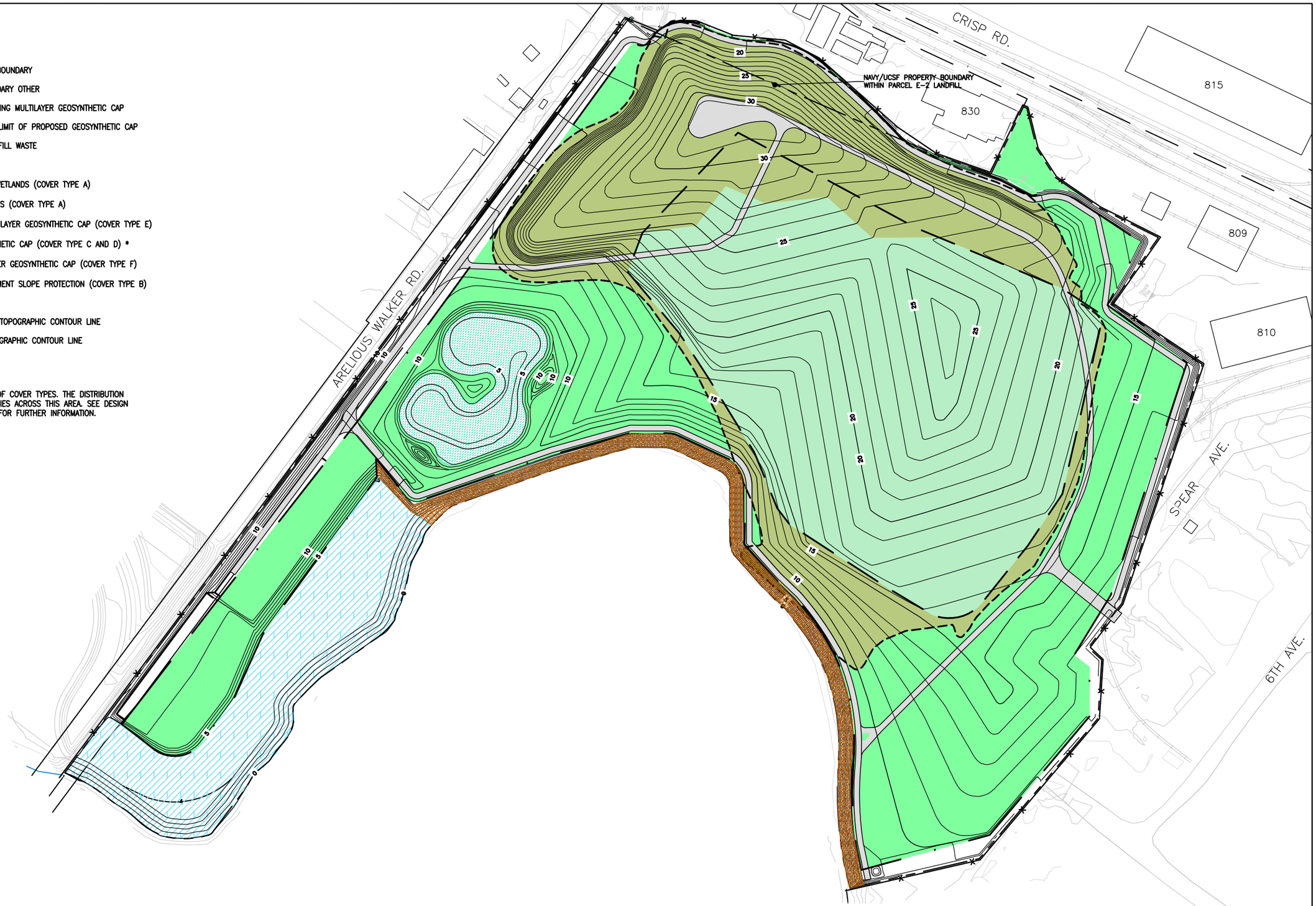
N:\Graphics\200525-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\Hot Spot Excavations - Panhandle.mxd Last updated: 6/13/2013 at 9:24:47 AM

LEGEND:

- PARCEL E-2 BOUNDARY
- PARCEL BOUNDARY OTHER
- LIMIT OF EXISTING MULTILAYER GEOSYNTHETIC CAP
- APPROXIMATE LIMIT OF PROPOSED GEOSYNTHETIC CAP
- LIMIT OF LANDFILL WASTE
- FENCE
- FRESHWATER WETLANDS (COVER TYPE A)
- TIDAL WETLANDS (COVER TYPE A)
- EXISTING MULTILAYER GEOSYNTHETIC CAP (COVER TYPE E)
- NEW GEOSYNTHETIC CAP (COVER TYPE C AND D) *
- NEW MULTILAYER GEOSYNTHETIC CAP (COVER TYPE F)
- RIPRAP REVETMENT SLOPE PROTECTION (COVER TYPE B)
- SERVICE ROAD
- FINISH GRADE TOPOGRAPHIC CONTOUR LINE
- EXISTING TOPOGRAPHIC CONTOUR LINE

NOTE:

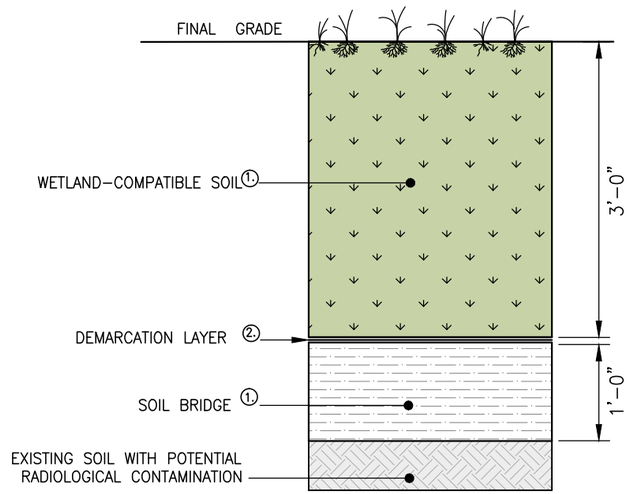
* SEE FIGURE 14 FOR DETAILS OF COVER TYPES. THE DISTRIBUTION OF COVER TYPES C AND D VARIES ACROSS THIS AREA. SEE DESIGN DRAWINGS C11, C12 AND C13 FOR FURTHER INFORMATION.



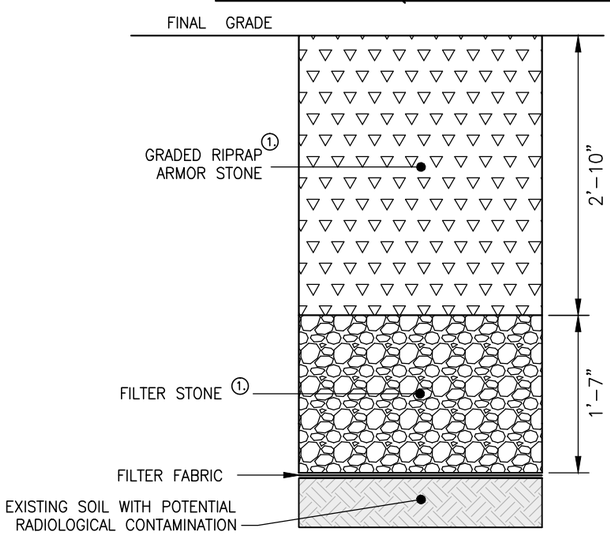
ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome St., Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: Department of the Navy BRAC PMO West	FINAL COVER SYSTEM			
	LOCATION: Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 05/23/13	CHECKED BY: PL 05/23/13	PROJECT NO. 25-049	FIG NO. 13

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\13.dwg LAYOUT NAME: 13 PLOTTED: Thursday, June 06, 2013 - 10:13am

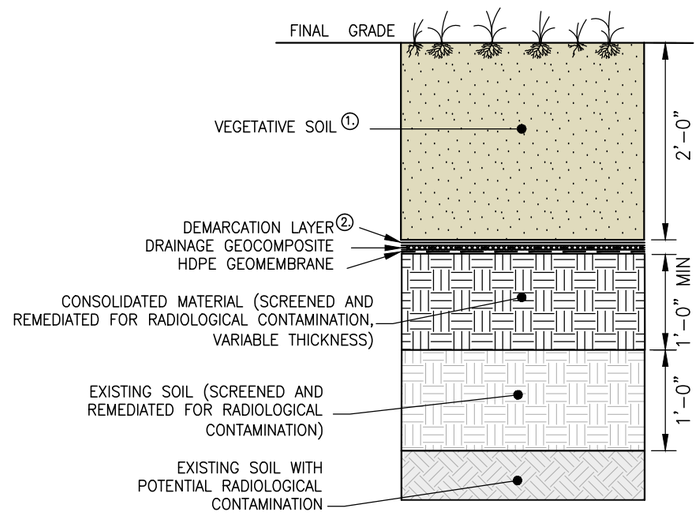
COVER TYPE A (TIDAL AND FRESHWATER WETLANDS)



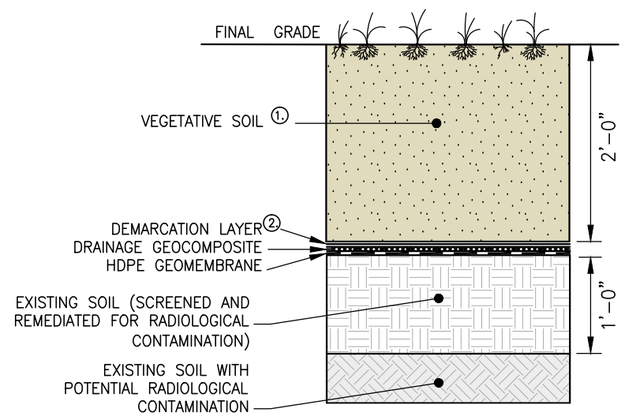
COVER TYPE B (REVETMENT ARMOR)



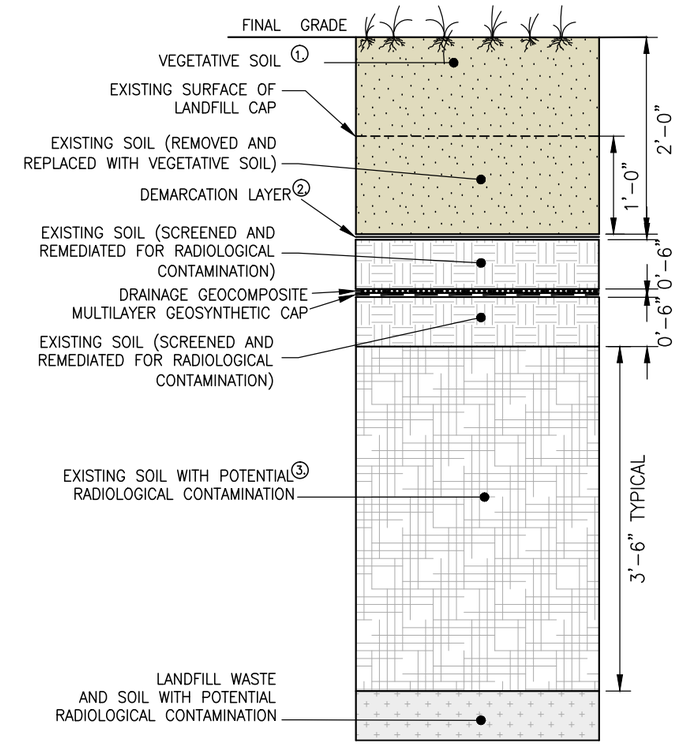
COVER TYPE C (PROPOSED GEOSYNTHETIC CAP)



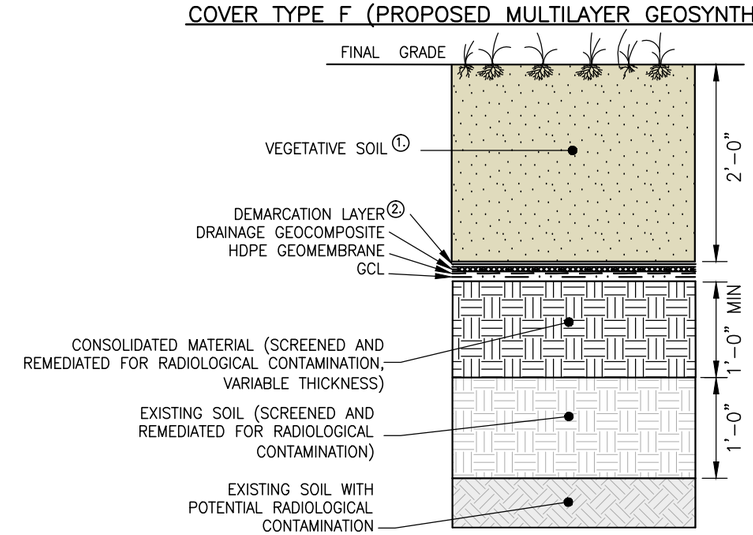
COVER TYPE D (PROPOSED GEOSYNTHETIC CAP)



COVER TYPE E (EXISITNG MULTILAYER GEOSYNTHETIC CAP)



COVER TYPE F (PROPOSED MULTILAYER GEOSYNTHETIC CAP)



NOTES:

1. IMPORTED FILL MATERIAL WILL MEET CHEMICAL (NONRADIOLOGICAL AND RADIOLOGICAL) ACCEPTANCE CRITERIA (SEE APPENDIX C).
2. DEMARCATION LAYER WILL CONSIST OF MAGNETIC MARKING TAPE AND ORANGE–COLORED GEOTEXTILE.
3. EXISTING SOIL PLACED ON TOP OF LANDFILL DURING PRELIMINARY CLOSURE ACTIVITIES IN 1974 AND 2000 (AFTER MILITARY OPERATIONS CEASED).
4. LOCATIONS OF COVER TYPES PRESENTED ON FIGURE 11.
5. HDPE = HIGH–DENSITY POLYETHYLENE.
6. GCL = GEOSYNTHETIC CLAY LINER.

NOT TO SCALE

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome St., Suite 200
San Francisco, California 94104
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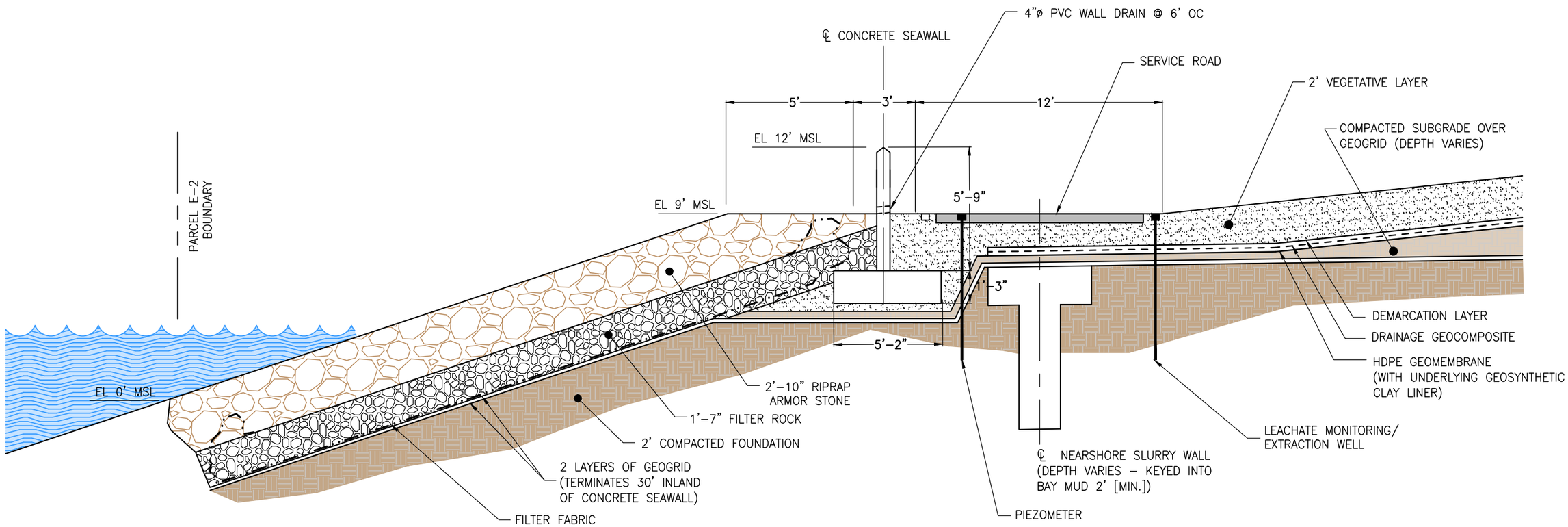
CLIENT: Department of the Navy BRAC PMO West	FINAL COVER DETAILS			
LOCATION: Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 05/23/13	CHECKED BY: PL 05/23/13	PROJECT NO. 25–049	FIG NO. 14

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\14.dwg LAYOUT NAME: 14 PLOTTED: Thursday, June 06, 2013 – 10:21am



LEGEND:

- RIPRAP ARMOR STONE
- FILTER ROCK
- COMPACTED FOUDATION
- VEGETATIVE LAYER
- COMPACTED SUBGRADE OVER GEOGRID
- SAN FRANCISCO BAY
- FILTER FABRIC

HDPE	HIGH-DENSITY POLYETHYLENE
MSL	MEAN SEA LEVEL
PVC	POLYVINYL CHLORIDE

NOT TO SCALE

ERRG Engineering/Remediation Resources Group, Inc.
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San Francisco, California 94104
(415) 395-9974

CLIENT:	Department of the Navy BRAC PMO West	SHORELINE REVETMENT DETAIL			
LOCATION:	Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 05/23/13	CHECKED BY: PL 05/23/13	PROJECT NO. 25-049	FIG NO. 15

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\15.dwg LAYOUT NAME: 15 PLOTTED: Thursday, May 23, 2013 - 2:03pm

LEGEND:

- NEW LANDFILL GAS EXTRACTION WELL
- NEW LANDFILL GAS MONITORING PROBE
- EXISTING LFG VENT
- EXISTING LFG (TO BE DECOMMISSIONED)
- EXISTING LANDFILL GAS MONITORING PROBE
- CONDENSATE SUMP
- BUTTERFLY VALVE
- HP — HIGH POINT
- BURIED LANDFILL GAS HEADER, 6" HDPE
- BURIED LANDFILL GAS LATERAL PIPE, 4" HDPE
- SLURRY WALL
- BARRIER WALL
- SERVICE ROAD
- FRESHWATER WETLAND (COVER TYPE A)
- TIDAL WETLANDS (COVER TYPE A)

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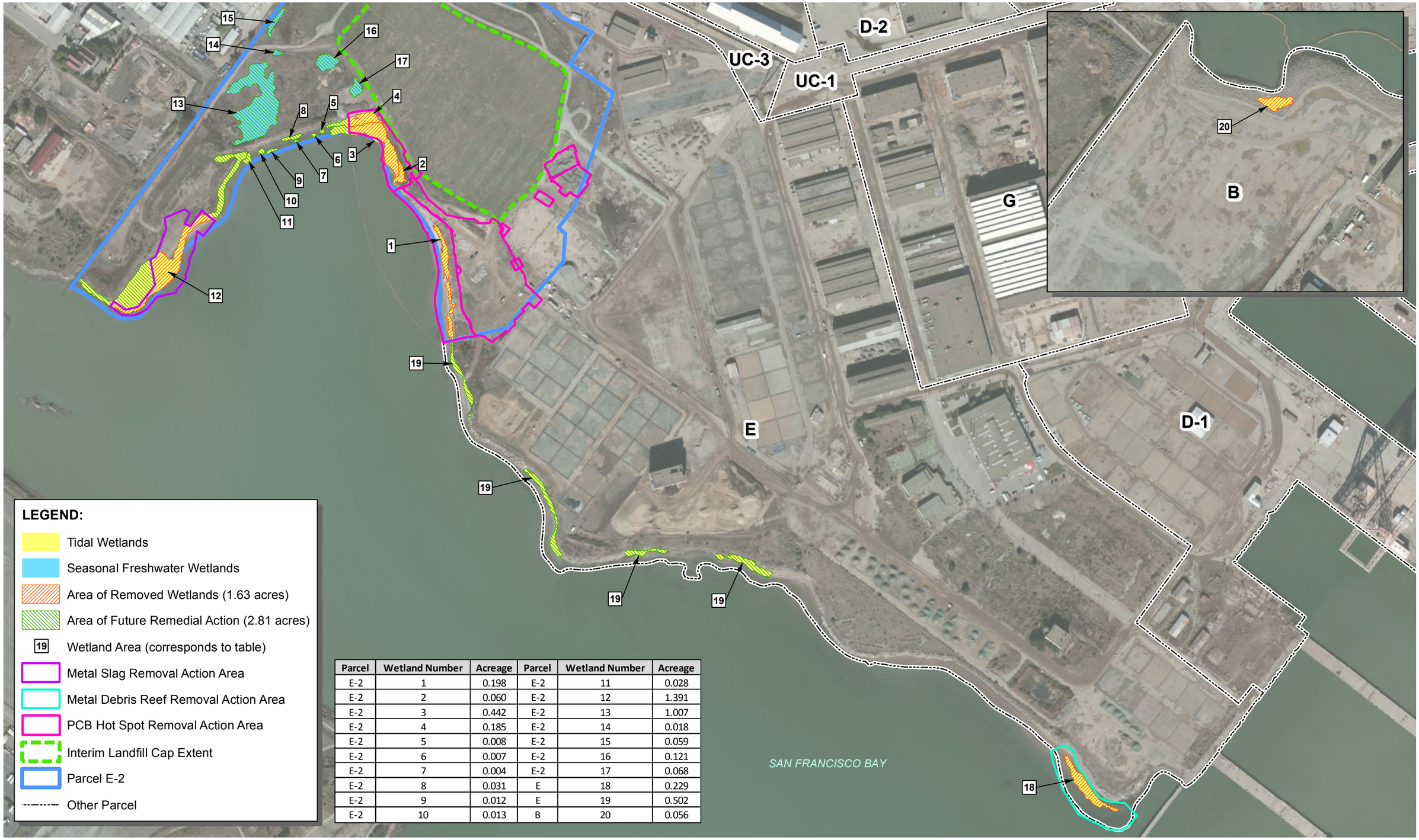
CLIENT:	Department of the Navy BRAC PMO West	LANDFILL GAS COLLECTION SYSTEM PLAN			
LOCATION:	Hunters Point Naval Shipyard San Francisco, California	DRAWN BY: SC 03/22/13	CHECKED BY: PL 03/22/13	PROJECT NO. 25-049	FIG NO. 16

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\DBR\16.dwg LAYOUT NAME: 16 PLOTTED: Tuesday, June 18, 2013 - 9:09am



Parcel	Wetland Number	Acreage	Parcel	Wetland Number	Acreage
E-2	1	0.198	E-2	11	0.028
E-2	2	0.060	E-2	12	1.391
E-2	3	0.442	E-2	13	1.007
E-2	4	0.185	E-2	14	0.018
E-2	5	0.008	E-2	15	0.059
E-2	6	0.007	E-2	16	0.121
E-2	7	0.004	E-2	17	0.068
E-2	8	0.031	E	18	0.229
E-2	9	0.012	E	19	0.502
E-2	10	0.013	B	20	0.056

IMAGERY SOURCE: ESRI WORLD IMAGERY GIS WEB SERVICE, 2013
REFERENCE: SHAW ENVIRONMENTAL, INC.

N

0 400
SCALE: 1" = 400 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

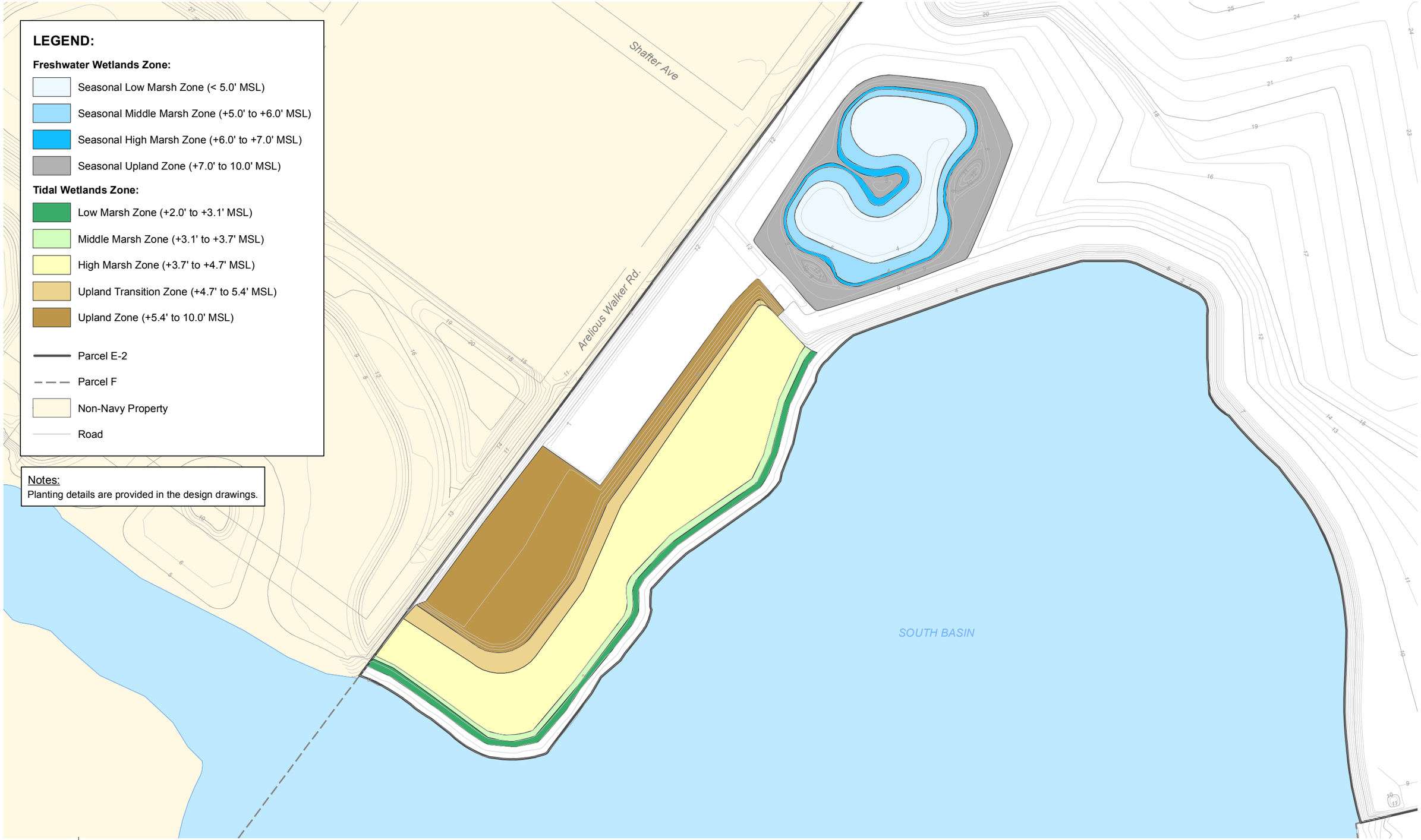
CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST

LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA

IMPACTED WETLANDS AT HPNS

DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
JJC 02/20/13	DB 02/20/13	25-049	17

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\Impacted Wetlands.mxd Last updated: 6/14/2013 at 2:53:30 PM



0 150
SCALE: 1" = 150 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	WETLANDS PLANTING ZONES		
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 03/28/13	CHECKED BY: DB 03/28/13	PROJECT NO. 25-049	FIG NO. 18

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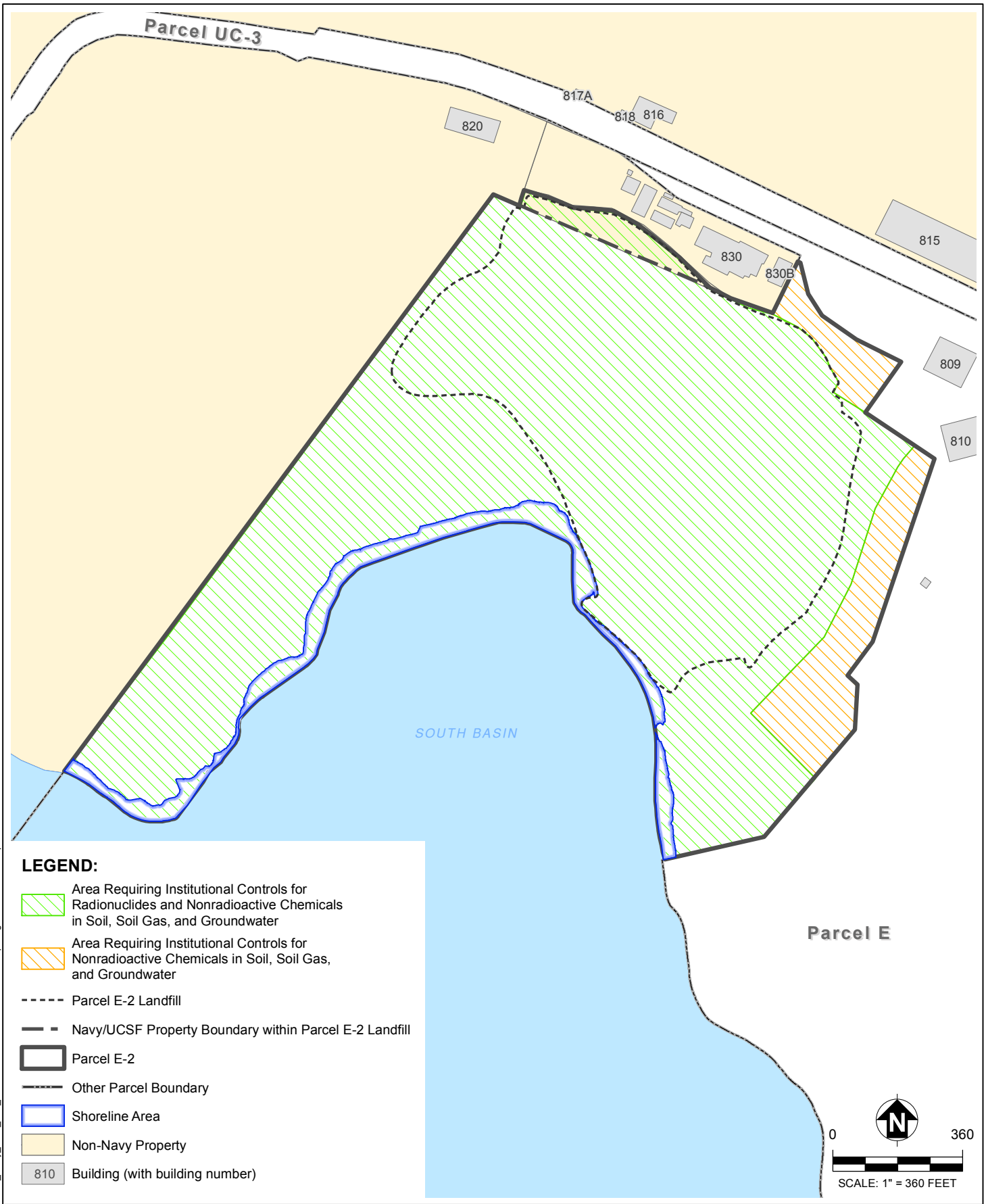

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CLIENT:				
DEPARTMENT OF THE NAVY, BRAC PMO WEST	AREAS REQUIRING INSTITUTIONAL CONTROLS			
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	JS 02/20/13	25-049	19

Tables

Table 1. ARARs for Design Components

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Chemical-Specific ARARs for Solid Waste, Soil, Sediment, and Subsurface Air		
Department of Toxic Substances Control [c] / State Water Resources Control Board [c] / California Department of Resources Recycling and Recovery		
This requirement controls release of methane.	Cal. Code Regs, tit. 27, § 20921(a)	Provides that methane must not exceed 1.25 percent by volume in air within onsite structures, and concentrations of methane migrating from the Parcel E-2 Landfill must not exceed 5 percent by volume in air at the property boundary (or an alternative boundary) in accordance with Cal. Code Regs, tit. 27, § 20925. Design includes an active LFG abatement system to control LFG migration and to allow for long-term monitoring of gases generated by landfill waste. System and perimeter LFG monitoring network is incorporated into the design to allow for compliance with system and perimeter sampling. Design includes a RAMP that details the monitoring of LFG, and will establish the frequency of LFG monitoring during the operational life of the active system.
Federal Location-Specific ARARs		
National Historic Preservation Act of 1966, as Amended (16 USC § 1470-470x-6)[c]		
Action to preserve historic properties; planning of action to minimize harm to properties listed on or eligible for listing on the National Register of Historic Places	16 USC § 470-470x-6 36 CFR Part 800 40 CFR § 6.301(b)	The State Historic Preservation Office will be notified about areas where the remedy will potentially affect sensitive archaeological areas. Shellmound site in the northwest portion of Parcel E-2 was identified as potentially sensitive in the "Basewide Archaeological Monitoring and Discovery Plan, Hunters Point Naval Shipyard, San Francisco County, California," March 2009.
Migratory Bird Treaty Act of 1972 (16 USC §§ 703 through 712)[c]		
Protects almost all species of native migratory birds in the United States from unregulated "take," which can include poisoning at hazardous waste sites.	16 USC § 703	There will be no unregulated take of migratory birds permitted on site during the course of this remedy.
Coastal Zone Management Act (16 USC §§ 1451 through 1464)[c]		
Conduct activities in a manner consistent with approved state management programs to the maximum extent practicable.	16 USC § 1456(c) 15 CFR § 930.30	The selected remedy will comply with the Coastal Zone Management Act and San Francisco Bay Plan to the maximum extent practicable. The selected remedial design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The SF-BWQMP will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
Federal Location-Specific ARARs *(continued)*		
Clean Water Act of 1977, as Amended, § 404 (33 USC § 1344)[c]		
Action to prohibit discharge of dredged or fill material into wetland without permit.	33 USC § 1344	Substantive provisions (see action-specific ARARs) are applicable because discharge of dredged or fill material is planned as part of the remedy. The selected remedial design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The proposed SF-BWQMP will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy.
State Location-Specific ARARs		
McAteer-Petris Act (California Government Code §§ 66600 through 66661)[c]		
Reduce fill and disposal of dredged material in San Francisco Bay, maintain marshes and mudflats to the fullest extent possible to conserve wildlife, abate pollution, and protect the beneficial uses of the San Francisco Bay.	Bay Plan at Cal. Code Regs, tit. 14, §§ 10110 through 11990	The selected remedial design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The proposed SF-BWQMP will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy.
California Department of Fish and Game (California Fish & Game Code)[c]		
Fully protected birds or parts thereof may not be taken or possessed at any time. The following are fully protected birds: American Peregrine Falcon, California Brown Pelican, California Black Rail, California Clapper Rail, California Condor, California Least Tern, Golden Eagle, Greater Sandhill Crane, Light-footed Clapper Rail, Southern Bald Eagle, Trumpeter Swan, White-tailed Kite, and Yuma Clapper Rail.	California Fish & Game Code § 3511	There will be no unregulated take of fully protected birds permitted on site during the course of this remedy.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Location-Specific ARARs *(continued)*		
California Department of Fish and Game (California Fish & Game Code)[c]		
Prohibits the passage of enumerated substances or materials into waters of the state deleterious to fish, plant life, or birds.	Not authorized under California Water Code § 13263 or a waiver issued pursuant to subdivision (a) of § 13269 of the California Water Code California Fish & Game Code § 5650(a), (b), and (c)	The selected remedial design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The shoreline construction proposed SF-BWQMP will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy.
Federal Action-Specific ARARs for Containment		
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i])[c]		
Waste to remain in a unit will be compacted before any portion of the final cover is installed.	Cal. Code Regs. tit. 22, § 66264.228(e)(1)	Design of final cover requires compaction of soil to an average of 90 percent of the maximum dry density depending on the layer and cover type. The final graded cover will promote BMPs for surface water runoff and reduce potential soil erosion and offsite migration.
The final cover will prevent the downward entry of water into the closed landfill throughout a period of at least 100 years.	Cal. Code Regs. tit. 22, § 66264.310(a)(1)	This requirement only pertains to the final cover at the Parcel E-2 Landfill. Design of the final landfill cover includes the extension of an existing multilayer geosynthetic cap to cover the extents of the landfill. Existing and new multilayer caps include 2 feet of vegetative soil layers over the extent of the landfill. The drainage geocomposite and HDPE in the cap, along with final site grade and perimeter drainage controls, are all incorporated to minimize water percolation through the landfill.
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i])[c]		
The final cover will accommodate lateral and vertical shear forces generated by the maximum credible earthquake so that the integrity of the cover is maintained.	Cal. Code Regs. tit. 22, § 66264.310(a)(5)	Final cover and containment systems were designed to withstand the peak ground acceleration associated with the maximum credible earthquake of magnitude 8.0. Slope stability of design under static and seismic conditions was verified using numeric model. Final cover slope to be mostly 4 percent, with the steepest areas no more than 3:1 (H:V).

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
Federal Action-Specific ARARs for Shoreline Construction		
Clean Water Act, as Amended, § 404 (Title 33 USC § 1344)[c]		
Address specific restrictions on the discharge of dredged or fill material into waters of the United States, and require that appropriate and practicable steps be taken to minimize adverse impacts.	40 CFR §§ 230.10; 230.70 through 230.77	Design includes the requirement for a RAWP that includes a SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The proposed SF-BWQMP will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy. Design includes requirement for implementation of a SWPPP, including stormwater BMPs, during construction to control migration of suspended sediment off site and into waters of the United States. Design features include a perimeter drainage system surrounding the landfill to limit groundwater migration through waste and into waters of the United States. Design grade includes surface water runoff and erosion controls to minimize discharges of sediments and toxic substances that might adversely affect surface water quality and waters of the United States. Compliance with 40 CFR § 230.10 is evaluated using factual determinations, per 40 CFR § 230.11, for the proposed action. Potential actions to minimize adverse impacts are identified at 40 CFR §§ 230.70 through 230.77. The shoreline construction proposed under the selected remedy will comply with the specified discharge restrictions and will incorporate appropriate steps to minimize adverse impacts to waters of the United States. Appendix O in the RI/FS Report provides an evaluation relative to these requirements (ERRG and Shaw, 2011).
Factual determinations will be made for the remedial actions involving discharge of dredged or fill material into waters of the United States.	40 CFR §§ 230.11; 230.20 through 230.25; 230.31; 230.32; 230.41; 230.42; and 230.53	Compliance with 40 CFR § 230.10 is evaluated using factual determinations, per 40 CFR § 230.11, for the proposed action. Potential actions to minimize adverse impacts are identified at 40 CFR § 230.70 through § 230.77. The shoreline construction proposed under the selected remedy will comply with the specified discharge restrictions and will incorporate appropriate steps to minimize adverse impacts to waters of the United States.
Clean Water Act, as Amended, § 404 (Title 33 USC § 1344)[c]		
Compensatory mitigation will be made to offset losses from unavoidable impacts to waters of the United States.	40 CFR § 230.93	Design includes the restoration of tidal wetlands and freshwater wetlands in the Panhandle Area. The proposed cleanup and wetlands restoration will create conditions that have a higher ecological value relative to existing conditions. No mitigation is required for other (non-wetland) aquatic resources at Parcel E-2 that will be lost as part of the cleanup process
Address the required content for mitigation plans.	40 CFR § 230.94(c)	The content for mitigation plans was incorporated into the DBR, RAMP, and OMP.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
Federal Action-Specific ARARs for Shoreline Construction *(continued)*		
Clean Water Act, as Amended, § 404 (Title 33 USC § 1344)[c]		
Address ecological performance standards and monitoring requirements for mitigation projects.	40 CFR §§ 230.95, 230.96, 230.97; 33 CFR § 320.4; and 33 CFR §§ 330.1(e)(3)	Ecological performance standards and monitoring requirements were incorporated, as appropriate, into the DBR, RAMP, and OMP for Parcel E-2.
Address the long-term management methods for compensatory mitigation projects.	40 CFR § 230.97	Long-term management methods were incorporated, as appropriate, into the DBR, RAMP, and OMP for Parcel E-2.
Address the substantive requirements of the general policies for evaluating permit applications for discharge of dredged or fill material into waters of the United States.	33 CFR § 320.4	Design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States and to comply with the substantive provisions of the permit during implementation of the remedy. Design also includes requirement for implementation of a SWPPP, including stormwater BMPs, during construction to control migration of suspended sediment off site and into waters of the United States.
Address the substantive requirements of the terms and conditions for the nationwide permit program, which authorizes discharges having minimal impacts.	33 CFR §§ 330.1(e)(3)	Design includes the requirement for a RAWP that includes an SF-BWQMP specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States and to comply with the substantive provisions of the permit during implementation of the remedy. Design also includes requirement for implementation of a SWPPP, including stormwater BMPs, during construction to control migration of suspended sediment off site and into waters of the United States.
Federal Action-Specific ARARs for Landfill Gas Treatment		
Clean Air Act (Title 42 USC § 7401 et seq.)[c]		
LFG system will not discharge into the atmosphere from any miscellaneous operation an emission containing more than 6.8 kilograms (15 pounds) per day and containing a concentration of more than 300 parts per million of total carbon on a dry basis.	BAAQMD Regulation 8, Rule 2	Design includes an active LFG abatement system to control LFG migration and to allow for long-term monitoring of gases generated by landfill waste. System and perimeter LFG monitoring network is incorporated into the design to allow for compliance with system and boundary sampling.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
Federal Action-Specific ARARs for Leachate Collection and Control		
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i])[c]		
Operate a leachate collection and removal system until leachate is no longer detected (this regulation does not require the installation of a leachate collection system).	Cal. Code Regs. tit. 22, § 66264.310(b)(2)	Design will accommodate the relevant and appropriate control of leachate as required based on the results of future groundwater monitoring. Design of south perimeter landfill cap termination includes a series of wells that will be used for monitoring groundwater, and may be used for future groundwater/leachate extraction.
State Action-Specific ARARs for Containment		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
Diversion and drainage facilities will be designed, constructed, and maintained to accommodate the anticipated volume of precipitation and peak flows. In addition, erosion and related damage of the final cover due to drainage must be prevented throughout the post-closure maintenance period.	Cal. Code Regs. tit. 27, § 20365(c) and (d) and § 21090(c)(4)	Design of the final cover will prevent erosion, slope failure, washout, and overtopping. Design of final cover requires compaction of soil to an average of 90 percent of the maximum dry density depending on the layer and cover type. The final graded will promote BMPs for surface water runoff and reduce potential soil erosion and offsite migration. Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the vegetative establishment plan within the OMP.
The final cover of closed landfills will be designed, graded, and maintained to prevent ponding and to prevent site erosion caused by high runoff velocities. Slopes should be at least 3 percent.	Cal. Code Regs. tit. 27, § 21090(b)(1)	Design of final cover requires compaction of soil to an average of 90 percent of the maximum dry density depending on the layer and cover type. The final graded will promote BMPs for surface water runoff and reduce potential soil erosion and offsite migration. Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the vegetative establishment plan within the OMP.
Closed landfills shall be provided with not less than 2 feet of appropriate materials as a foundation layer for the final cover. These materials may be soil, contaminated soil, incinerator ash, or other waste materials, provided that such materials have appropriate engineering properties to be used for a foundation layer. The foundation layer shall be compacted to the maximum density obtainable at optimum moisture content using methods that are in accordance with accepted civil engineering practice. A lesser thickness may be allowed for units if the differential settlement of waste and ultimate land use will not affect the structural integrity of the final cover.	Cal. Code Regs. tit. 27, § 21090(a)(1)	Design includes a 2-foot compacted foundation and subgrade layers as a foundation for the protective liner. The subgrade comprises existing soil or consolidated waste screened in place for radioactivity. Design of final cover requires compaction of soil to an average of 90 percent of the maximum dry density depending on the layer and cover type. The foundation layers will be graded to promote surface water runoff and reduce potential soil erosion and offsite migration.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Containment *(continued)*		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
The low hydraulic conductivity layer will be directly overlain by an erosion-resistant layer. Closed landfills will be provided with an uppermost cover layer consisting of either a vegetative layer consisting of not less than 1 foot of soil capable of sustaining native or other suitable plant growth or a mechanically erosion-resistant layer.	Cal. Code Regs. tit. 27, § 21090(a)(3)	Design includes a minimum of 2-foot vegetative soil layer for landfill covers. Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the vegetative establishment plan within the OMP
Requires that the operator dismantle and remove site structures at the time of closure to protect public health and safety in accordance with the closure plan.	Cal. Code Regs. tit. 27, § 21137	The site will be prepared and finalized in accordance with the RD. Any closed site structures will be either demolished or preserved for the long-term maintenance of Parcel E-2.
Contains general standards for the design of the final cover.	Cal. Code Regs. tit. 27, § 21140(a) and (b)	The designed cover will function with minimal maintenance and control vectors, prevent exposure to landfill contents, and include a post-closure OMP to ensure the stability and integrity of the cover.
Contains general standards for landfill grading.	Cal. Code Regs. tit. 27, § 21142(a)	Design of final grade is in accordance with the substantive requirements of the Cal. Code Regs. Design of the final cover includes the extension of an existing multilayer geosynthetic cap to cover the extent of the landfill. Existing and new multilayer caps include 2 feet of vegetative soil layers over the extent of the landfill. The cap will be designed to function with minimal maintenance and control vectors, prevent exposure to landfill contents, and include a post-closure OMP to ensure the stability and integrity of the cover.
Contains general standards for slope stability.	Cal. Code Regs. tit. 27, § 21145(a)	The cap will be designed to function with minimal maintenance and control vectors, prevent exposure to landfill contents, and include a post-closure OMP to ensure the stability and integrity of the cover. Slope stability of design under static and seismic conditions was verified using numeric model. Final cover slope to be mostly 4 percent with the steepest areas no more than 3:1 (H:V).

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Containment *(continued)*		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
The drainage and erosion control system will be designed and maintained to (1) ensure integrity of post-closure land uses, roads, and structures; (2) prevent public contact with waste and leachate; (3) ensure the integrity of gas monitoring and control systems; (4) prevent safety hazards; and (5) prevent exposure of waste.	Cal. Code Regs. tit. 27, § 21150(a)	Design of final cover requires compaction of soil to an average of 90 percent of the maximum dry density depending on the layer and cover type. The final graded cover will promote BMPs for surface water runoff and reduce potential soil erosion and offsite migration. Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the vegetative establishment plan within the OMP.
State Action-Specific ARARs for Shoreline Construction		
McAteer-Petris Act (California Government Code § 66600 through § 66661)[c]		
Tidal marshes and tidal flats should be conserved to the fullest possible extent. Projects harming tidal marshes and tidal flats should be allowed only for purposes providing substantial public benefits and only if there is no feasible alternative. Restoration projects should include a monitoring program with biological and physical goals and success criteria.	Part III of Bay Plan (Findings and Policies Concerning Tidal Marshes and Tidal Flats around the Bay, Policies 1 and 5)	Design includes the restoration of tidal wetlands and freshwater wetlands in the Panhandle Area. The proposed cleanup and wetlands restoration will create conditions that have a higher ecological value relative to existing conditions. No mitigation is required for other (non-wetland) aquatic resources at Parcel E-2 that will be lost as part of the cleanup process. The RAMP includes a monitoring program with biological and physical goals and success criteria for the restoration project.
To prevent damage by flooding, shoreline structures should be designed to consider future sea level rise and subsidence for the expected life of the project.	Part IV of Bay Plan (Findings and Policies Concerning Safety of Fills in the Bay, Policies 4 and 5)	Design of revetment riprap size and height includes consideration of sea level rise and subsidence for the expected life of the project. Design includes requirement for implementation of a SWPPP, including stormwater BMPs, during construction to control suspended sediment migration off site and into waters of the United States.
Riprap revetments will be constructed of properly sized and placed material. Protective projects should be maintained to ensure that the shoreline will be protected from tidal erosion. Protective projects should include nonstructural methods such as marsh vegetation where feasible.	Part IV of Bay Plan (Findings and Policies Concerning Shoreline Protection around the Bay, Policies 2, 3, and 4)	Design of revetment riprap armor size and crest height includes consideration of sea level rise, wind and wave dynamics and subsidence for the expected life of the project.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Shoreline Construction *(continued)*		
McAteer-Petris Act (California Government Code § 66600 through § 66661)[c]		
Fills in accord with the Bay Plan will be the minimum necessary to achieve its purpose and meet one of the following criteria outlined in Bay Plan policies: (a) filling supports bay-related purposes (e.g., ports, water-related recreation, etc.); (b) filling is needed for infrastructure for which there is no other alternative (e.g., airports, roads, etc.); or (c) filling is minor and needed to improve shoreline appearance or public access.	Part IV of Bay Plan (Findings and Policies Concerning Fills in Accord with the Bay Plan, Policy 1)	Design involves varying degrees of excavation of contaminated sediment to protect human health and the environment that require minor filling of onsite tidal marshes, the loss of which would be mitigated by the Navy.
Minor fill to improve shoreline appearance is permissible if (1) the fill is necessary because the present appearance adversely affects the enjoyment of the bay and its shoreline; (2) it is either physically impractical or economically infeasible to improve the appearance without filling; (3) the amount of filling is the minimum necessary to improve shoreline appearance; (4) the proposed project would improve the shoreline appearance; and (5) the fill would not adversely affect enjoyment of the bay and its shoreline, and the fill will not have any adverse effect on present or future use designated in the Bay Plan.	Cal. Code Regs, tit. 14, § 10700	Design involves varying degrees of excavation of contaminated sediment to protect human health and the environment that require minor filling of onsite tidal marshes, the loss of which would be mitigated by the Navy.
Activities affecting the San Francisco Bay. Measures to compensate for unavoidable adverse impacts to natural resources of the bay should be required. Mitigation projects should be sited as close to the impact site as practicable. The amount and type of mitigation should be based on an analysis of the probability of success of the mitigation project, the expected delay between the impact and the functioning mitigation site, and the type and quality of ecological functions of the mitigation site compared with the impacted site.	Part IV of Bay Plan (Findings and Policies Concerning Mitigation, Policies 1, 2, and 4 through 7)	Design includes the restoration of tidal wetlands and freshwater wetlands in the Panhandle Area. The proposed cleanup and wetlands restoration will create conditions that have a higher ecological value relative to existing conditions. No mitigation is required for other (non-wetland) aquatic resources at Parcel E-2 that will be lost as part of the cleanup process.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Landfill Gas Monitoring and Control		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
Contains general standards for a LFG monitoring network. Requires that the LFG monitoring system be designed to account for specific site characteristics.	Cal. Code Regs. tit. 27, § 20923	Design includes an active LFG abatement system to control LFG migration and to allow for long-term monitoring of gases generated by landfill waste. System and perimeter LFG monitoring network is incorporated into the design to allow for compliance with system and boundary sampling.
Perimeter subsurface monitoring wells shall be installed around the waste disposal footprint but not within refuse.	Cal. Code Regs. tit. 27, § 20925(a)(1)	To avoid installing the existing monitoring probes within decomposable waste, alternative LFG compliance locations were designated north of the Parcel E-2 boundary and in the UCSF compound. The alternative compliance locations (and portions of the existing LFG control system) are on property that the Navy transferred to UCSF. The Navy and UCSF have negotiated an easement (July 21, 2006) that contains the LFG control and monitoring system and allows the Navy to maintain and monitor its facilities on UCSF property.
Perimeter monitoring wells shall be located at or near the disposal site permitted facility boundary.	Cal. Code Regs. tit. 27, § 20925(a)(2)	The existing GMP locations are either at or near the Parcel E-2 boundary or within a negotiated monitoring easement, and the proposed GMPs will be at the Parcel E-2 boundary. No GMPs are located along the boundary segments formed by San Francisco Bay and its contiguous tidal drainages.
The lateral spacing between adjacent monitoring wells shall not exceed 1,000 feet.	Cal. Code Regs. tit. 27, § 20925(b)(1)	The spacing between the existing GMPs are approximately 150 feet or less. The approximate lateral distance from the southwestern and southeastern shoreline probes across the San Francisco Bay shoreline boundary is approximately 1,590 feet.
The spacing of monitoring wells shall be determined based upon, but not limited to the nature of the structure to be protected and its proximity to the refuse.	Cal. Code Regs. tit. 27, § 20925(b)(2)	Wells shall be spaced to align with gas permeable structural or stratigraphic features, such as dry sand or gravel, offsite or onsite structures, and areas of dead or stressed vegetation that might be caused by LFG migration: The proposed GMPs were sited to align with gas permeable soil as observed and documented in previous exploratory borings and geologic cross sections. The probe locations were also adjusted to facilitate collocation with other existing environmental monitoring facilities. No areas of differentiated vegetative stress were evident in aerial photographs reviewed for this site.
Monitoring well spacing shall be reduced as necessary to protect persons and structures threatened by LFG migration.	Cal. Code Regs. tit. 27, § 20925(b)(3)	The original GMP spacing was reduced by constructing additional probes to better protect nearby offsite structures and persons. Based on a Navy proposal approved by the DTSC on October 20, 2008, monitoring has been discontinued at the following locations: GMP02A, GMP03, GMP04A, GMP05B, GMP06B, GMP09, GMP12, GMP25, and GMP26. Consistent absence of detection of LFG at these GMPs supports the conclusion that the remaining GMPs are sufficiently protective for early detection and control of LFG migration. All GMPs will be maintained intact until equilibrium conditions are established and all required remedial activities are complete.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Landfill Gas Monitoring and Control *(continued)*		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
The depth of the wellbore of all monitoring wells shall equal the maximum depth of waste.	Cal. Code Regs. tit. 27, § 20925(c)(1)	The construction dimensions of the GMPs are summarized in the DBR. The lowest elevation of the base of waste placement throughout the landfill (approximately -13 feet msl) is generally below the lowest seasonal groundwater surface elevation (which varies with location between 1 and 5 feet msl).
A shallow probe shall be installed 5 to 10 feet below the surface.	Cal. Code Regs. tit. 27, § 20925(c)(1)(A)	Existing GMP20 and GMP21 have single shallow probe casings with shallow sampling zones between 3.5 and 4.5 feet below ground surface. Existing GMP8A, GMP10, and GMP11A have single shallow probe casings with shallow sampling zones between 4 and 6.5 feet below ground surface.
An intermediate probe shall be installed at or near half the depth of the waste.	Cal. Code Regs. tit. 27, § 20925(c)(1)(B)	Per Cal. Code Regs. tit. 27 § 20925(c)(1)(F), intermediate probes are not required when the maximum depth of waste does not exceed 30 feet. The maximum depth to the estimated base of waste does not exceed 30 feet in the Parcel E-2 Landfill.
A deep probe shall be set at or near the depth of the waste.	Cal. Code Regs. tit. 27, § 20925(c)(1)(C)	Because of the shallow groundwater at this site, there was insufficient depth to install more than one probe casing in the GMPs.
The specified depths of monitoring probes within the wellbore shall be adjusted based on geologic data obtained during drilling, and probes shall be placed.	Cal. Code Regs. tit. 27, § 20925(c)(1)(D)	The specified sample zone depths of the existing GMPs were adjusted to accommodate encountered transmissive soil materials and the shallow depth to groundwater.
All probes shall be installed above the permanent low seasonal water table, above and below perched groundwater, and above bedrock.	Cal. Code Regs. tit. 27, § 20925(c)(1)(E)	The existing GMPs all have monitoring zones installed above 4 feet msl, which is the low seasonal groundwater level documented in August 2007.
When the depth of the waste does not exceed 30 feet, the operator may reduce the number of probes to two, with one probe located in the shallow zone as indicated above and the other located adjacent to permeable soil at or near the depth of the waste.	Cal. Code Regs. tit. 27, § 20925(c)(1)(F)	The depth at the well locations to the estimated base of waste placement is generally less than 20 feet, thus the existing GMPs were provided with only single shallow casings.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Landfill Gas Monitoring and Control *(continued)*		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
To isolate monitored zones within the wellbore and prevent contamination of perched ground water and permanent groundwater, the operator shall provide a minimum seal of 5 feet of bentonite at the surface and between the monitored zones.	Cal. Code Regs. tit. 27, § 20925(d)(3)	Four of the 35 existing GMPs are 4.5 to 5.5 feet in total depth and contain only 1 foot of bentonite seal. All probes, including the four shallow probes include 2-foot Portland cement grout seals. The short bentonite seal at these locations should not pose any significant increase in the potential for undetected LFG migration or groundwater contamination. The 13 proposed GMPs are also relatively shallow (<9 feet well bore depth). The proposed surface seals consist of 2 to 3 feet of bentonite overlain by a 2-foot Portland cement grout seal. The LFG monitoring plan for Parcel E-2 Landfill is generally in compliance with the intent of the revised Cal. Code Regs. tit. 27 requirements. Nonconformities in the existing monitoring network include San Francisco Bay and its wetland extensions form natural hydraulic barriers that front approximately 50 percent of the landfill area and mitigate the requirement for GMPs along these boundary segments. Most of the GMPs are provided with a standard 5-foot deep surface seal, including 2 feet of Portland cement grout and 3 feet of bentonite. The shallowest GMPs (5.5 to 7.5 feet deep) are provided with a minimum of 2 feet of Portland cement grout and 1 to 2 feet of bentonite.
Provides requirements for monitoring structures.	Cal. Code Regs. tit. 27, § 20931	The design requires a RAMP and an OMP that will establish the frequency of LFG monitoring during the operational life of the active system. The design of the monitoring network will encompass onsite structures, including buildings, basements, manholes, pipelines, and utility vaults. Methods for onsite structural monitoring may include periodic monitoring using either permanently installed probes or gas surveys, or continuous monitoring systems.
Requires that all GMPs and onsite structures be sampled for methane during the monitoring period.	Cal. Code Regs. tit. 27, § 20932	The design requires a RAMP and an OMP that will establish the frequency of LFG monitoring during the operational life of the active system.
Establishes the frequency for LFG monitoring.	Cal. Code Regs. tit. 27, § 20933	The design requires a RAMP and an OMP that will establish the frequency of LFG monitoring during the operational life of the active system.
Describes actions to be taken if the results of LFG monitoring indicate that concentrations of methane exceed levels set forth in § 20921(a).	Cal. Code Regs. tit. 27, § 20937	The design requires a RAMP and an OMP that will establish the frequency of LFG monitoring during the operational life of the active system.

Table 1. ARARs for Design Components *(continued)*

Design Requirement	Citation [a,b]	Element Addressing Basis of Design Criteria
State Action-Specific ARARs for Leachate Collection and Control		
State Water Resources Control Board / California Department of Resources Recycling and Recovery[c]		
During the post-closure maintenance period, the owner and operator will ensure that leachate collection and control are performed in a manner that prevents public contact and controls vectors, nuisance, and odors. (This section does not require installation of a new leachate collection system.)	Cal. Code Regs. tit. 27, § 21160(a) and (c)	Design will accommodate the relevant and appropriate control of leachate based on the results of future groundwater monitoring. Design of South perimeter landfill cap termination includes a series of wells that will be used for monitoring groundwater and may be used for future groundwater/leachate extraction.

Notes:

a = Many action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables.

b = Only the substantive provisions of the requirements cited in this table are ARARs.

c = Statutes and policies and their citations are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Navy accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only pertinent substantive requirements of the specific citations are considered ARARs.

ARARs = applicable or relevant and appropriate requirements
BAAQMD = Bay Area Air Quality Management District
BMPs = best management practices
Cal. Code Regs. = California Code of Regulations
CFR = Code of Federal Regulations
ch. = Chapter
DBR = Design Basis Report
DTSC = Department of Toxic Substances Control
ERRG = Engineering/Remediation Resources Group, Inc.
GMPs = gas monitoring probes
HDPE = high-density polyethylene
LFG = landfill gas
msl = mean sea level
Navy = Department of the Navy
OMP = Operations and Maintenance Plan
RAMP = Remedial Action Monitoring Plan
RAWP = Remedial Action Work Plan
RI/FS = Remedial Investigation/Feasibility Study
SF-BWQMP = San Francisco Bay Water Quality Monitoring Plan
Shaw = Shaw Environmental, Inc.
SWPPP = Stormwater Pollution Prevention Plan
tit. = Title
UCSF = University of California, San Francisco
USC = United States Code
§ = Section

Table 2. Remediation Goals for Nonradioactive Chemicals in Soil and Sediment

Exposure Scenario	COC/COEC	Remediation Goal (mg/kg)	Exposure Scenario	COC/COEC	Remediation Goal (mg/kg)
Recreational	Antimony	270	Construction Worker *(continued)*	Dioxin (TEQ)	0.000023
	Aroclor-1242	0.74		Heptachlor epoxide	1
	Aroclor-1248	0.74		Indeno(1,2,3-cd)pyrene	6.5
	Aroclor-1254	0.74		Iron	93,000
	Aroclor-1260	0.74		Lead	800
	Arsenic	11.1		Manganese	6,900
	Benzo(a)anthracene	1.3		Naphthalene	75
	Benzo(a)pyrene	0.33		Total PCBs (non-dioxin)	2.1
	Benzo(b)fluoranthene	1.3		Total TPH	3,500
	Benzo(k)fluoranthene	1.3		Vanadium	310
	Dieldrin	0.12	Terrestrial Wildlife	Cadmium	4.2
	Heptachlor epoxide	0.21		Copper	470
	Indeno(1,2,3-cd)pyrene	1.3		Lead	197
	Lead	155		Manganese	2,433
	Total PCBs (Non-Dioxin)	0.74		Mercury	1.0
Construction Worker	4,4'-DDT	45		Nickel	1,941
	Antimony	120		Vanadium	117
	Aroclor-1016	7.4		Zinc	719
	Aroclor-1242	2.1		Total DDT	3.53
	Aroclor-1248	2.1		Total PCBs	37
	Aroclor-1254	2.1		Total HMW PAHs	231
	Aroclor-1260	2.1	Aquatic Wildlife	Antimony	25
	Arsenic	11.1		Copper	270
	Benzo(a)anthracene	6.5		Lead	218
	Benzo(a)pyrene	0.65		Mercury	0.71
	Benzo(b)fluoranthene	6.5		Nickel	112
	Benzo(k)fluoranthene	6.5		Zinc	410
	Cadmium	150		Total DDTs	0.046
	Copper	11,000		Dieldrin	0.008
	Dibenz(a,h)anthracene	1.1		Endrin	0.045
	Dieldrin	0.57		Total PCBs	0.18

Notes: The basis (risk-based or ambient level) for the remediation goals is presented in Sections 7 and 9 of the RI/FS Report (ERRG and Shaw, 2011).

COC = chemical of concern
COEC = chemical of ecological concern
DDT = dichlorodiphenyltrichloroethane
ERRG = Engineering/Remediation Resources Group, Inc.
HMW = high-molecular weight
mg/kg = milligrams per kilogram
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
RI/FS = Remedial Investigation/Feasibility Study
Shaw = Shaw Environmental, Inc.
TEQ = toxic equivalent

Table 3. Remediation Goals for Radionuclides in Soil and Sediment

Radionuclide of Concern	Exposure Scenario	
	Outdoor Worker (pCi/g)	Resident[a] (pCi/g)
Cesium-137	0.113	0.113
Cobalt-60	0.252[b]	0.252[b]
Radium-226	1.0[c]	1.0[c]
Strontium-90	10.8	0.331

Notes: The basis (risk-based) for the remediation goals is presented in Sections 7 and 9 of the radiological addendum for Parcel E-2 (ERRG and RSRS, 2011).

a = Residential use is not planned for Parcel E-2, but residential goals are proposed as an additional level of protection.

b = Remediation goal for cobalt-60 was revised to support efficient laboratory gamma spectroscopy analysis of soil samples. This revised remediation goal maintains morbidity risks within the EPA-defined acceptable range and permits an exposure level that does not increase the risk of cancer from a potential exposure to cobalt-60.

c = Remediation goal is 1 pCi/g above background per agreement with EPA (established in "Final Basewide Radiological Removal Action, Action Memorandum – Revision 2006, Hunters Point Shipyard, San Francisco, California," dated April 21, 2006), and is consistent with the radiological-related remedies selected in the RODs for Parcels B, G, and D-1 and UC-1. The radium-226 background level for surface soil is 0.633 pCi/g. The radium-226 background level for storm drain and sewer lines is 0.485 pCi/g. The background levels for radium-226 may be reevaluated in the Parcel E-2 RD and are subject to regulatory agency approval.

EPA = U.S. Environmental Protection Agency

ERRG = Engineering/Remediation Resources Group, Inc.

pCi/g = picocuries per gram

RD = remedial design

RODs = Records of Decision

RSRS = Radiological Survey and Remedial Services, LLC

Table 4. Remediation Goals for Groundwater

Exposure Scenario	COC/COEC	Remediation Goal (µg/L)	Exposure Scenario	COC/COEC	Remediation Goal (µg/L)
Construction Worker Exposure to A-Aquifier Groundwater	Benzo(a)anthracene	0.67	Domestic Use of B-Aquifier Groundwater	Bis(2-ethylhexyl)phthalate	10
	Benzo(a)pyrene	0.05		beta-BHC	0.05
	Benzo(b)fluoranthene	0.45		Carbon tetrachloride	0.5
	Benzo(k)fluoranthene	0.45		Chloroform	80
	Dibenz(a,h)anthracene	0.05		Chromium VI	109
	Indeno(1,2,3-cd)pyrene	0.31		Chrysene	0.56
	Lead	15		Dibenz(a,h)anthracene	2
Domestic Use of B-Aquifier Groundwater	1,1-Dichloroethane	5		Dieldrin	0.02
	1,2,3-Trichloropropane	1		Heptachlor	0.01
	1,2-Dichloroethane	0.5		Heptachlor epoxide	0.01
	1,4-Dichlorobenzene	5		Heptachlor epoxide A	0.01
	4-Nitrophenol	3.4		Heptachlor epoxide B	0.01
	Aroclor-1016	0.5		Indeno(1,2,3-cd)pyrene	0.2
	Aroclor-1242	0.5		Iron	10,950
	Aroclor-1254	0.5		Lead	15
	Aroclor-1260	0.5		Methylene chloride	5
	Arsenic	10		Naphthalene	1
	Benzene	1		Tetrachloroethene	5
	Benzo(a)anthracene	0.2		Thallium	2
	Benzo(a)pyrene	0.2		Trichloroethene	5
	Benzo(b)fluoranthene	0.2		Vinyl chloride	0.5
	Benzo(k)fluoranthene	0.2	Wildlife in the bay	Total TPH (goals vary based on distance from the bay)[a]	1,400 to 20,000

Notes: The basis (risk-based, regulatory limit, or ambient level) for the remediation goals is presented in Sections 7 and 9 of the RI/FS Report (ERRG and Shaw, 2011).

[a] =The distance-based TPH criteria are as follows:

Distance from shoreline (feet)	Total TPH (µg/L)	Distance from shoreline (feet)	Total TPH (µg/L)
0–<25	1,400	125–<150	6,949
25–<50	1,467	150–<175	9,539
50–<75	2,092	175–<200	12,604
75–<100	3,216	200–<225	16,145
100–<125	4,839	≥225	20,000

BHC = benzene hexachloride
COC = chemical of concern
COEC = chemical of ecological concern
ERRG = Engineering/Remediation Resources Group, Inc.
RI/FS = Remedial Investigation/Feasibility Study
Shaw = Shaw Environmental, Inc.
TPH = total petroleum hydrocarbons
µg/L = micrograms per liter

Table 5. Groundwater Monitoring Wells

Well Identification	Destroy/ Replace	Northing[1] (NAD 27)	Easting[1] (NAD 27)	TOC Elevation[2] (feet above msl)	Total Depth[2] (feet bgs)	Casing Diameter (inch)
IR01MW02B	Preserve	452007.01	1457473.14	20.61	38.4	4
IR01MW03A	Destroy	451996.46	1457455.15	19.89	27.4	4
IR01MW05A	Preserve	451762.98	1458002.94	22.56	28.6	4
IR01MW09B	Preserve	451290.82	1458505.39	10.05	41.7	4
IR01MW10A	Preserve	451907.02	1457292.06	13.75	21.8	4
IR01MW11A	Destroy	451641.33	1458216.10	17.96	19.1	4
IR01MW12A	Preserve	451630.00	1458205.87	18.25	24.0	4
IR01MW16A	Preserve	451755.59	1457454.14	24.55	27.8	4
IR01MW18A	Preserve	451487.25	1457687.80	23.58	30.9	4
IR01MW26B	Preserve	451271.75	1457811.83	23.95	54.4	4
IR01MW31A	Preserve	451709.011	1457116.55	13.81	26.2	4
IR01MW366A	Preserve	451037.32	1458222.66	17.31	16.5	4
IR01MW366B	Preserve	451007.20	1458260.65	16.70	56.4	4
IR01MW38A	Preserve	451265.67	1457596.95	17.36	22.5	4
IR01MW402A	Preserve	451251	1456651	12.51	19.7	4
IR01MW403A	Preserve	451847.70	1457178.34	13.00	20.6	4
IR01MW403B	Preserve	451841.71	1457154.81	10.54	36.2	4
IR01MW42A	Destroy	450889.75	1458140.92	13.28	26.7	4
IR01MW48A	Preserve	451235.85	1457143.10	10.96	19.8	4
IR01MW53B	Preserve	451238.77	1457131.51	10.01	45.3	4
IR01MW60A	Preserve	450982.10	1457652.69	14.60	20.1	4
IR01MW62A	Preserve	450608.60	1456381.74	7.91	14.5	4
IR01MW63A	Preserve	450630.55	1456254.12	7.88	19.5	4
IR01MW64A	Preserve	450754.84	1457820.09	14.27	18.7	4
IR01MW65A	Preserve	450523.25	1456435.14	8.69	21.9	4
IR01MW66A	Preserve	450425.93	1457852.57	10.66	14.7	4
IR01MWI-2	Destroy	451135.36	1458317.88	13.22	21.4	2
IR01MWI-5	Preserve	451213.23	1457828.20	24.18	23.6	2
IR01MWI-7	Destroy	451007.29	1456811.57	5.81	13.0	2
IR01MWI-9	Preserve	451131.18	1456783.29	8.04	13.6	2
IR01MWLF1A	Preserve	451550.12	1457298.01	20.83	22.3	4
IR01MWLF2A	Preserve	452019.12	1457360.85	19.62	23.5	4
IR01MWLF4B	Preserve	450788.85	1458040.22	14.48	56.2	4
IR01P04A	Destroy	451986.83	1457476.89	21.61	30.3	2
IR04MW13A	Replace[3]	450972.31	1458394.71	12.55	22.1	4

Table 5. Groundwater Monitoring Wells *(continued)*

Well Identification	Destroy/ Replace	Northing[1] (NAD 27)	Easting[1] (NAD 27)	TOC Elevation[2] (feet above msl)	Total Depth[2] (feet bgs)	Casing Diameter (inch)
IR04MW31A	Preserve	450800.36	1458293.35	12.53	28.5	4
IR04MW36A	Destroy[4]	451298.96	1458528.10	9.84	26.4	4
IR12MW11A	Preserve	450553.71	1458252.10	14.10	19.6	4
IR75MW05B	Destroy	452234	1457022	15.57	20.75	4
IR76MW13A	Preserve	452147	1457665	19.69	23.2	4
NMW01B	New	450601.97	1458286.55	Unknown	Unknown	Unknown
NMW02A	Replace TW031[5]	451148.15	1457560.67	Unknown	Unknown	Unknown
NMW03A	Replace TW013	451272.86	1457332.90	Unknown	Unknown	Unknown
NMW04A	Replace TW021[5]	451118.81	1456911.66	Unknown	Unknown	Unknown
NMW05B	New	450295.40	1457998.49	Unknown	Unknown	Unknown
NMW06A	Replace TW028B[5]	450715.83	1456569.46	Unknown	Unknown	Unknown
NMW07A	New	451292.21	1458496.83	Unknown	Unknown	Unknown
NPZ01A	New	450434.05	1457759.34	Unknown	Unknown	Unknown
NPZ02A	New	450697.51	1457554.03	Unknown	Unknown	Unknown
NPZ03A	New	450954.68	1457554.03	Unknown	Unknown	Unknown
NPZ04A	New	451102.52	1457517.59	Unknown	Unknown	Unknown

Notes:

1. = Northing and Easting data from topographic land surveys performed by Espinoza Survey, Inc. (NAD 1927 Zone III [Hunters Point West 1 PID HT0613] USFT, NGVD 29 less correction 7.76 feet MSL) on 10/29/2012-10/30/2012, 11/12/2012, 11/20/2012, 12/03/2012, 12/10/2012, and 12/12/2012.
2. = TOC elevations and total depths taken from the Groundwater Monitoring Report (October 2011 — June 2012), Hunters Point Naval Shipyard (Kleinfelder, 2012).
3. = Well IR04MW13A was destroyed to facilitate excavation during the Phase 2 TCRA at the PCB Hot Spot Area; this well will be replaced for remedial action monitoring. The replacement well will be reconstructed to its original specifications; the RA contractor will coordinate with the basewide groundwater monitoring program contractor to establish well placement and construction details.
4. = Well IR04MW36A is not required for remedial action monitoring because it is located in Parcel E (beyond the point of compliance). This well is located in an area that was formerly part of Parcel E-2 but was moved to Parcel E (during a boundary change made in August 2012).
5. = Several new monitoring wells are being installed in the location of previous temporary well samples; completion depths will be estimated based upon these previous temporary wells.

bgs = below ground surface

msl = mean sea level

NAD = North American Datum

PCB = Polychlorinated Biphenyl

TCRA = time-critical removal action

TOC = top of casing

Table 6. Hot Spot Goals for Soil and Sediment

Hot Spot Tier	Impacted Media	COC/COEC	Hot Spot Goal (mg/kg)	Basis for Hot Spot Goal
Tier 1	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Heptachlor epoxide	1.9	10 times RG for recreational users[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
	Sediment	Copper	2,700	10 times RG for aquatic wildlife[a]
		Lead	2,180	10 times RG for aquatic wildlife[a]
		Total PCBs	1.8	10 times RG for aquatic wildlife[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 2	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
	Sediment	Copper	2,700	10 times RG for aquatic wildlife[a]
		Lead	2,180	10 times RG for aquatic wildlife[a]
		Total PCBs	1.8	10 times RG for aquatic wildlife[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 3	Soil	Lead	19,700	100 times RG for terrestrial wildlife[a]
		Total PCBs	74	100 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
Tier 4	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Total PCBs	7.4	10 times RG for recreational users[a]
		Total TPH	3,500	TPH source criterion[b]
		Zinc	7,190	10 times RG for terrestrial wildlife[a]
Tier 5	Soil	Copper	4,700	10 times RG for terrestrial wildlife[a]
		1,1-Dichloroethane	2.8	Residential RBC (for Parcel E)[c]
		Lead	1,970	10 times RG for terrestrial wildlife[a]
		Tetrachloroethene	0.48	Residential RBC (for Parcel E)[c]

Table 6. Hot Spot Goals for Soil and Sediment *(continued)*

Hot Spot Tier	Impacted Media	COC/COEC	Hot Spot Goal (mg/kg)	Basis for Hot Spot Goal
Tier 5 *(cont.)*	Soil	Total TPH	3,500	TPH source criterion[b]
		Trichloroethene	2.9	Residential RBC (for Parcel E)[c]
		Vinyl chloride	0.024	Residential RBC (for Parcel E)[c]

Notes: COCs and COECs for hot spots identified on Figure 10.

a = RGs for recreational users, terrestrial wildlife, and aquatic wildlife are presented in Section 9.1.1 of the RI/FS Report (ERRG and Shaw, 2011).

b = TPH source criterion (Shaw, 2007). The TPH source criterion represents the most conservative evaluation criterion for potential sources of groundwater contamination that may impact aquatic wildlife in San Francisco Bay, and is selected as the hot spot goal in areas where total TPH is known to be present in groundwater at concentrations exceeding the corresponding RG (see Section 9.3.1 of the RI/FS Report [ERRG and Shaw, 2011]).

c = Residential RBCs for the select VOCs are presented as part of the human health risk assessment for Parcel E (Barajas & Associates, Inc., 2008); these VOCs are present in Parcel E-2 and impact groundwater at Parcel E at concentrations that pose a risk to humans. These RBCs represent the most conservative evaluation criteria and are selected as hot spot goals for the purpose of maximizing the effectiveness of the VOC source removal effort and on the presumption that, based on available site data, the VOC source area is limited in volume (see Figure 12-8, of the RI/FS Report [ERRG and Shaw, 2011]).

COC = chemical of concern

COEC = chemical of ecological concern

ERRG = Engineering/Remediation Resources Group, Inc.

mg/kg = milligram per kilogram

PCBs = polychlorinated biphenyls

RBC = risk-based concentration

RG = remediation goal

RI/FS = Remedial Investigation/Feasibility Study

Shaw = Shaw Environmental, Inc.

TPH = total petroleum hydrocarbons

VOCs = volatile organic compounds

Table 7. Proposed Hot Spot Excavations

Excavation ID No.[1]	Chemical(s) Driver	Area (square feet)[2]	Depth (feet bgs)[2]	Total (with 1:1 benching) (bank cubic yards)
T1-EX-1A-1	PCBs	4,012	13	2,557
T1-EX-1A-2	PCBs	400	5	74[3]
T2-EX-2A-1	PCBs	1,455	5	269[3]
T2-EX-2A-2	PCBs	3,284	6	842
T2-EX-3A	Lead	18,619	3	2,069[3]
T2-EX-3B	Lead	1,600	16	2,010
T2-EX-3C	Lead	1,600	8	702
T2-EX-3D	Lead	948	6	328
T2-EX-4	Copper	1,600	3	178[3]
T2-EX-5	PCBs	1,600	10	854
T3-EX-1-1	Lead and TPH	1,800	5	333[3]
T3-EX-2-1	TPH	175	5	32[3]
T3-EX-2-2A	TPH	800	5	148
T3-EX-2-2B	TPH	1,400	8	564
T4-EX-1	TPH	1,600	10	963
T4-EX-2	TPH	1,600	10	963
T4-EX-3	PCBs, copper, lead, and zinc	7,653	10	3,765
T4-EX-4	PCBs	1,600	10	666
T5-EX-1	Copper lead, and TPH	3,907	8	1,485
T5-EX-2-1	PCE	6,259	13	4,194
			Total Volume:	**22,996**

Notes:

1 = Delineation of hot spot extents based on decision criteria described in Section 3.2.2 of this Design Basis Report. Decision criteria are based on RI/FS and post-excavation sample data.

2 = Limits of excavation must be confirmed by preexcavation samples. Post-excavation confirmation samples must be collected before backfilling is approved.

3 = No benching required.

bgs = below ground surface

PCBs = polychlorinated biphenyls

PCE = tetrachloroethene

RI/FS = remedial investigation/feasibility study

TPH = total petroleum hydrocarbons

Table 8. Hunters Point Tide Data

Elevations of Tidal Datum (feet)	MLLW[1]	NGVD 29
Highest Observed Water Level (12/27/74)	8.16	5.04
Mean Higher High Water	6.73	3.61
Mean High Water (Mean High Tide Line)	6.10	2.98
Mean Tide Level	3.61	0.49
NGVD 29	3.12	0.00
Mean Low Water	1.12	-2.00
Mean Lower Low Water	0.00	-3.12
Lowest Observed Water Level (12/01/75)	-1.86	-4.98

Notes:

1 = Tidal datum (MLLW) at Hunters Point, San Francisco Bay, California, was obtained from Station ID 9414358, published by NOAA (2009).

MLLW = mean lower low water

NGVD 29 = National Geodetic Vertical Datum 1929

Table 9. Existing Gas Monitoring Probes

Area	Monitoring Location ID No.[1]	Screened Interval (feet bgs)
Fence Line GMPs	GMP01A	6.0 to 13.5
	GMP07A	6.0 to 13.5
	GMP08A	4.5 to 9.5
	GMP10	4.0 to 6.5
	GMP11A	4.0 to 5.5
	GMP20	3.5 to 4.5
	GMP21	3.5 to 4.5
UCSF Compound GMPs	GMP22	6.0 to 13.5
	GMP23	6.0 to 13.5
	GMP24	6.0 to 13.0
Crisp Road GMPs	GMP13	6.0 to 12.0
	GMP14	6.0 to 10.0
	GMP15	6.0 to 12.0
	GMP16	5.0 to 10.0
	GMP17	6.0 to 10.0
	GMP18	6.0 to 12.0
	GMP19	4.5 to 5.5
	GMP27	4.7 to 22.2
	GMP28	6.2 to 21.2
	GMP29	6.2 to 18.7
	GMP30	4.5 to 17.0
	GMP31	6.0 to 16.0
	GMP32	4.75 to 14.75
	GMP33	5.0 to 17.0
	GMP34	6.0 to 21.0
	GMP35	5.0 to 23.0

Notes:

1. = Based on a Navy proposal approved by the Department of Toxic Substances Control on October 20, 2008, monitoring was discontinued at the following locations: GMP02A, GMP03, GMP04A, GMP05B, GMP06B, GMP09, GMP12, GMP25, and GMP26. Monitoring at GMP08A, GMP23, and GMP24 will continue monthly, while all other locations will be monitored quarterly.

bgs = feet below ground surface

GMPs = gas monitoring probes

UCSF = University of California, San Francisco

Table 10. LFG Flare Capacity Ranges Based on RI/FS LFG Generation Estimate

	Number of Operating Hours per Day			
	24	**16**	**12**	**8**
Methane Concentration	Initial Flare Heat Loading (MMBtu/hr)			
30%	0.5	0.8	1.1	1.6
35%	0.6	1.0	1.3	1.9
40%	0.7	1.1	1.5	2.2
45%	0.8	1.2	1.6	2.5
50%	0.9	1.4	1.8	2.7

Notes: Heat loading assumes base LFG generation / extraction rate of 30 scfm LFG at 50%v methane concentration (ERRG and Shaw, 2011).

CEB 50 standard capacity = 0.17 to 1.7 MMBtu/hr.

CEB 100 standard capacity = 0.34 to 3.4 MMBtu/hr.

Undiluted methane concentration (50%) was varied by adding dilution air concentrations in the ratio of 1:5 oxygen to nitrogen.

CEB = clean emissions burner

ERRG = Engineering/Remediation Resources Group, Inc.

LFG = landfill gas

MMBtu/hr = million British thermal units per hour

RI/FS = Remedial Investigation/Feasibility Study

scfm = standard cubic feet per minute

Shaw = Shaw Environmental, Inc.

Table 11. LFG Blower Capacity Ranges Based on RI/FS LFG Generation Estimate

	Number of Operating Hours per Day			
	24	16	12	8
Methane Concentration	Initial Blower Flow Loading (scfm)			
30%	50	75	100	150
35%	43	64	86	129
40%	38	56	75	113
45%	33	50	67	100
50%	30	45	60	90

Notes:

Flow loading assumes base LFG generation / extraction rate of 30 scfm LFG at 50%v methane concentration (ERRG and Shaw, 2011).

Undiluted methane concentration (50%) was varied by adding dilution air concentrations in the ratio of 1:5 oxygen to nitrogen.

ERRG = Engineering/Remediation Resources Group, Inc.

LFG = landfill gas

RI/FS = Remedial Investigation/Feasibility Study

scfm = standard cubic feet per minute

Shaw = Shaw Environmental, Inc.

Table 12. LFG Generation Modeling Results

Year	High Organics Scenario[1] (scfm)	90% Recovery Scenario[2] (scfm)
2015	34	31
2020	31	28
2025	28	25
2030	25	22
2035	23	20
2040	21	18
2045	19	17

Notes:

1. = AP-42 semi-arid area default model assumptions k = 0.02 year-1, L_0 = 124 m^3/Mg, CH_4 = 50%v.
2. = Applied 90% recovery factor to EPA LandGEM model results for well density and containment cap characteristics.

EPA = U.S. Environmental Protection Agency

LFG = landfill gas

scfm = standard cubic feet per minute

Table 13. LFG Condensate Generation Estimates

Year	Estimated High Condensate Generation Rate (gpd)[1]	Estimated Low Condensate Generation Rate (gpd)[2]
2015	16	11
2020	14	10
2025	13	9
2030	12	7
2035	11	7
2040	10	6
2045	9	6

Notes:

1. = High condensate generation assumes AP-42 LFG high organics generation rate, 2X dilution factor and minimum annual ambient temperatures.

2. = Low condensate generation assumes maximum annual ambient temperatures.

gpd = gallons per day

LFG = landfill gas

Table 14. Summary of Wetlands Areas at HPNS

Wetland Area[1]	Parcel	Existing Wetland Acreage
Tidal Wetlands		
1	E-2	0.198
2	E-2	0.060
3	E-2	0.442
4	E-2	0.185
5	E-2	0.008
6	E-2	0.007
7	E-2	0.004
8	E-2	0.031
9	E-2	0.012
10	E-2	0.013
11	E-2	0.028
12	E-2	1.391
18	E	0.229
19	E	0.502
20	B	0.056
	Total Tidal Wetlands at HPNS:	*3.166*
Freshwater Wetlands (Seasonal)		
13	E-2	1.007
14	E-2	0.018
15	E-2	0.059
16	E-2	0.121
17	E-2	0.068
	Total Freshwater Wetlands at HPNS:	*1.273*
	Total Combined Wetlands at HPNS:	*4.439*

Notes

1. = Wetland area as shown on Figure 15.

HPNS = Hunters Point Naval Shipyard

Table 15. Proposed Wetlands Areas to be Mitigated

Parcel	Wetland Area Losses (to date)	Wetland Area Losses (Future Remedial Action)	Wetland Losses Required to be Mitigated at HPNS	Wetlands Proposed in Parcel E-2 RD
Tidal Wetlands				
B	0.056 acres lost permanently[1]	N/A	0.056 acres	0 acres
E	0.229 acres lost permanently[2]	0.502 acres lost permanently	0.731 acres	0 acres
E-2	0.591 acres lost temporarily[3] 0.698 acres lost permanently[4]	0.720 acres lost temporarily[5] 0.370 acres lost permanently[6]	2.379 acres	3.242 acres
Total:	*1.574 acres*	*1.592 acres*	*3.166 acres*	*3.242 acres*
Seasonal Freshwater Wetlands				
Parcel E-2	0.458 acres lost permanently[7]	0.815 acres lost temporarily[8]	1.273 acres	1.590 acres
Total:	*0.458 acres*	*0.815 acres*	*1.273 acres*	*1.590 acres*
		Total:	**4.439 acres**	**4.832 acres[9]**

Notes:

1. = Wetlands previously lost during construction of shoreline revetment as part of the remedial action at IR-07/18.
2. = Wetlands previously lost during TCRA at Metal Debris Reef.
3. = Wetlands previously lost during TCRA at Metal Slag Area
4. = Wetlands previously lost during Phase 2 TCRA at PCB Hot Spot Area.
5. = Wetlands to be lost during construction of new tidal wetlands as part of the remedy at Parcel E-2.
6. = Wetlands to be lost during construction of shoreline revetment as part of the remedy at Parcel E-2.
7. = Wetlands to be lost during removal of hot spots and construction of final cover.
8. = Wetlands to be lost during construction of new freshwater wetlands (seasonal).
9. = The new tidal and freshwater wetlands will fully mitigate the impacts of past and future cleanup actions and will result in a compensation ratio for restoration of wetland habitat of 1:1. The 1:1 mitigation ratio was agreed upon by the Navy and the Bay Coastal Development Commission prior to the start of previous removal actions, and the mitigation ratio was also documented in the Final Wetlands Mitigation and Monitoring Plan (Shaw Environmental, Inc., 2009) and Final Record of Decision (Department of the Navy, 2012). This mitigation ratio will result in no net loss of wetland habitat at HPNS. In addition, contiguous, more highly functioning tidal and freshwater wetlands will be of greater value as compared with the small, individual, isolated patches of wetlands that were lost.

IR = Installation Restoration
NA = not applicable
PCB = polychlorinated biphenyl
RD = remedial design
TCRA = time-critical removal action

Table 16. Wetland Planting Zones

Zone[1,2]	Area (in square feet)	Area (in acres)	Elevation (NGVD 29)
Tidal Wetlands			
Low Marsh Zone	12,139	0.28	Between +2.0 feet msl to +3.1 feet msl
Middle Marsh Zone	15,686	0.36	Between +3.1 feet msl and +3.7 feet msl
High Marsh Zone	99,255	2.27	Between +3.7 feet msl and +4.7 feet msl
Transition Zone	19,385	0.45	Between +4.7 feet msl and +5.4 feet msl
Upland Zone	69,208	1.59	Between +5.4 feet msl and +10.0 feet msl
Freshwater Wetlands (Seasonal)			
Low Marsh Zone	38,813	0.89	Below +5.0 feet msl
Middle Marsh Zone	22,188	0.51	Between +5.0 feet msl and +6.0 feet msl
High Marsh Zone	8,302	0.19	Between +6.0 feet msl and +7.0 feet msl
Upland Zone	42,166	0.97	Between +7.0 feet msl and +10.0 feet msl

Notes:

1. = Mean high tide is +2.98 feet msl NGVD 29 with normal maximum high tides ranging up to +3.61 feet msl NGVD 29. The maximum spring high tide at Hunters Point is +5.04 feet msl NGVD 29.

2. = Planting zones for seed mixes will have a 1-foot vertical overlap to increase success rate.

msl = mean sea level

NGVD 29 = National Geodetic Vertical Datum 1929

Appendix A. Design Calculations

List of Design Calculations

A1 Hot Spot Excavation Volumes A-2
A2 Grading Volumes A-7
A3 Cover Quantities A-14
A4 Landfill Area Surface Runoff - Ditch Sizing and Capacity Design A-19
A5 Culvert and Discharge Pipe Sizing A-28
A6 Soil Erosion A-50
A7 Tidal Datums A-73
A8 Fetch Distances and Wind Parameters A-99
A9 Wave Generation A-117
A10 Armor Stone Size A-131
A11 Armor Layer Thickness A-135
A12 Wave Runup A-138
A13 Wave Breaking Depth A-143
A14 Revetment Wall Design Criteria A-143
A15 Revetment Wall Structural Calculations A-153
A16 Filter Stone Size A-194
A17 Shoreline Revetment Material Quantities A-198
A18 Excavation Volume Outside Slurry Wall A-204
A19 Slurry Wall, Groundwater Inceptor, and Leachate Monitoring Trench Material Quantities A-209
A20 Landfill Gas System - Extraction Well Radius of Influence (*to be completed at a later date*) A-214
A21 Landfill Gas System - Header Pipe Flow Headloss and Sizing (*to be completed at a later date*) A-216
A22 Landfill Gas System - Condensate Generation A-218
A23 Headwall Sizing A-225

A1. Hotspot Excavation Volumes

Project	HPNS, Parcel E-2	Component/System:	Hotspot Excavation Volumes
Prepared by:	CEW	Checked by:	JS
Date	5-2013	Date	5-2013

PURPOSE

The purpose of this calculation brief is to estimate the excavation volumes associated with the proposed hotspot excavations at Parcel E-2.

DATA

- Hot spots identified in the Remedial Investigation/Feasibility Study (RI/FS) Report for Parcel E-2 (ERRG, 2011) that have not been removed to date.
- Confirmation sampling results from the Final Removal Action Completion Report (RACR) (Phase 1), PCB Hot Spot Soil Excavation Site at Parcel E and E-2, (TtECI, 2007)
- Confirmation sampling results from the Internal Draft RACR, Phase II, Time-Critical Removal Action for the PCB Hot Spot Area at Parcel E-2, (Shaw, 2012).
- Confirmation sampling results from the Final Action Memorandum, Time-Critical Removal Action for the PCB Hot Spot Area at Parcels E and E-2 (Navy, 2005).
- Topographic land survey data collected on 10/29/2012, 10/30/2012, 11/12/2012, 11/20/2012, 12/03/2012, 12/10/2012, and 12/12/2012. Horizontal Datum: NAD 1927 Zone III [Hunters Point West 1 PID HT0613] USFT, Vertical Datum: NGVD 29

METHODOLOGY

Hot spots were identified using data from the RI/FS, Phase II RACR, and Final Action Memorandum. The historical data were summarized on Figures 10 and 11 of this Design Basis Report (DBR). The estimated extents of the hot spots (based on the data analysis presented on Figure 12 of this DBR) were drawn on Remedial Design Drawing C-4 (Appendix B of this DBR). The areas of the hotspot shown on Drawing C4 were calculated using the area command in AutoCAD Civil 3-D 2013 (CAD). Bank volume calculations assumed a 1:1 sloping for all excavations over 5 feet deep. Slope volumes were calculated by multiplying the area of the slope excavation by the proposed depth of the excavation by a factor of 0.5. (see Attachment 1).

To verify the areas generated using CAD, several excavation volumes were also calculated manually using hand-measured excavation dimensions.

CALCULATION RESULTS

Using the methodology described above, the total volume of hotspot soil requiring excavation, is 17,189 bank cubic yards. Adjusting for sloping (at a rate of 1:1), the total volume of soil to be excavated increases to 22,996 bank cubic yards. A table summarizing the estimated excavation volume for each hot spot is included as Attachment 1 and is also included on Drawing C4. Manual calculations verified the accuracy of the areas calculated using CAD.

REFERENCES

Engineering/Remediation Resources Group (ERRG), 2011. "Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

U.S. Department of the Navy (Navy), 2005, Final Action Memorandum, Time-Critical Removal Action for the PCB Hotspot Area at Parcels E and E-2, Hunters Point Shipyard, San Francisco, California, Southwest Division Naval Facilities Engineering Command, May.

Shaw, 2012, Internal Draft Removal Action Completion Report (RACR), Phase II, Time-Critical Removal Action for the PCB Hot Spot Area at Parcel E-2, Hunters Point Shipyard, San Francisco, California, Southwest Division Naval Facilities Engineering Command, November.

Tetra Tech EC, Inc. (TtECI), 2007a. "Final Removal Action Completion Report, PCB Hot Spot Soil Excavation Site, Parcels E and E-2, Hunters Point Shipyard, San Francisco, California." October 31.

ATTACHMENTS

Attachment 1. Estimated Hotspot Excavation Volumes

Attachment 1. Estimated Hotspot Excavation Volumes

Attachment 1. Estimated Hotspot Excavation Volumes

EXCAVATION ID	AREA (square feet)	DEPTH (feet)	TOTAL (cubic yards)	TOTAL (with 1:1 benching) (cubic yards)
T1-EX-1A-1	4,012	13	1,932	2,557
T1-EX-1A-2	400	5	74	74*
T2-EX-2A-1	1,455	5	269	269*
T2-EX-2A-2	3,284	6	730	842
T2-EX-3A	18,619	3	2,069	2,069*
T2-EX-3B	1,600	16	948	2,010
T2-EX-3C	1,600	8	474	702
T2-EX-3D	948	6	211	328
T2-EX-4	1,600	3	178	178*
T2-EX-5	1,600	10	593	854
T3-EX-1-1	1,800	5	333	333*
T3-EX-2-1	175	5	32	32*
T3-EX-2-2A	800	5	148	148*
T3-EX-2-2B	1,400	8	415	564
T4-EX-1	1,600	10	593	963
T4-EX-2	1,600	10	593	963
T4-EX-3	7,653	10	2,834	3,765
T4-EX-4	1,600	10	593	666
T5-EX-1	3,907	8	1,158	1,485
T5-EX-2-1	6,259	13	3,014	4,194
		Total Volume:	17,189	22,996

* No sloping required.

A2. Grading Volumes

Project	HPNS, Parcel E-2	**Component/System:**	Grading Volumes
Prepared by:	PDL	**Checked by:**	
Date	5-2013	**Date**	5-2013

PURPOSE

The purpose of this calculation brief is to estimate the soil grading volumes associated with the proposed grading plan for Parcel E-2.

DATA

Topographic data from the following design drawings were converted to surfaces to allow for the calculation of the grading volumes:

- C-1 Site and Existing Conditions
- C-11 Subgrade Excavation Plan
- C-12 Foundation Plan
- C-13 Final Grading Plan

METHODOLOGY

Volumes were calculated using the composite volume calculation tool in AutoCAD Civil 3-D 2013. This tool interpolates between two 3-D surfaces to determine the cut and fill volumes between them. The order of the calculations was performed, as follows:

- Subgrade cut and fill volumes were determined by comparing the surface elevations between the existing ground surface and the excavated subgrade surface
- Foundation layer cover volume (fill) was determined by comparing the surface elevations between the excavated subgrade surface and the top of foundation layer surface
- Finish grade cover volume (fill) was determined by comparing the surface elevations between the top of foundation layer surface and the finish grade surface

The designed cover system varies by area across the site, as follows:

- Cover Type A (Tidal and Freshwater Wetlands): 1 foot soil bridge over subgrade soil to foundation layer, and 3 feet wetland compatible soil to finish grade
- Cover Type B (Shoreline Revetment): Volume and material quantity for revetment armor and filter stone were calculated in the Shoreline Revetment Material Quantities calculation brief.
- Cover Type C: 1 foot screened soil over subgrade soil to foundation layer , geosynthetic layers, and 2 feet imported vegetative soil to finish grade
- Cover Type D: 1 foot screened soil and minimum 1foot consolidated material over subgrade soil to foundation layer, geosynthetic layers, and 2 feet imported vegetative soil to finished grade

- Cover Type E: removal of 1-foot of the 18-inch existing soil cover 2 vegetated soil placed over the existing multilayer cap,.
- Cover Type F: 1 foot screened soil and minimum 1foot consolidated material over subgrade soil to foundation layer, multiple geosynthetic layers, and 2 feet imported vegetative soil to finished grade

The existing ground surface was developed based on survey data collected by ESP Surveying, Inc. between October 12th, 2012 and December 12th, 2012.

CALCULATIONS

AutoCAD Calculation:

The results of the AutoCAD volume calculations are presented in the following tables.

Cut Volumes:

Cut Volume - Existing Ground Surface to Subgrade Surface	
	Volume (yd^3)
Tidal Wetlands	30,332
Panhandle	5,392
Freshwater Wetlands	16,458
Landfill	21,470
North Perimeter	6,409
East Adjacent	6,002
Shoreline	4,159
Revetment	4,932
Subtotal	**95,154**

The volume provided for the total subgrade cut was calculated using the AutoCAD composite volume calculation tool and was taken from Drawing C11 (May 28, 2013). The AutoCAD volume report is presented at the back of this brief in Attachment 1.

Overall Site Fill:

The overall fill volumes to provide capacity at the site for consolidating the cut volumes and to provide cover soils were calculated.

Fill Volume - Existing Ground Surface to Subgrade Surface	
	Volume (yd^3)
Tidal Wetlands	0
Panhandle	4,189
Freshwater Wetlands	7,762
Landfill	0
North Perimeter	4,180
East Adjacent	5,655
Shoreline	5,715
Revetment	0
Subtotal	**27,501**

Fill Volume - Subgrade Surface to Foundation Surface	
	Volume (yd^3)
Subtotal	**88,460**

The subgrade fill and foundation fill volumes were calculated using the AutoCAD composite volume calculation tool on May 28, 2013 to determine the available capacity for soil consolidation. The AutoCAD volume report is presented at the back of this brief in Attachment 1.

Fill Volume - Foundation Surface to Finished Grade Surface	
Foundation Surface to Finished Grade Surface	**Volume (yd^3)**
Total	**156,191**

The volume provided for the total cover fill volumes was calculated using the AutoCAD composite volume calculation tool on May 28, 2013. The AutoCAD volume report is presented at the back of this brief in Attachment 1.

CONCLUSIONS

The volumes calculated using AutoCAD give approximate total grading volumes associated with the design are as follows:

- Existing Grade Surface to Subgrade Surface (Total Cut) = 95,150 yd^3
- Existing Grade Surface to Subgrade Surface (Total Fill) = 27,500 yd^3
- Subgrade to Top of Foundation Layer Surface (Fill) = 88,460 yd^3
- Top of Foundation Layer to Finish Grade Surface (Fill) = 150,000 yd^3

The total cut volume of 95,150 yd^3 will be screened for radionuclides and if clean will be consolidated as fill under the cover system at the site. The total subgrade and foundation fill volumes, except for the wetland bridge volumes, provide approximately 115,960 yd^3 of capacity for the cut volume and any additional waste soil that comes from slurry wall and subdrain construction.

REFERENCES

Engineering/Remediation Resources Group (ERRG), 2011. "Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

ATTACHMENTS

Attachment 1. AutoCAD Cut & Fill Volume Reports

Attachment 1. AutoCAD Cut & Fill Volume Reports

Cut/Fill Summary - 05/28/13

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
shoreline area	**1.000**	**1.000**	116691.49 Sq. Ft.	4158.91 Cu. Yd.	5715.48 Cu. Yd.	1556.57 Cu. Yd.<Fill>
revetment	**1.000**	**1.000**	48985.83 Sq. Ft.	4931.82 Cu. Yd.	0 Cu. Yd.	4726.41 Cu. Yd.<Cut>
landfill	**1.000**	**1.000**	586094.74 Sq. Ft.	21469.94 Cu. Yd.	0 Cu. Yd.	21348.53 Cu. Yd.<Cut>
tidal wtlnds	**1.000**	**1.000**	159867.68 Sq. Ft.	30331.90 Cu. Yd.	0 Cu. Yd.	30331.89 Cu. Yd.<Cut>
east-adjacent	**1.000**	**1.000**	347296.43 Sq. Ft.	6002.15 Cu. Yd.	5654.82 Cu. Yd.	347.33 Cu. Yd.<Cut>
freshwater	**1.000**	**1.000**	214343.61 Sq. Ft.	16457.92 Cu. Yd.	7762.38 Cu. Yd.	8695.54 Cu. Yd.<Cut>
panhandle	**1.000**	**1.000**	133074.08 Sq. Ft.	5392.08 Cu. Yd.	4189.48 Cu. Yd.	1202.60 Cu. Yd.<Cut>
north-perimeter	**1.000**	**1.000**	341007.13 Sq. Ft.	6409.46 Cu. Yd.	4180.32 Cu. Yd.	2229.15 Cu. Yd.<Cut>
foundt-finish	**1.000**	**1.000**	1925685.77 Sq. Ft.	0 Cu. Yd.	156190.54 Cu. Yd.	156179.67 Cu. Yd.<Fill>
subgd-foundation	**1.000**	**1.000**	1921266.96 Sq. Ft.	0 Cu. Yd.	88459.99 Cu. Yd.	88265.20 Cu. Yd.<Fill>

A3. Cover Quantities

Project	HPNS, Parcel E-2	**Component/System:**	Cover Quantities
Prepared by:	PDL	**Checked by:**	DB
Date	3-2013	**Date**	3-2013

PURPOSE

The purpose of this calculation brief is to estimate the material quantities for import soil and geosynthetic components required to construct the proposed cover system for the Parcel E-2 Remedial Design over a prepared foundation surface of consolidated or existing soils.

DATA

The different cover types are described in the Design Basis Report for the Remedial Design. These include the Tidal and Freshwater Wetlands (Cover Type A), The Proposed Geosynthetic Cap (Cover Types C and D), the Existing Multilayer Geosynthetic Cap (Cover E) and the Proposed Multilayer Geosynthetic Cap (Cover F). The material quantities for the Revetment Construction (Cover Type B) are presented in a separate calculation. The surface areas for the different cover types were based upon the limits shown of the Final Grading Plan, Design Drawing C-13 of the Remedial Design.

The cover types consist of the following components:

Tidal Wetlands	**Freshwater Wetlands**	**Proposed Geosynthetic Cap**	**Existing Multilayer Geosynthetic Cap**	**Proposed Multilayer Geosynthetic Cap**
3-foot layer of wetlands compatible soil	3-foot layer of wetlands compatible soil	2-foot layer of vegetative soil	2-foot layer of vegetative soil	2-foot layer of vegetative soil
Demarcation Layer	Demarcation Layer	Demarcation Layer	Demarcation Layer	Demarcation Layer
1-foot soil bridge layer	1-foot soil bridge layer	Geocomposite drainage layer	Geocomposite drainage layer	Geocomposite drainage layer
		60-mil HDPE geomembrane	6-inches existing soil cover	60-mil HDPE geomembrane
			Existing 60-mil	Geosynthetic clay

			HDPE geomembrane layer	layer (GCL)
			Existing GCL layer	

METHODOLOGY

The plan areas for the different cover types were calculated using the area tool in AutoCAD Civil 3-D 2013. This tool determines the area based upon the coordinates of a closed line that marks the limit of each area. The surface areas provided by AutoCAD were for the outer limits of each cover type. Where the one type of cover is nested within another, the inner areas were subtracted from the outer area. Where the proposed multilayer cap overlapped the northwest corner of the existing multilayer, the area of the overlap was calculated and added to the proposed multilayer area and subtracted from the existing multilayer area to determine the extent of new cover components required.

The final plan area for the two wetlands areas are taken directly from AutoCAD limit areas. The final plan area for the proposed geosynthetic cap was determined by subtracting the limit areas of the two wetlands and the limit area of the proposed multilayer cap. The final plan area of the existing multilayer cap was determined by subtracting the existing/proposed multilayer overlap area. And the final plan area of the proposed multilayer cap was determined by subtracting the limit area of the existing multilayer cap and adding the existing/proposed multilayer overlap area.

The final plan areas were adjusted based upon the average design slopes within those areas based on the final grade contours to get the slope areas. The slope areas are presented in square feet (ft^2).

The soil layer quantities were calculated by multiplying the slope area by the layer thickness and converting to cubic yards (yd^3).

The square footage for the geosynthetic components is based upon the slope areas with a 5 percent increase to account for overlap during construction.

CALCULATION RESULTS

Surface Areas:

	AutoCAD Cover Limits Area (ft^2)	Final Plan Area (ft^2)	Average Slope (%)	Slope Area (ft^2)
Tidal Wetlands	163,263	163,263	1	164,896
Freshwater Wetlands	61,281	61,281	0	61,281
Proposed Geosynthetic Cap	1,655,195	626,614	5	657,945
Existing Multilayer Cap	593,538	531,168	3	547,103
Proposed Multilayer Cap	967,300	436,132	10	479,745
Proposed/Existing Multilayer Overlap	62,370	-	-	-

Soil Volumes:

	Slope Area (ft^2)	2-ft Vegetative Soil layer (yd^3)	3-ft Wetlands compatible soil layer (yd^3)	1-ft Soil Bridge layer (yd^3)
Tidal Wetlands	164,896	-	18,322	6,107
Freshwater Wetlands	61,281	-	6,809	2,270
Proposed Geosynthetic Cap	657,945	48,737	-	-
Existing Multilayer Cap	547,103	40,526	-	-
Proposed Multilayer Cap	479,745	35,537	-	-

New Geosynthetic Components:

	Slope Area (ft^2)	Demarcation layer (ft^2)	Geocomposite layer (ft^2)	60-mil HDPE geomembrane (ft^2)	GCL (ft^2)
Tidal Wetlands	164,896	173,140	-	-	-
Freshwater Wetlands	61,281	64,345	-	-	-

Proposed Geosynthetic Cap	657,945	690,842	690,842	690,842	-
Existing Multilayer Cap	547,103	574,458	-	-	-
Proposed Multilayer Overlap	479,745	503,732	503,732	503,732	503,732

CONCLUSIONS

The quantities calculated for the various components of the different cover types equate to the following total combined material quantities that will need to be imported to complete the cover:

Vegetative Soil: 124,799 yd^3 placed
Wetlands Compatible Soil: 25,131 yd^3 placed
Bridge Soil: 8,377 yd^3 placed

Demarcation layer: 2,006,518 ft^2
Geocomposite: 1,194,574 ft^2
60-mil HDPE geomembrane: 1,194,574 ft^2
GCL : 503,732 ft^2

REFERENCES

Engineering/Remediation Resources Group (ERRG), 2011. "Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

A4. Landfill Area Surface Runoff - Ditch Sizing and Capacity Design

Project	HPNS, Parcel E-2	Component/System:	Landfill Area Surface Runoff - Ditch Sizing and Capacity Design
Prepared by:	CMW	Checked by:	PDL
Date	3-2013	Date	3-2013

PURPOSE

The purpose of this calculation is to design the surface water controls for Parcel E-2 that will handle the landfill area surface runoff flows generated by 100-year and 1000-year design storm events. The sizes and capacities of the proposed earth lined trapezoidal channels will be based on hydrologic analyses of the contributing catchment sub-areas.

The design storms are based upon the construction standards for Class II and Class III waste management units presented in Table 4.1 of the Title 27 CCR 21650-21690.

The hydrologic flow rates were determined utilizing the Rational Method. Ditch sizing was determined using Manning's equation for open channel flow.

Nine ditches along the landfill area are identified in Drawing C-22. Catchment sub-areas for each ditch were delineated based on topographic information from the design finished grade and are shown in Drawing C22. Each catchment sub-area drains into its respective ditch.

DATA

The following design data are being used for this calculation:

- All catchment sub-areas are assumed to be 100% pervious; a runoff coefficient (C) of 1 is used
- Uniform open channel flow is assumed
- Design Storm rainfall intensities were obtained from the NOAA Atlas 14, Volume 6, Version 2 Precipitation Frequency Data Server:

Table 1.

Design Storm	Rainfall Intensity (in/hr)
100-yr, 24-hr	0.2183
1000-yr, 24-hr	0.3125
100-yr, 1-hr	1.16
1000-yr, 1-hr	1.62

METHODOLOGY

AutoCAD Civil 3-D 2013 was used to generate surface flow directions over the landfill area based on topographic information from the design finished grade, and catchment sub-areas A through M were delineated. Landfill area perimeter ditches were identified for sub-areas A, B, G, H, I, and J, and ditches along the landfill area slopes were identified for sub-areas C, D, and E. No ditches was identified for sub-area F, where surface runoff will sheet flow into the freshwater wetland, or for sub-areas K, L, and M where flow will sheet flow into the Bay. The catchment sub-area areas and ditch lengths were determined using AutoCAD:

Table 2.

Catchment Sub-Area	Area (ft^2)	Area (acres)	Ditch Length (ft)
A	29,210	0.67	284
B	86,968	2.00	661
C	143,750	3.30	254
D	67,803	1.56	292
E	116,187	2.67	525
F	212,769	4.88	N/A
G	42,375	0.97	739
H	72,063	1.65	120
I	168,503	3.87	687
J	193,588	4.44	1015
K	220,523	5.06	N/A
L	98,076	2.25	N/A
M	42,206	0.97	N/A

The estimated storm runoff flow rates for catchment sub-areas A through M were determined utilizing the Rational Method.

The estimated ditch capacities for catchment sub-areas A, B, C, D, E, G, H, I, and J were determined utilizing Manning's equation for open channel flow.

CALCULATIONS

1. Determine the estimated storm runoff flows for catchment sub-areas utilizing the Rational Method.

Rational Method equation:

$$Q_1 = C * i * A$$

Where:

Q_1 = storm runoff flow rate (ft^3/sec)

C = developed runoff coefficient (dimensionless); assumed to be 1
i = rainfall intensity (in/hr);
A = area of catchment sub-area (acres)

The estimated storm runoff flow rates calculated for each catchment sub-area are summarized below:

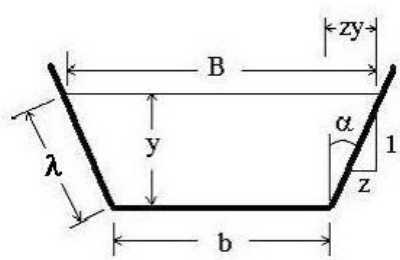
Table 3.

Rational Method Estimated Storm Runoff Flow Rates Q_1 (ft^3/sec)				
Catchment Sub-Area	100-yr, 24-hr Design Storm	1000-yr, 24-hr Design Storm	100-yr, 1-hr Design Storm	1000-yr, 1-hr Design Storm
A	0.146	0.210	0.778	1.086
B	0.582	0.833	3.094	4.321
C	0.720	1.031	3.828	5.346
D	0.340	0.486	1.806	2.522
E	1.303	1.865	6.922	9.667
G	0.212	0.304	1.128	1.576
H	0.574	0.821	3.047	4.256
I	1.418	2.030	7.535	10.523
J	2.388	3.419	12.690	17.722
K	1.105	1.582	5.873	8.201
L	0.492	0.704	2.612	3.647
M	0.212	0.303	1.124	1.570

2. Determine the maximum flow capacity of each ditch and velocity of flow utilizing Manning's equation for open channel flow.

Given:

Trapezoidal ditch:



Trapezoidal Cross Section

Bengtson, Harlan. *Calculation of Hydraulic Radius for Uniform Open Channel Flow*

b = minimum ditch bottom width = 2 ft

B = minimum ditch top width = 6 ft

y = minimum ditch depth = 1 ft

R = hydraulic radius (ft) = A/P = 0.618 ft

A = cross sectional area of trapezoidal ditch = 4 ft^2

$$A = y\left(\frac{b+B}{2}\right)$$

P = wetted perimeter of trapezoidal ditch = 6.472 ft

$$P = b + 2\sqrt{\left(\frac{B-b}{2}\right)^2 + y^2}$$

S = minimum channel slope = 0.005 (dimensionless)

n = Manning's roughness coefficient = 0.02 (dimensionless)

The value for n was selected based on a channel condition of smooth, well-packed earth (Bankston and Baker, 1995).

a) Determine the maximum flow capacity utilizing Manning's equation for open channel flow (Bedient and Huber, 2002).

$$Q_2 = \frac{(1.49)\text{ x } R^{\frac{2}{3}}\text{ x } S^{\frac{1}{2}}\text{ x A}}{\text{n}}$$

Where Q_2 = maximum flow rate capacity (ft^3/sec)

$$Q_2 = \frac{(1.49)\text{ x }(0.618\text{ ft})^{\frac{2}{3}}\text{ x }(.005)^{\frac{1}{2}}\text{ x }(4\text{ sq. ft})}{0.02}$$

$$Q_2 = 15.289\ \frac{ft^3}{sec}$$

Catchment sub-area maximum flow rate capacity Q_2 = $15.289\ \frac{ft^3}{sec}$ > storm runoff flow rate Q_1 in Table 3? YES for all sub-areas and design storms ***except sub-area J using 1000-yr, 1-hr design storm***.

- For sub-area J, increase minimum ditch depth and minimum ditch top width:

  b = minimum ditch bottom width = 2 ft

  B = minimum ditch top width = 7 ft

  y = minimum ditch depth = 1.25 ft

  R = hydraulic radius (ft) = A/P = 0.741 ft

  A = cross sectional area of trapezoidal ditch = 5.625 ft^2

$$A = y\left(\frac{b+B}{2}\right)$$

P = wetted perimeter of trapezoidal ditch = 7.590 ft

$$P = b + 2\sqrt{\left(\frac{B-b}{2}\right)^2 + y^2}$$

S = minimum channel slope = 0.005 (dimensionless)

n = Manning's roughness coefficient = 0.02 (dimensionless)

- Determine the maximum flow capacity of new ditch:

$$Q_2 = \frac{(1.49) \text{ x } R^{\frac{2}{3}} \text{ x } S^{\frac{1}{2}} \text{ x } A}{n}$$

Where Q_2 = flow rate (ft^3/sec)

$$Q_2 = \frac{(1.49) \text{ x } (0.741\text{ft})^{\frac{2}{3}} \text{ x } (.005)^{\frac{1}{2}} \text{ x } (5.625 \text{ sq. ft})}{0.02}$$

$$Q_2 = 24.265\ \frac{ft^3}{sec}$$

- Is catchment sub-area J maximum flow rate capacity $Q_2 = 24.265\ \frac{ft^3}{sec} >$ storm runoff flow rate Q_1 in Table 3? YES

b) Determine the maximum velocity of the flow and check against erosion and scouring. Utilize the Manning equation and solve for depth of flow:

Given:

- Storm runoff flow rate (Q_1) from Table 3
- Trapezoidal ditch dimensions as determined above
- Design channel slope (S_D) from ditch invert elevations shown on Drawing C-22 and ditch lengths from Table 2:

$$S_D = \frac{Invert\ Elevation_{End} - Invert\ Elevation_{Start}}{Ditch\ Length}$$

Solve for:

- Depth of flow (y) using Manning's equation
- Area of flow

$$A = y\left(\frac{b+B}{2}\right)$$

- Velocity of flow

$$V = \frac{Q_1}{A}$$

The results for velocity of flow for each sub-area ditch and design storm are as follows:

Table 4.

100-yr, 24-hr Design Storm					
Catchment Sub-Area	Q_1 (ft^3/sec)	S_D	Solved: y (ft)	A (ft^2)	V (ft/sec)
A	0.146	0.0085	0.051	0.204	0.718
B	0.582	0.0085	0.117	0.468	1.244
C	0.720	0.0197	0.103	0.412	1.749
D	0.340	0.0068	0.090	0.360	0.944
E	1.303	0.0076	0.196	0.784	1.662
G	0.212	0.005	0.074	0.074	2.870
H	0.574	0.005	0.136	0.544	1.054
I	1.418	0.005	0.234	0.936	1.515
J	2.388	0.005	0.320	1.280	1.866

Table 5.

1000-yr, 24-hr Design Storm					
Catchment Sub-Area	Q_1 (ft^3/sec)	S_D	Solved: y (ft)	A (ft^2)	V (ft/sec)
A	0.210	0.0085	0.064	0.256	0.819
B	0.833	0.0085	0.145	0.580	1.437
C	1.031	0.0197	0.128	0.512	2.014
D	0.486	0.0068	0.112	0.448	1.086
E	1.865	0.0076	0.243	0.972	1.919
G	0.304	0.005	0.093	0.372	0.817
H	0.821	0.005	0.168	0.672	1.222
I	2.030	0.005	0.290	1.160	1.750
J	3.419	0.005	0.397	1.588	2.153

Table 6.

100-yr, 1-hr Design Storm					
Catchment Sub-Area	Q_1 (ft^3/sec)	S_D	Solved: y (ft)	A (ft^2)	V (ft/sec)
A	0.778	0.0085	0.139	0.556	1.399
B	3.094	0.0085	0.319	1.276	2.425
C	3.828	0.0197	0.281	1.124	3.406
D	1.806	0.0068	0.246	0.984	1.835
E	6.922	0.0076	0.537	2.148	3.223
G	1.128	0.005	0.204	0.816	1.383

H	3.047	0.005	0.371	1.484	2.054
I	7.535	0.005	0.643	2.572	2.930
J	12.690	0.005	0.889	3.556	3.569

Table 7.

1000-yr, 1-hr Design Storm					
Catchment Sub-Area	Q_1 (ft^3/sec)	S_D	Solved: y (ft)	A (ft^2)	V (ft/sec)
A	1.086	0.0085	0.17	0.680	1.598
B	4.321	0.0085	0.39	1.560	2.770
C	5.346	0.0197	0.344	1.376	3.885
D	2.522	0.0068	0.301	1.204	2.094
E	9.667	0.0076	0.659	2.636	3.667
G	1.576	0.005	0.249	0.996	1.582
H	4.256	0.005	0.454	1.816	2.344
I	10.523	0.005	0.791	3.164	3.326
J	17.722	0.005	1.03	4.635	3.824

For all ditches and design storms, the approximate velocity is less 4 ft/sec. The allowable mean velocity to protect against erosion or scour in grass-lined channels is 240 ft/min (Bankston and Baker, 1995), so no additional material needs to be placed along the ditch slopes to prevent erosion and scouring of side slopes.

CONCLUSIONS

Catchment sub-area ditches A, B, C, D, E, G, H, and J are estimated to have a capacity of approximately 15.3 ft^3/sec, and ditch J is estimated to have a capacity of approximately 24.3 ft^3/sec, based on the design parameters. These flow rates exceed the storm runoff flow rates estimated for each catchment sub-area using 100-yr, 24-hr; 1000-yr, 24-hr; 100-yr, 1-hr; and 1000-yr, 1-hr design storms. The calculated flow velocities will not cause scour or erosion along the bottom or side slopes of the proposed earth lined channels.

REFERENCES

California Code of Regulations (CCR) Title 27 § 21650-21690. "Chapter 3. Criteria for All Waste Management Units, Facilities, and Disposal Sites."

"Point Precipitation Frequency Estimates". NOAA Atlas 14, Volume 6, Version 2.

Bankston, J. David and Fred Eugene Baker, 1995. "Open Channel Flow in Aquaculture", March.

Bedient, Philip B. and Huber, Wayne C, 2002. "Hydrology and Floodplain Analysis."

Bengtson, Harlan. “Calculation of Hydraulic Radius for Uniform Open Channel Flow,” September 2010. Available at: < http://www.brighthubengineering.com/hydraulics-civil-engineering/67126-calculation-of-hydraulic-radius-for-uniform-open-channel-flow/ >

A5. Culvert and Discharge Pipe Sizing

PURPOSE AND SITE CONDITIONS

The purpose of these calculations is to evaluate the design for the underground storm water discharge pipes and culverts for the Remedial Design for the Hunters Point Parcel E-2 Landfill This includes the discharge structures for the proposed freshwater wetlands and for the perimeter surface water runoff channel along the east perimeter of the parcel. Both of these discharge structures will outfall into San Francisco Bay and will require a tidal valve at the end of the outfall pipes. Also a culvert will be constructed along the perimeter surface water runoff channel where it is crossed by the site maintenance road coming off of Spear Ave.

Discharge from the freshwater wetlands will be through an SDR 17 solid-wall HDPE pipe. This wall thickness was selected in order to allow the tidal valve to be clamped firmly in place. The valve will be installed at the far end of the pipe near the western end of the revetment. Wave crests are generally perpendicular to the shoreline in this area. Therefore, the wave forces will tend to push the valve toward the pipe.

Discharge of the perimeter channel will be through an SDR 17 solid-wall HDPE pipe. This wall thickness was selected in order to allow the tidal valve to be clamped firmly in place. The discharge end of the outfall pipe will be located near the southern end of the revetment. Wave crests may tend to be parallel in this area, and could therefore push a valve sideways from the pipe. In order to eliminate the potential for the valve to be separated from the pipe, the valve will be installed inside of a manhole located upstream from the outfall end of the pipe. There will be a run of pipe from the downstream end of the channel to the manhole. The tidal valve will be installed inside of the manhole at the downstream end of this pipe. A second pipe run will go from the manhole, through the revetment, and discharge to the bay. This run will have an open end at the outfall. Any bay water that may flow back into the pipe, as a result of waves or high water, will be contained inside the manhole.

The culvert pipe under the maintenance road will be a double-wall corrugated HDPE pipe with flared ends.

DATA

The sizing of the discharge pipes and culverts will be based upon the surface water runoff generated by the design storm event for the site. A 1,000-year/24-hour storm event will be used to size all the surface water control features at the site.

From the surface runoff calculations that were used to evaluate the drainage area that contributes to the Freshwater Wetlands, the 1,000-year/24-hour storm will result in a flow of 5.0 cfs into the Freshwater Wetlands.

From the surface runoff calculations that were used to evaluate the drainage area that contributes to the flow into the perimeter channel outfall, the 1,000-year/24-hour storm will result in a flow of 3.96 cfs into the perimeter channel outfall pipe.

From the surface runoff calculations that were used to evaluate the drainage area that contributes to the flow through the perimeter channel roadway culvert, the 1,000-year/24-hour storm will result in a flow of 2.66 cfs into the roadway culvert.

A Manning's n value of 0.033, which corresponds to a gravel-bottom channel with riprap side slopes, was used for the outfall of the Freshwater Wetlands and the Perimeter Drainage Channel. A Manning's n value of 0.027, which corresponds to an earthen channel vegetated with short grass, was used for the culvert of the Perimeter Drainage Channel. A table showing Manning's n values is attached.

The Perimeter Drainage Channel was designed with a 2-foot wide bottom and 2 to 1 side slopes (ERRG, 2013).

METHODOLGY

A software program, HY-8 Culvert Analysis Program, Version 7.2 (HY-8) available on the Federal Highway Administration (FHWA) website was used to evaluate the pipeline flow characteristics. The methods used by the software are described in Hydraulic Design of Highway Culverts (FHWA, 2012).

The input data (Crossing Data) for each set of evaluations is attached. The HY-8 Analysis Results for each case are also attached.

CONCLUSIONS

The HY-8 Analysis Results for the Freshwater Wetlands show that a 20-inch OD (17.5-inch ID) solid-wall HDPE pipe will experience a headwater elevation of 7.32 feet when subject to the 24-hour design flow of 5.0 cfs. This elevation is 1.32 feet above the pipe invert elevation (6.00 msl) but below the perimeter elevation of the freshwater wetlands area of 10.0 msl. The pipe is capable of handling a

sustained flow of up to 13.56 cfs before the headwater surface overtops the revetment crest elevation of 12.0 msl. The tailwater velocity at 5.0 cfs is 2.19 ft/s. At this velocity, erosion of the riprap-lined discharge channel will not be an issue.

The HY-8 Analysis Results for the Perimeter Drainage Channel outfall show that a 20-inch OD (17.5-inch ID) solid-wall HDPE pipe will experience a headwater elevation of 7.14 feet when subject to the 24-hour design flow of 3.96 cfs. This elevation is 1.14 feet above the pipe invert elevation (6.50 msl). The pipe is capable of handling a sustained flow of up to 18.63 cfs before the headwater surface overtops the revetment crest elevation of 12.0 msl. The tailwater velocity at 3.96 cfs is 3.54 ft/s. At this velocity, erosion of the revetment armor will not be an issue.

The HY-8 Analysis Results for the roadway culvert in the Perimeter Drainage Channel show that an 18-inch ID double-wall HDPE pipe will experience a headwater elevation of 11.62 feet when subject to the 24-hour design flow of 2.66 cfs. This elevation is 0.94 feet above the pipe invert elevation (10.68 msl). This pipe is capable of handling the 100-year/1-hour peak flow of 9.1 cfs without overtopping the roadway. The pipe is capable of handling a sustained flow of up to 11.24 cfs before the headwater surface overtops the roadway surface crest elevation of 13.8 msl. The tailwater velocity at 2.66 cfs is 1.90 ft/s. At this velocity, scour in the downstream channel will not be an issue.

REFERENCES

Federal Highway Administration website: HY-8 Culvert Analysis Program, Version 7.2. https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/

Federal Highway Administration. 2012. "Hydraulic Design of Highway Culverts." Publication No. FHWA-HIF-12-026. April.

ATTACHMENTS

Attachment 1. Wetlands HY-8 20in HDPE Input Data

Attachment 2. FW Lagoon Culvert Report A

Attachment 3. FW Lagoon Culvert Report B

Attachment 4. Perimeter HY-8 18in HDPE Input Data

Attachment 5. Perimeter Channel 18in Culvert Report A

Attachment 6. Perimeter Channel 18in Culvert Report B

Attachment 7. Perimeter HY-8 20in HDPE Input Data

Attachment 8. Perimeter Channel 20in Outfall Report A

Attachment 9. Perimeter Channel 20in Outfall Report B

Attachment 1. Wetlands HY-8 20in HDPE Input Data

Crossing Data - Freshwater Lagoon

Crossing Properties

Name: Freshwater Lagoon

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.01	cfs
Design Flow	5.00	cfs
Maximum Flow	10.00	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	4.00	ft
Side Slope (H:V)	3.00	_:1
Channel Slope	0.0100	ft/ft
Manning's n (channel)	0.0330	
Channel Invert Elevation	4.00	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.00	ft
Crest Length	500.00	ft
Crest Elevation	12.00	ft
Roadway Surface	Gravel	
Top Width	12.00	ft

Culvert Properties

Freshwater Lagoon 20" OD H

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Freshwater Lagoon 20" OD HDPE	
Shape	Circular	
Material	Smooth HDPE	
Diameter	1.46	ft
Embedment Depth	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Square Edge with Headwall	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	6.00	ft
Outlet Station	310.00	ft
Outlet Elevation	4.00	ft
Number of Barrels	1	

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Attachment 2. FW Lagoon Culvert Report A

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Freshwater Lagoon

Headwater Elevation (ft)	Total Discharge (cfs)	Freshwater Lagoon 20" OD HDPE Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6.02	0.01	0.01	0.00	1
6.51	1.01	1.01	0.00	1
6.75	2.01	2.01	0.00	1
6.96	3.01	3.01	0.00	1
7.15	4.01	4.01	0.00	1
7.32	5.00	5.00	0.00	1
7.49	6.00	6.00	0.00	1
7.68	7.00	7.00	0.00	1
7.88	8.00	8.00	0.00	1
8.21	9.00	9.00	0.00	1
8.92	10.00	10.00	0.00	1
12.00	13.56	13.56	0.00	Overtopping

Attachment 3. FW Lagoon Culvert Report B

HY-8 Analysis Results

Culvert Summary Table - Freshwater Lagoon 20" OD HDPE

Culvert Crossing: Freshwater Lagoon

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.01	0.01	6.02	0.02	0.0*	6-FFt	0.01	0.01	0.01	0.01	0.78	0.22
1.01	1.01	6.51	0.51	0.0*	6-FFc	0.33	0.37	0.37	0.17	2.99	1.29
2.01	2.01	6.75	0.75	0.0*	6-FFc	0.48	0.53	0.53	0.26	3.61	1.63
3.01	3.01	6.96	0.96	0.0*	6-FFc	0.60	0.66	0.66	0.32	4.08	1.86
4.01	4.01	7.15	1.15	0.0*	6-FFc	0.70	0.77	0.77	0.38	4.48	2.04
5.00	5.00	7.32	1.32	0.0*	6-FFc	0.80	0.87	0.87	0.43	4.83	2.19
6.00	6.00	7.49	1.49	0.24	6-FFc	0.90	0.95	0.95	0.48	5.21	2.32
7.00	7.00	7.68	1.68	0.79	6-FFc	1.01	1.03	1.03	0.52	5.54	2.43
8.00	8.00	7.88	1.88	1.57	6-FFc	1.13	1.10	1.10	0.56	5.94	2.53
9.00	9.00	8.21	2.12	2.21	6-FFc	1.30	1.17	1.17	0.59	6.28	2.62
10.00	10.00	8.92	2.38	2.92	6-FFc	1.46	1.21	1.21	0.63	6.72	2.70

Attachment 4. Perimeter HY-8 18in HDPE Input Data

Crossing Data - Perimeter Channel

Crossing Properties

Name: Perimeter Channel

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	2.66	cfs
Maximum Flow	9.10	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.00	ft
Side Slope (H:V)	2.00	_:1
Channel Slope	0.0050	ft/ft
Manning's n (channel)	0.0270	
Channel Invert Elevation	10.47	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.00	ft
Crest Length	22.00	ft
Crest Elevation	13.80	ft
Roadway Surface	Gravel	
Top Width	30.00	ft

Culvert Properties

Perimeter Channel 18" ID HDP

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Perimeter Channel 18" ID HDPE	
Shape	Circular	
Material	Smooth HDPE	
Diameter	1.50	ft
Embedment Depth	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	10.68	ft
Outlet Station	44.00	ft
Outlet Elevation	10.47	ft

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Attachment 5. Perimeter Channel 18in Culvert Report A

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Perimeter Channel

Headwater Elevation (ft)	Total Discharge (cfs)	Perimeter Channel 18" ID HDPE Discharge (cfs)	Roadway Discharge (cfs)	Iterations
10.68	0.00	0.00	0.00	1
11.21	0.91	0.91	0.00	1
11.44	1.82	1.82	0.00	1
11.62	2.66	2.66	0.00	1
11.81	3.64	3.64	0.00	1
12.13	4.55	4.55	0.00	1
12.28	5.46	5.46	0.00	1
12.43	6.37	6.37	0.00	1
12.57	7.28	7.28	0.00	1
12.80	8.19	8.19	0.00	1
13.06	9.10	9.10	0.00	1
13.80	11.24	11.24	0.00	Overtopping

Attachment 6. Perimeter Channel 18in Culvert Report B

HY-8 Analysis Results

Culvert Summary Table - Perimeter Channel 18" ID HDPE

Culvert Crossing: Perimeter Channel

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	10.68	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
0.91	0.91	11.21	0.53	0.05	1-S2n	0.34	0.35	0.34	0.26	3.11	1.37
1.82	1.82	11.44	0.76	0.18	1-S2n	0.49	0.50	0.49	0.39	3.63	1.70
2.66	2.66	11.62	0.94	0.27	1-S2n	0.60	0.62	0.60	0.48	4.02	1.90
3.64	3.64	11.81	1.13	0.35	1-S2n	0.72	0.73	0.72	0.56	4.36	2.07
4.55	4.55	12.13	1.31	1.45	2-M2c	0.82	0.82	0.82	0.63	4.61	2.21
5.46	5.46	12.28	1.49	1.60	2-M2c	0.92	0.90	0.90	0.69	4.93	2.32
6.37	6.37	12.43	1.68	1.75	2-M2c	1.02	0.97	0.98	0.75	5.23	2.42
7.28	7.28	12.57	1.89	1.89	2-M2c	1.14	1.04	1.04	0.80	5.54	2.51
8.19	8.19	12.80	2.12	2.04	2-M2c	1.31	1.10	1.11	0.85	5.86	2.59
9.10	9.10	13.06	2.38	2.22	2-M2c	1.50	1.16	1.17	0.90	6.18	2.67

Attachment 7. Perimeter HY-8 20in HDPE Input Data

Crossing Data - Perimeter Channel Outfall

Crossing Properties

Name: Perimeter Channel Outfall

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	3.96	cfs
Maximum Flow	14.70	cfs
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	20.00	ft
Side Slope (H:V)	20.00	_:1
Channel Slope	0.3300	ft/ft
Manning's n (channel)	0.0330	
Channel Invert Elevation	5.10	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.00	ft
Crest Length	200.00	ft
Crest Elevation	12.00	ft
Roadway Surface	Gravel	
Top Width	17.00	ft

Culvert Properties

Perimeter Channel 20" OD HD

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Perimeter Channel 20" OD HDPE	
Shape	Circular	
Material	Smooth HDPE	
Diameter	1.46	ft
Embedment Depth	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Square Edge with Headwall	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	6.00	ft
Outlet Station	59.00	ft
Outlet Elevation	5.50	ft
Number of Barrels	1	

Help Click on any icon for help on a specific topic

Energy Dissipation Analyze Crossing OK Cancel

Attachment 8. Perimeter Channel 20in Outfall Report A

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Perimeter Channel Outfall

Headwater Elevation (ft)	Total Discharge (cfs)	Perimeter Channel 20" OD HDPE Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6.00	0.00	0.00	0.00	1
6.63	1.47	1.47	0.00	1
6.95	2.94	2.94	0.00	1
7.14	3.96	3.96	0.00	1
7.47	5.88	5.88	0.00	1
7.75	7.35	7.35	0.00	1
8.07	8.82	8.82	0.00	1
8.46	10.29	10.29	0.00	1
8.92	11.76	11.76	0.00	1
9.44	13.23	13.23	0.00	1
10.03	14.70	14.70	0.00	1
12.00	18.63	18.63	0.00	Overtopping

Attachment 9. Perimeter Channel 20in Outfall Report B

HY-8 Analysis Results

Culvert Summary Table - Perimeter Channel 20" OD HDPE

Culvert Crossing: Perimeter Channel Outfall

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	6.00	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
1.47	1.47	6.63	0.63	0.0*	6-FFc	0.38	0.46	0.46	0.03	3.30	2.42
2.94	2.94	6.95	0.95	0.27	6-FFc	0.55	0.65	0.65	0.04	4.05	3.15
3.96	3.96	7.14	1.14	0.48	6-FFc	0.65	0.77	0.77	0.05	4.46	3.54
5.88	5.88	7.47	1.47	0.91	6-FFc	0.82	0.94	0.94	0.07	5.16	4.10
7.35	7.35	7.75	1.75	1.29	6-FFc	0.95	1.05	1.05	0.08	5.67	4.46
8.82	8.82	8.07	2.07	1.86	6-FFc	1.09	1.15	1.15	0.09	6.22	4.76
10.29	10.29	8.46	2.46	2.28	6-FFc	1.29	1.23	1.23	0.09	6.87	5.04
11.76	11.76	8.92	2.92	2.75	6-FFc	1.46	1.30	1.30	0.10	7.49	5.29
13.23	13.23	9.44	3.44	3.28	6-FFc	1.46	1.37	1.37	0.11	8.18	5.52
14.70	14.70	10.03	4.03	3.87	6-FFc	1.46	1.44	1.44	0.12	8.86	5.73

A6. Soil Erosion

Project	HPS, Parcel E-2	Component/System:	Soil Erosion
Prepared by:	SCL	Checked by:	PDL
Date	1-2013	Date	1-2013

PURPOSE AND SITE CONDITIONS

The purpose of this calculation is to evaluate the soil erosion caused by wind and runoff from the design cover at Parcel E-2 at Hunters Point Naval Shipyard located in San Francisco, California. The calculated soil loss will be compared to the maximum acceptable soil loss value of 2 tons/acre/year that was suggested at an ASCE short course, Design of Waste Containment Liner and Final Closure Systems, presented in 1997.

METHODOLGY

In order to determine the erosion from surface runoff from the final cap on Parcel E-2, the Universal Soil Loss Equation was used in accordance with methods prescribed by the Natural Resources Conservation Services (NRCS).

The erosion caused by wind was calculated using methods described in the United States Department of Agriculture Handbook No. 346.

SOIL LOSS DUE TO RUNOFF

The erosion caused by runoff was determined using the Universal Soil Loss Equation (USLE) as shown below:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Where:

A	=	annual soil loss due to runoff (tons/acre/year)
R	=	rainfall energy factor (ton/acre)
K	=	soil erodibility factor
LS	=	length-slope factor
C	=	cropping management factor
P	=	erosion control factor

Rainfall and Runoff Factor (R)

The Site is located in San Francisco County, CA. From the Isoerodent map of California (EPA, 2001), the R factor is estimated to be:

R Factor = 40 tons/acre

Soil Erodibility Factor (K)

Value based on conservative K value from an estimate of suitable cover soil based on performance and availability. A Fine Sandy Loam was chosen with an organic content less than 0.5% (Table 5.3, Steward 1975).

K = 0.35

Slope Length Gradient Factor (LS)

The Site area can be broken into three controlling surfaces in order to determine the LS factor. Three slope lines were taken from the Southern Slope, one from the northern slope, and one from the panhandle area as shown on Figure 1.

Southern Slope

Line #	Length (ft)	Slope%
1	1080	1.5
2	420	3
3	480	3
Average	470	2.5

Northern Slope

Line #	Length (ft)	Slope%
4	280	7

Panhandle

Line #	Length (ft)	Slope%
5	100	3%

The LS factor can be obtained through the following formula (referenced from Ontario Ministry of Agriculture)

$LS = [0.065 + 0.0456(slope) + 0.006541(slope)^2] \times (slope_length / const)^{NN}$

Where (const) = 72.5 for imperial units, and (NN) varies with slope by Table 3B (attached)

Southern Slope - 6% slope, Slope_Length = 470 feet, NN = 0.4

Northern Slope – 7% slope, Slope_length = 280 feet, NN = 0.5

Panhandle – 3% slope, Slope_Length = 100 feet, NN = 0.4

Southern Slope:

$LS = [0.065 + 0.0456(2.5) + 0.006541(2.5)^2] \times (660/ 72.5)^{0.4}$

$\mathbf{LS_{SS} = 0.53}$

Northern Slope:

$LS = [0.065 + 0.0456(7.0) + 0.006541(7.0)^2] \times (280/ 72.5)^{0.5}$

$\mathbf{LS_{NS} = 1.38}$

Panhandle:

$LS = [0.065 + 0.0456(3) + 0.006541(3)^2] \times (100 / 72.5)^{0.4}$

$\mathbf{LS_{PH} = 0.30}$

Cropping Management Factor (C)

The Site shall have a vegetative cover resembling Hay and Pasture crops (untilled) to control surface erosion over the cover and cut slopes (Table 4A). Based on this surface parameter, the C Factor is obtained from the crop type factor (Table 4A) and the tillage method factor (Table 4B)

Tables: http://www.omafra.gov.on.ca/english/engineer/facts/00-001.htm#tab4a

Crop type factor for Hay and Pasture crops = 0.02

Tillage Method Factor for spring plow = 0.25

$$C = 0.2 * 0.25 = 0.005$$

$$\boldsymbol{C = 0.005}$$

Erosion Control Factor (P)

A conservative estimate is assuming that no erosion control practices are in place and that the representative surface is an up and down slope.

P = 1 (Table 4A)

Universal Soil Loss Equation Solution:

$$A = R * K * LS * C * P$$

Southern Slope

$$A_{SS} = (40\frac{tons}{acre}) * (0.35) * 0.531 * 0.005 * 1$$

$$\boldsymbol{A_{SS} = 0.03717\ tons/acre/year}$$

Northern Slope

$$A_{NS} = \left(40\frac{tons}{acre}\right) * (0.35) * 1.38 * 0.005 * 1$$

$$\boldsymbol{A_{NS} = 0.0966\ tons/acre/year}$$

Panhandle

$$A_{PH} = \left(40\frac{tons}{acre}\right) * (0.35) * 0.3 * 0.005 * 1$$

$$\boldsymbol{A_{PH} = 0.021\ tons/acre/year}$$

Prior to the establishment of the vegetation, the crop management factor C = 1.0. In this case, the soil loss due to runoff for each area would be:

Southern Slope

$$\boldsymbol{A_{SS} = 7.434\ tons/acre/year}$$

Northern Slope

$$\boldsymbol{A_{NS} = 19.32\ tons/acre/year}$$

Panhandle

$$\boldsymbol{A_{PH} = 4.2\ tons/acre/year}$$

METHODOLGY FOR SOIL LOSS DUE TO WIND

$$E = f(I', K', C', L', V)$$

Where:

E	=	annual soil loss due to wind (tons/acre/year)
I'	=	soil erodibility factor
K'	=	soil ridge roughness factor
C'	=	Local Average Monthly or Annual Climate Factor
L'	=	Median Unsheltered Field Length along Direction of Prevailing Wind
V	=	Equivalent vegetative cover in pounds per acre

Let $\boldsymbol{E1 = I'}$

Using the attached sieve analysis for the cover soil, approximately 0.1% of the soil is retained on the number 20 sieve (0.84 mm), from Table 3, the soil erodibility factor was extrapolated to a value of approximately 430. The table recommends for fully crusted soil surface, values are approximately shown. A conservative approach is to use the values shown, knowing that the site is represented neither by a fully crusted soil surface nor by tilled or disturbed soil. Therefore:

$$I' = 430\frac{tons}{acre} * \frac{1}{3} = 134\frac{tons}{acre}$$

Let $E2 = I' * K'$

Using Figure 7, conservatively assume the field is flat and smooth, soil ridge roughness Kr = 0 and therefore K' = 1.0. Therefore:

$$E2 = 134\frac{tons}{acre} * 1.0 = 134\frac{tons}{acre}$$

Let $E3 = E2 * C$

C = 10 percent per month per the C factor isoline map developed by the NRCS in 1987

$$E3 = 134\frac{tons}{acre} * 0.1 = 13.4\frac{tons}{acre}year$$

Let $E4 = f(E2, E3, L)$

Use Figure 23 to determine E3. L' = 880 feet, as the longest unobstructed distance from the west.

$$E4 = 12$$

Prior to vegetation being established, the weight of vegetation covering of the soil is zero (V = 0). On figure 24 the lines for E4 = 12 tons per acre per year and V = 0 lbs per acre intersect at a value of:

$$\boldsymbol{E5 = 12\ tons/acre/year}\ \textbf{(Without vegetative cover)}$$

V is determined from the actual weight of vegetation and the type of stand of grass. Assuming a percent coverage of established vegetation at Hunters Point Shipyard of 90 percent and using the opinion of a seed specialist from Pacific Coast Seeds, the small grain mass coverage is 2,570 lbs of residue per acre from the table entitled "Percent ground cover to pounds residue." Vegetation at Hunters Point Shipyard was conservatively approximated as a combination of 45 percent blue grama, 30 percent buffalo grass, and 25 percent un-grazed western wheatgrass from NRCS guidance shown on the table titles "Properly grazed range grass mixtures". From this table, an equivalent flat small gain residue value of 3,570 corresponds to 900 lbs per acre of the chosen vegetation mixture. From Figure 9 then, a weight R' of 900 lbs per acre on smooth ground yields that V = 7,600 lbs/acre.

On figure 23, the lines for E4 = 12 tons per acre per year and V = 7,600 lbs per acre do not intersect, therefore the soil loss due to wind with an established vegetative cover is negligible.

$$\boldsymbol{E5 = 0\ tons/acre/year}\ \textbf{(With vegetation as described above)}$$

CONCLUSIONS

The maximum combined soil loss from water and wind effects over the design cover once vegetation is established is approximately 0.10 tons/acre/year. This is below the suggested maximum allowable soil loss value of 2.0 tons/acre/year, the final design cover will have sustainable soil losses once the vegetation establishment period is complete.

Prior to the establishment of the vegetation however, the maximum amount of soil loss from water and wind would be over 31 tons/acre/year, exceeding the maximum criteria. Best management practices for erosion control will need to be implemented until the vegetation has been established.

REFERENCES

Golden Gate Weather Services. 2012. "San Francisco International Airport Wind Analysis 1982-2012." December.

Ontario Ministry of Agriculture. "Universal Soil Loss Equation." http://www.omafra.gov.on.ca/english/engineer/facts/00-001.htm#tab3a

Richardson, G.N. 1997, "Design of Waste Containment Liner and Final Closure Systems," ASCE Sponsored Short Course, Portland, Oregon, February 27-28.

U.S. Army Corps of Engineers. 2002. "Coastal Engineering Manual - Part II." April.

U.S. Department of Agriculture 1996. " 27998 Federal Register Vol. 61, No. 108." June.

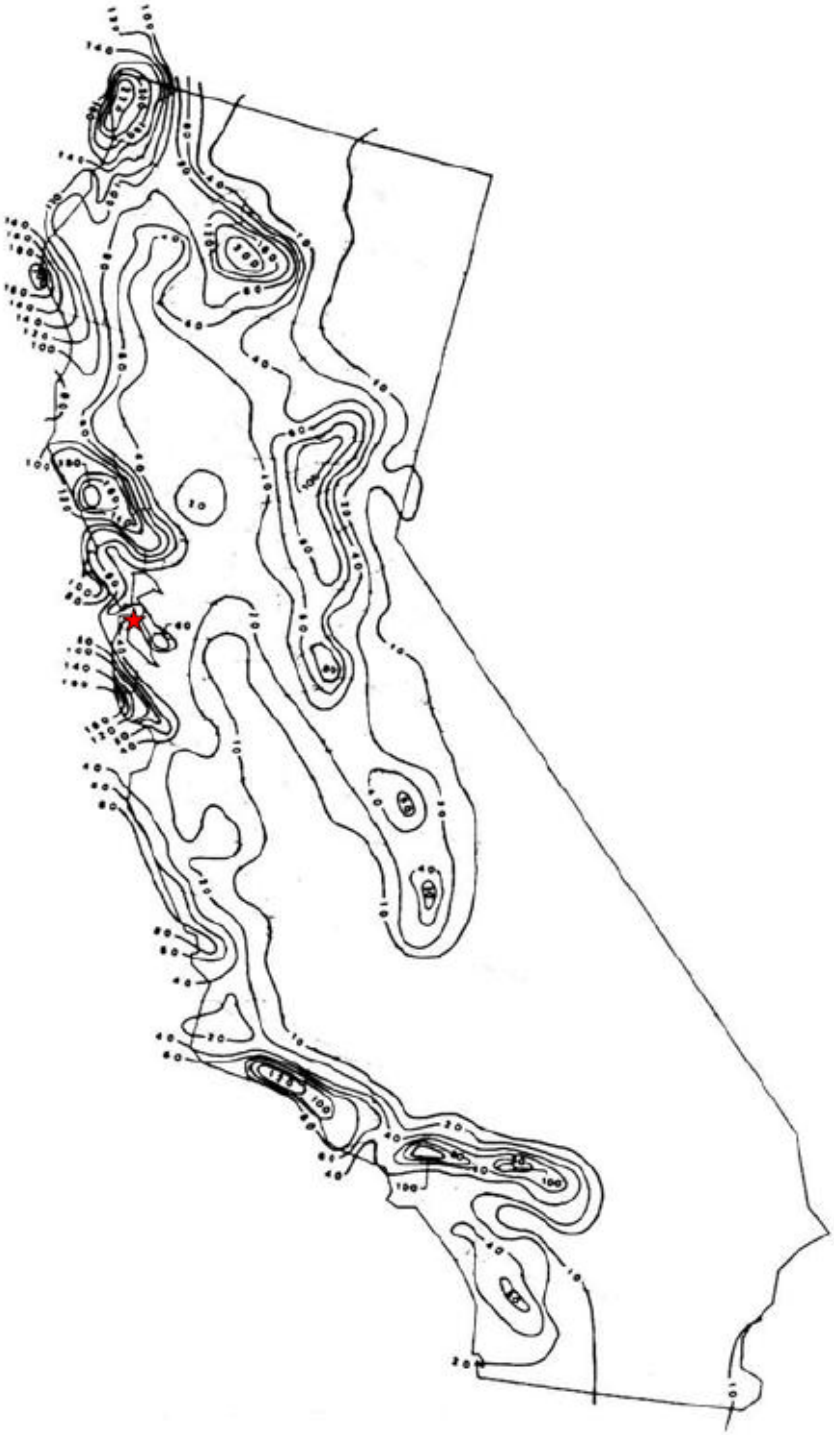
USDA, Handbook 346 – Wind Erosion Forces in the United States and their Use in Predicting Soil Loss.

ATTACHMENTS

Attachment 1. Water and Wind Erosion Wind Erosion References

Attachment 1. Water and Wind Erosion References

B-1: WATER EROSION REFERENCES



Values of the Annual Rainfall Energy Factor (R) in tons/acre

Isoerodent Map of California
Source: California EPA (2001)

TABLE 5.3 Magnitude of Soil Erodibility Factor, K

Technical Class	K for Organic Matter Content (%)		
	0.5	2	4
Sand	0.05	0.03	0.02
Fine sand	0.16	0.14	0.10
Very fine sand	0.42	0.36	0.28
Loamy sand	0.12	0.10	0.16
Loamy fine sand	0.24	0.20	0.16
Loamy very fine sand	0.44	0.38	0.30
Sandy loam	0.27	0.24	0.19
Fine sandy loam	0.35	0.30	0.24
Very fine sandy loam	0.47	0.41	0.35
Silt loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy clay loam	0.27	0.25	0.21
Clay loam	0.28	0.25	0.21
Silty clay loam	0.37	0.32	0.26
Sandy clay	0.14	0.13	0.12
Silty clay	0.25	0.23	0.19
Clay		0.13–0.2	

Source: After Steward et al. (1975)

Note: The values shown are the estimated averages of broad ranges of specific soil values. When a texture is near the borderline of two texture classes, use the average of the two *K* values.

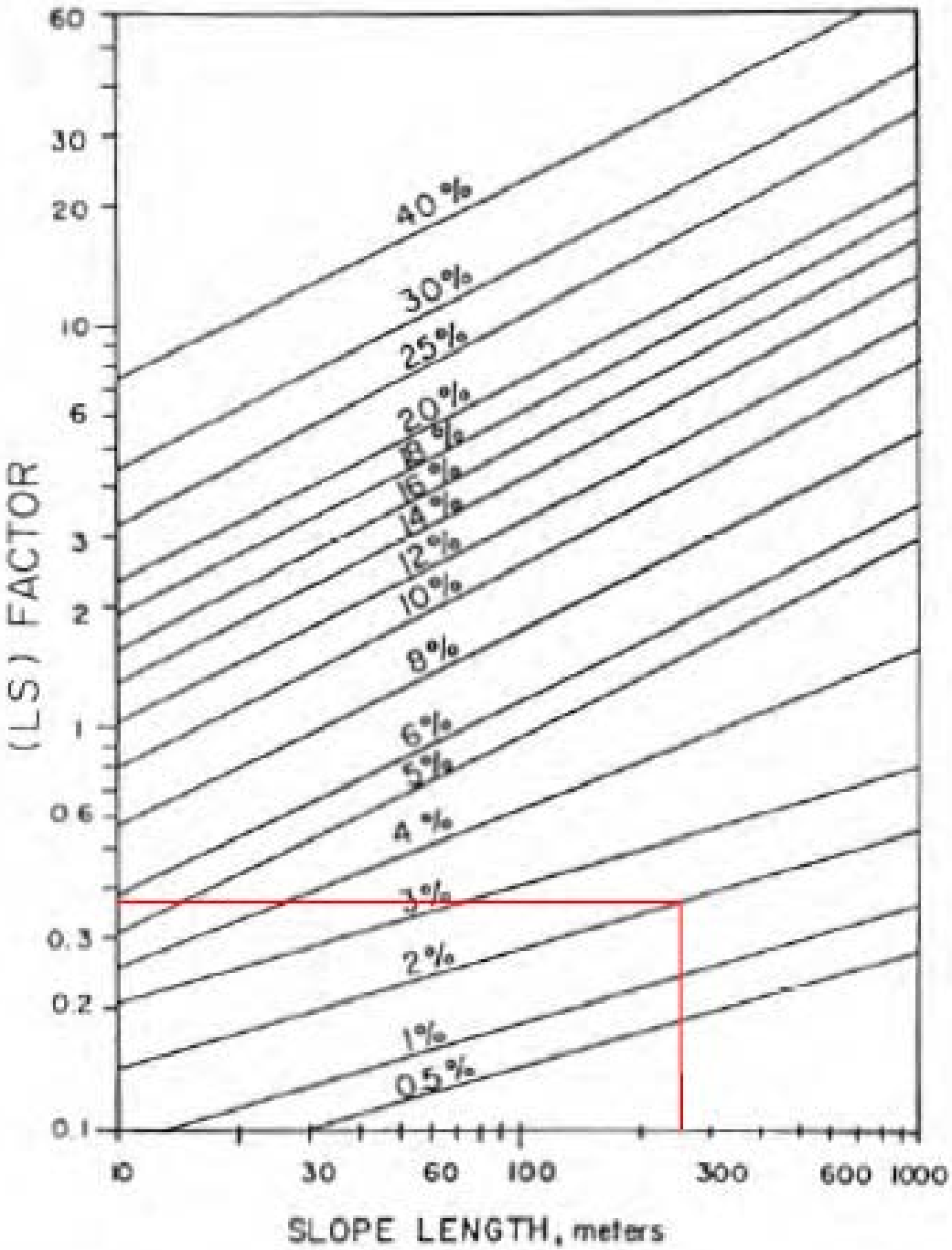


FIGURE 5.14. Slope-length factor (LS) for different slopes. (From Stewart et al., 1975.)

The cover and management factor, C, is the ratio of soil loss from land use under specified conditions to that from continuously fallow and tilled land. The USLE was developed for use on agricultural fields. It is adapted to use in nonagricultural conditions by appropriate selection of the C factor. This is often done by relating the land use conditions to some agricultural situation. For example, a firing range with a grass cover might be assumed to be similar to a pasture. Annual values of C for various cover and management conditions applicable to Army land uses are presented in Table A1.

Table A1 Cover management, "C" factors for permanent pasture, rangeland, and idle land.

Vegetal Canopy			Cover That Contacts the Surface					
			Percent Ground Cover					
Type and Height of Raised Canopy[2]	Canopy Covers[3] %	Type[4]	0	20	40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush, 0.5 m (1.6 ft.) fall ht.	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, 2 m 6.6 ft. fall ht.	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable, low brush , 4 m (13.1 ft.) fall ht.	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

[1]All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years.
[2]Average fall height of waterdrops from canopy to soil surface.
[3]Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a birds's-eye view).
[4]G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep. W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface, and/or undecayed residue).

Source: Reference not available. Downloaded from:
http://ecn.www.ecn.purdue.edu/~sedspec/sedspec/doc/usleapp.doc

B-2: WIND EROSION REFERENCES

TABLE 3.—*Soil erodibility I[1] for soils with different percentages of nonerodible fractions as determined by standard dry sieving*[1]

Dry soil fractions >0.84 mm. (percent) Tens ↓ / Units →	0	1	2	3	4	5	6	7	8	9
	Tons per acre	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*	*Tons per acre*
0	------	310	250	220	195	180	170	160	150	140
10	134	131	128	125	121	117	113	109	106	102
20	98	95	92	90	88	86	83	81	79	76
30	74	72	71	69	67	65	63	62	60	58
40	56	54	52	51	50	48	47	45	43	41
50	38	36	33	31	29	27	25	24	23	22
60	21	20	19	18	17	16	16	15	14	13
70	12	11	10	8	7	6	4	3	3	2
80	2	------	------	------	------	------	------	------	------	------

[1] For fully crusted soil surface, regardless of soil texture, erodibility *I* is, on the average, about one-sixth of that shown.

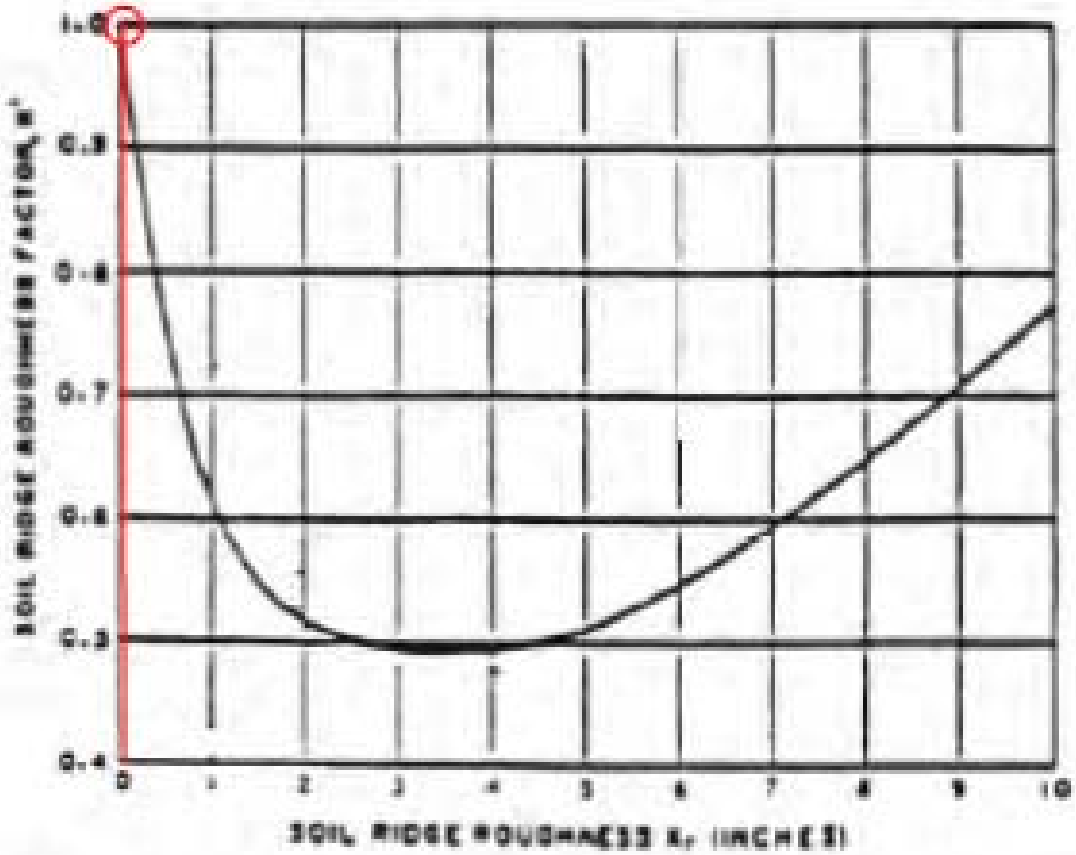
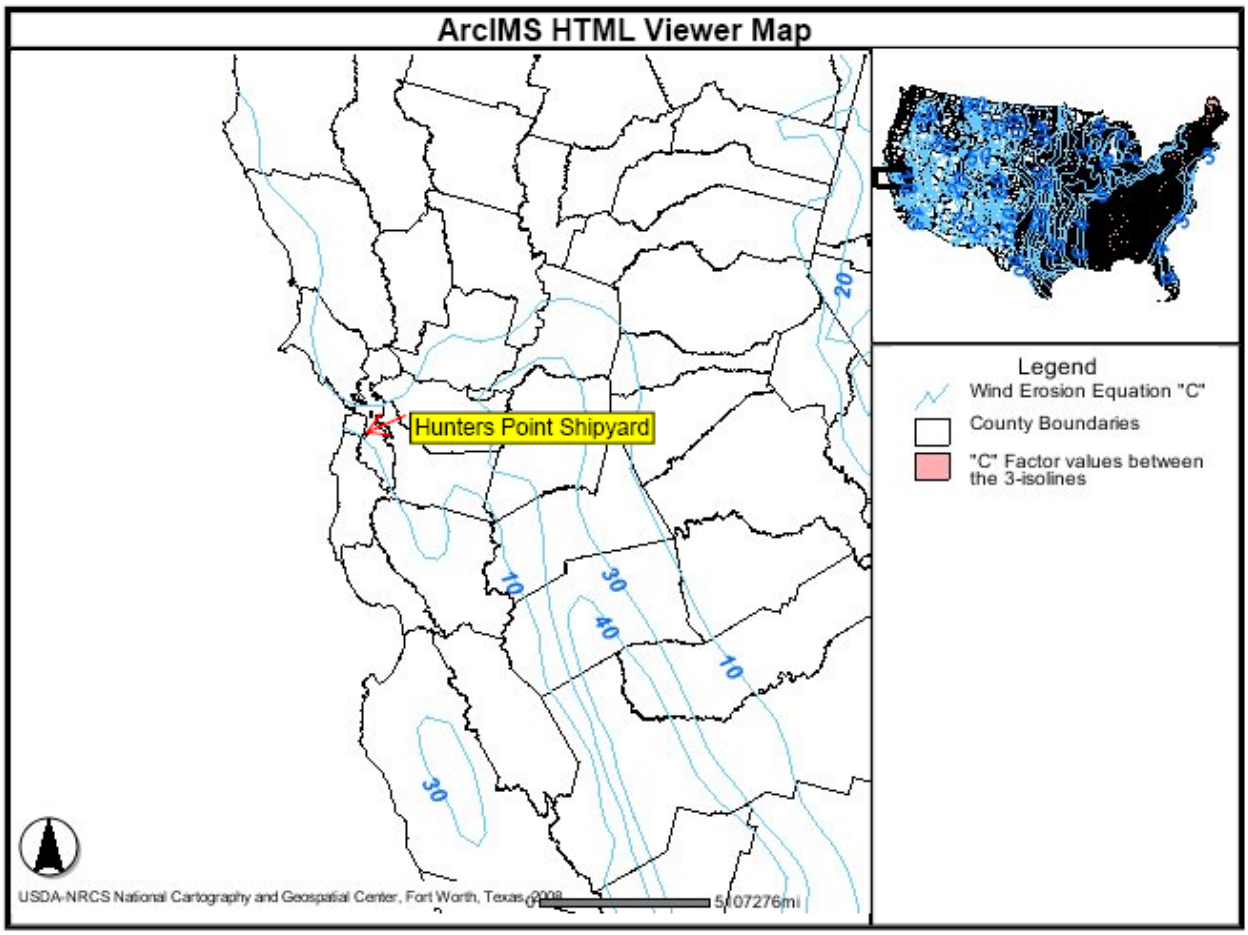


FIGURE 7.—Chart to determine soil ridge roughness factor K' from soil ridge roughness K.


ArcIMS HTML Viewer Map
Hunters Point Shipyard
20
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Legend
Wind Erosion Equation "C"
County Boundaries
"C" Factor values between the 3-isolines
USDA-NRCS National Cartography and Geospatial Center, Fort Worth, Texas, 2008
5.007276 mi

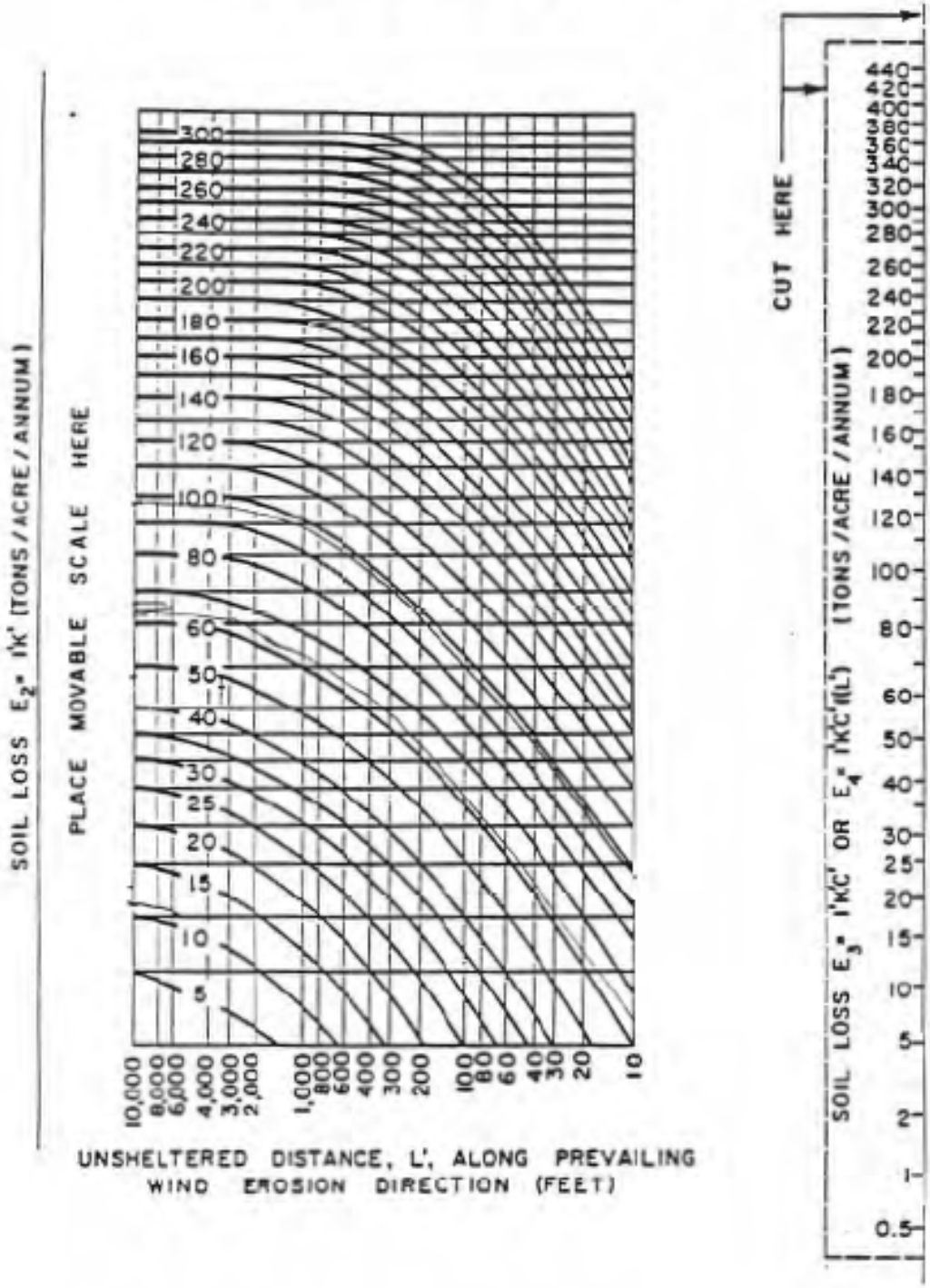


FIGURE 23.—Chart to determine soil loss $E_4 = I'K'C'/(L')$ from soil loss $E_2 = I'K'$ and $E_3 = I'K'C'$ and from unsheltered distance L' across field.

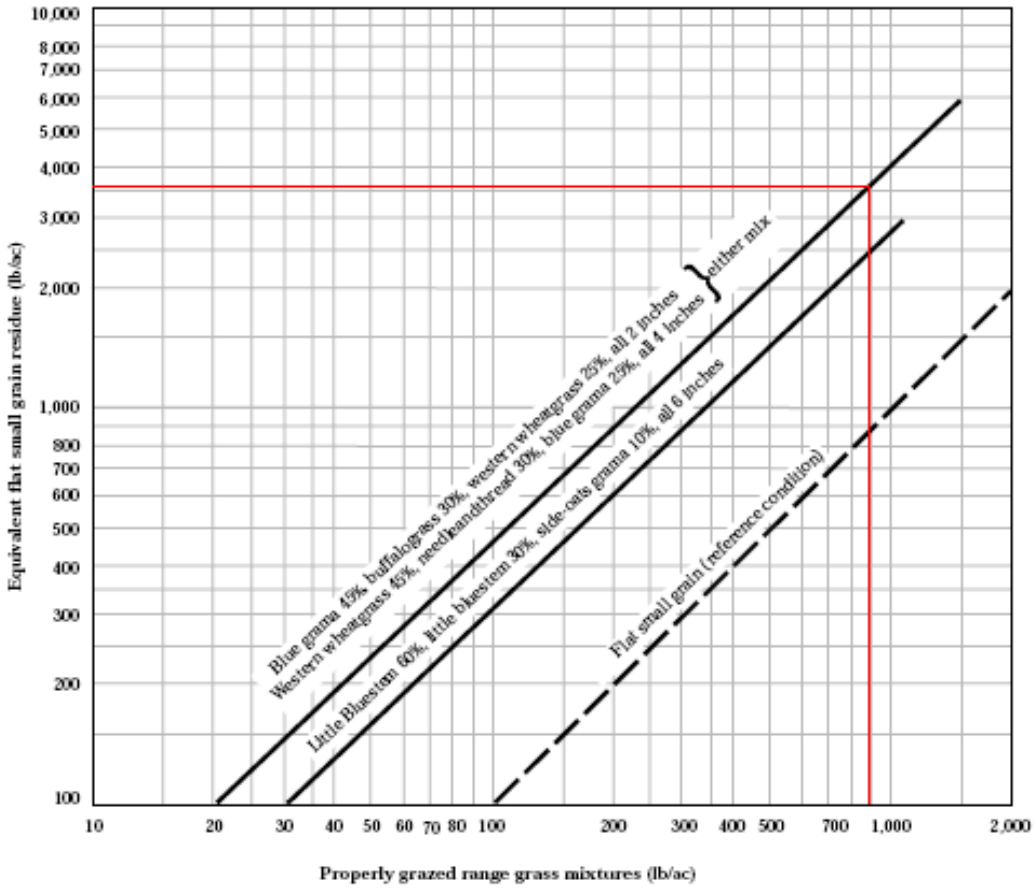
276-724 O-68—1

Percent ground cover to pounds residue				
The required crop residue may be expressed in percent ground cover in some plans and in pounds per acre in other plans. This table should be used to make the conversion from percent ground cover to pounds of residue. Residue weight varies with the variety of small grain grown. Some varieties might convert to more pounds than indicated on the table. Your SCS office may have a table that better represents the small grain varieties grown in your area	% cover	lbs. per acre	% cover	lbs. per acre
	5	80	55	1240
	10	160	60	1420
	15	250	65	1630
	20	350	70	1870
	25	450	75	2150
	30	550	80	2500
	35	670	85	2940
	40	790	90	3570
	45	930	95	4650
	50	1080	99	7140

New Mexico AGRONOMY TECHNICAL NOTE NO.73
http://www.nm.nrcs.usda.gov/technical/tech-notes/agro/ag73.doc

Flat small grain equivalent charts — Continued

Figure d-4 Flat small grain equivalents of properly grazed range grass mixture



Reference condition: Dry small grain stalks 10 inches long, lying flat on the soils surface in 10-inch rows perpendicular to wind direction, stalks oriented to wind direction.

Source: Lyles and Allison – 1980 Journal Range Management, 33(2), pages 143–146.

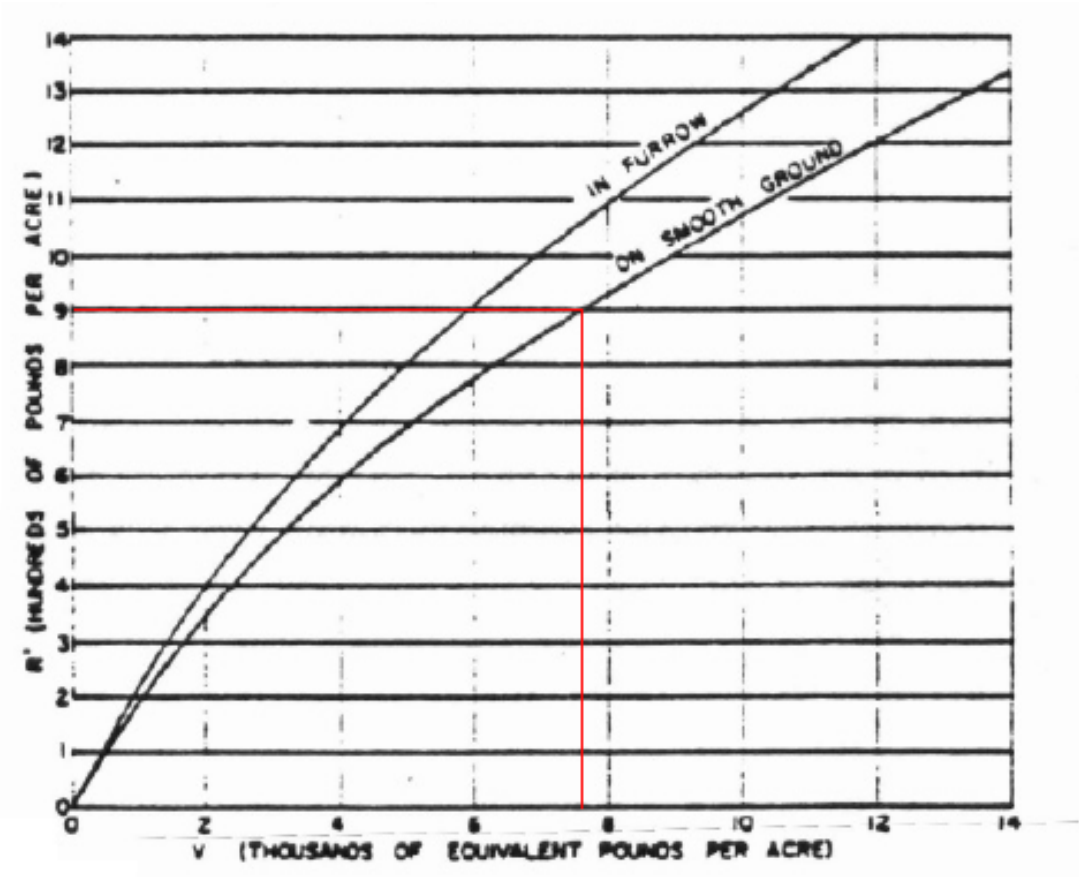


FIGURE 9.—Chart to determine V from R' or R' from V of live or dead small grain crops in seedling and stooling stage, above surface of ground, for crop in 3-inch-deep furrow as created by deep-furrow drill on smooth ground.

276-724 O-68—2

AGRICULTURE HANDBOOK 346, U.S. DEPT. OF AGRICULTURE

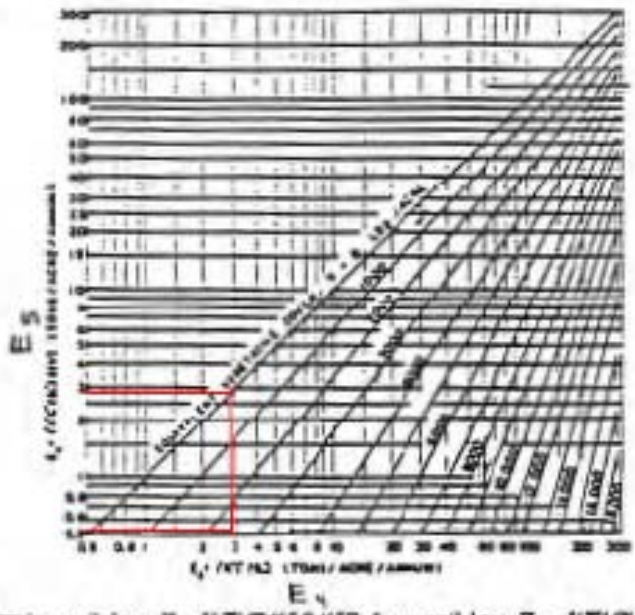


FIGURE 24.—Chart to determine soil loss $E = I'X'C'f(L')(V)$ from soil loss $E_4 = I'X'C'f(L')$ and from vegetative cover factor V. Chart can be used in reverse to determine V needed to reduce soil loss to any degree.

A7. Tidal Datums

Project	HPNS, Parcel E-2	**Component/System:**	Tidal Datums
Prepared by:	ALM	**Checked by:**	DB
Date	10-2012	**Date**	3-2013

PURPOSE

The purpose of this evaluation is to determine the tidal datums in the vicinity of Parcel E-2. These datums will be used to support the design of the shoreline protection structure for Parcel E-2.

DATA

There are two primary tidal datums that are used for the site. These datums are based on data published by the National Oceanographic and Atmospheric Administration (NOAA) National Ocean Service and the National Geodetic Survey (NGS) (NOAA, 2009 and NGS, 2012). Relevant data sheets from the NOAA and NGS information sources are attached to this brief for reference. All tidal elevation survey data are based on the following benchmark: Hunter West1 1941; Point ID HT0613; Tidal Station I.D. 9414358 (latitude: 37° 43.8' N and longitude: 122° 21.4' W). Tidal data from NOAA tidal epoch 1960 to 1978 were used in this analysis. A second tidal datum summary is available from NOAA for tidal epoch 1983 to 2001; however, the data set does not include information to relate the data to either the National Geodetic Vertical Datum (NGVD) 1929 or the North American Vertical Datum (NAVD) 1988. Therefore, data for the 1983 to 2001 tidal epoch were not included in this analysis.

The tidal datum elevations derived from the aforementioned sources are summarized in Table 1. All data were corrected to NGVD 1929; the universal vertical datum selected for this design package.

REFERENCES

NGS, 2012. http://www.ngs.noaa.gov/cgi-bin/ds_quads.prl. Last updated on 10/23/2012.

NOAA, 2009. http://tidesandcurrents.noaa.gov/benchmarks/benchmarks_old/9414358.html. Last updated on 2/2/2009.

U.S. Army Corps of Engineers, 1984. "San Francisco Bay Tidal Stage vs. Frequency Study." October.

ATTACHMENTS

Attachment 1. NGS Tidal Benchmarks Data for Hunters Point

Attachment 2. NOAA Tidal Datums for Tidal Epoch 1960 to 1978

Attachment 3. San Francisco Bay Tidal Stage vs. Frequency Study, Table 5

TABLE 1. Historical Tidal Datum Elevations

	Tidal Epoch	1960 to 1978	1960 to 1978
	Data Reduction Method	Tidal Station Data	NGVD = MLLW – 3.12[1]
	Reference Datum	MLLW	NGVD 1929
	Units	feet	feet
Tidal Datum	**Description**	**Historical Tidal Elevation**	
Extreme Tide	100 Year Return Interval	+9.8[2]	+6.7
HOWL	Highest Observed Tide	+8.16[3]	+5.04
MHHW	Mean Higher High Water	+6.73	+3.61
MHW	Mean High Water	+6.10	+2.98
MTL	Mean Tide Level	+3.61	+0.49
MSL	Mean Sea Level	+3.12	0.00
MLW	Mean Low Water	+1.12	-2.00
MLLW	Mean Lower Low Water	0.00	-3.12
LOWL	Lowest Observed Water Level	-1.86	-4.98

Notes:

1. NGVD = MLLW – 3.12' (Interpretation: MLLW reported as -3.12 NGVD)
2. From Table 5, San Francisco Bay Tidal Stage vs. Frequency Study, U.S. Army Corps of Engineers, 1984.
3. Highest observed tide recorded on December 27, 1974

Attachment 1. NGS Tidal Benchmarks Data for Hunters Point

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 7.89.6
1         National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
 HT0616 ***********************************************************************
 HT0616  TIDAL BM     -  This is a Tidal Bench Mark.
 HT0616  DESIGNATION -  4
 HT0616  PID          -  HT0616
 HT0616  STATE/COUNTY-  CA/SAN FRANCISCO
 HT0616  COUNTRY      -  US
 HT0616  USGS QUAD    -  HUNTERS POINT (1993)
 HT0616
 HT0616                         *CURRENT SURVEY CONTROL
 HT0616  ______________________________________________________________________
 HT0616* NAD 83(1986) POSITION- 37 43 45.     (N) 122 21 31.     (W)   SCALED
 HT0616* NAVD 88 ORTHO HEIGHT -     4.54   (+/-2cm)      14.9   (feet) VERTCON
 HT0616  ______________________________________________________________________
 HT0616  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
 HT0616  VERT ORDER      -  FIRST     CLASS II (See Below)
 HT0616
 HT0616.The horizontal coordinates were scaled from a topographic map and have
 HT0616.an estimated accuracy of +/- 6 seconds.
 HT0616.
 HT0616.The NAVD 88 height was computed by applying the VERTCON shift value to
 HT0616.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 HT0616
 HT0616.The vertical order pertains to the NGVD 29 superseded value.
 HT0616
 HT0616.This Tidal Bench Mark is designated as VM 8100
 HT0616.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
 HT0616
 HT0616;                    North         East    Units  Estimated Accuracy
 HT0616;SPC CA 3     -   638,040.    1,836,180.      MT  (+/- 180 meters Scaled)
 HT0616
 HT0616                          SUPERSEDED SURVEY CONTROL
 HT0616
 HT0616  NGVD 29 (??/??/92)    3.720  (m)           12.20   (f) ADJ UNCH    1 2
 HT0616
 HT0616.Superseded values are not recommended for survey control.
 HT0616
 HT0616.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HT0616.See file dsdata.txt to determine how the superseded data were derived.
 HT0616
 HT0616_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG565759(NAD 83)
 HT0616
 HT0616_MARKER: DB = BENCH MARK DISK
 HT0616_SETTING: 30 = SET IN A LIGHT STRUCTURE
 HT0616_SP_SET: PLATFORM
 HT0616_STAMPING: 4 1941
 HT0616_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY
 HT0616
 HT0616  HISTORY     - Date     Condition        Report By
 HT0616  HISTORY     - 1941     MONUMENTED       CGS
 HT0616  HISTORY     - 1956     GOOD             CGS
```

```
 HT0616
 HT0616                          STATION DESCRIPTION
 HT0616
 HT0616'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
 HT0616'AT HUNTERS POINT.
 HT0616'AT HUNTERS POINT, AT THEH SAN FRANCISCO NAVAL SHIPYARDS, AT
 HT0616'THE NORTHEAST CORNER OF A LARGE CONCRETE AND METAL MACHINE
 HT0616'SHOP BUILDING NO. 231, IN THE TOP OF THE SOUTHEAST CORNER OF THE
 HT0616'CONCRETE LOADING PLATFORM ON THE NORTH SIDE AND AT THE NORTHEAST
 HT0616'CORNER OF THE BUILDING, 96.0 FEET SOUTH OF THE SOUTH SIDE OF
 HT0616'DRY DOCK NO. 2, 0.5 FOOT NORTH OF THE NORTH WALL, AND ABOUT
 HT0616'3 FEET HIGHER THAN THE ASPHALT.
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
 HT0615 ***********************************************************************
 HT0615  TIDAL BM    -  This is a Tidal Bench Mark.
 HT0615  DESIGNATION -  5
 HT0615  PID         -  HT0615
 HT0615  STATE/COUNTY-  CA/SAN FRANCISCO
 HT0615  COUNTRY     -  US
 HT0615  USGS QUAD   -  HUNTERS POINT (1993)
 HT0615
 HT0615                        *CURRENT SURVEY CONTROL
 HT0615  ______________________________________________________________________
 HT0615* NAD 83(1986) POSITION- 37 43 45.     (N) 122 21 30.     (W)   SCALED
 HT0615* NAVD 88 ORTHO HEIGHT -     4.56   (+/-2cm)      15.0   (feet) VERTCON
 HT0615  ______________________________________________________________________
 HT0615  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
 HT0615  VERT ORDER      -  FIRST     CLASS II (See Below)
 HT0615
 HT0615.The horizontal coordinates were scaled from a topographic map and have
 HT0615.an estimated accuracy of +/- 6 seconds.
 HT0615.
 HT0615.The NAVD 88 height was computed by applying the VERTCON shift value to
 HT0615.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 HT0615
 HT0615.The vertical order pertains to the NGVD 29 superseded value.
 HT0615
 HT0615.This Tidal Bench Mark is designated as VM 8101
 HT0615.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
 HT0615
 HT0615;                    North         East    Units  Estimated Accuracy
 HT0615;SPC CA 3     -   638,040.    1,836,200.      MT  (+/- 180 meters Scaled)
 HT0615
 HT0615                          SUPERSEDED SURVEY CONTROL
 HT0615
 HT0615  NGVD 29 (??/??/92)    3.738  (m)           12.26   (f) ADJ UNCH    1 2
 HT0615
 HT0615.Superseded values are not recommended for survey control.
 HT0615
 HT0615.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HT0615.See file dsdata.txt to determine how the superseded data were derived.
 HT0615
 HT0615_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG565759(NAD 83)
 HT0615
 HT0615_MARKER: DB = BENCH MARK DISK
 HT0615_SETTING: 36 = SET IN A MASSIVE STRUCTURE
 HT0615_SP_SET: BUILDING
 HT0615_STAMPING: 5 1941
 HT0615_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
 HT0615
```

```
HT0615  HISTORY     - Date     Condition        Report By
HT0615  HISTORY     - 1941     MONUMENTED       CGS
HT0615  HISTORY     - 1956     GOOD             CGS
HT0615
HT0615                          STATION DESCRIPTION
HT0615
HT0615'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
HT0615'AT HUNTERS POINT.
HT0615'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARDS, ON THE
HT0615'SOUTH SIDE OF A LARGE CONCRETE AND METAL MACHINE SHOP BUILDING
HT0615'NO. 231, AT DOOR 16, IN THE TOP OF THE NORTHWEST CORNER OF THE
HT0615'CONCRETE LOADING PLATFORM, 6.2 FEET EAST OF THE EAST RAIL OF
HT0615'A RAILROAD TRACK LEADING THROUGH THE BUILDING, 0.5 FOOT SOUTH
HT0615'OF THE SOUTH WALL OF THE BUILDING, AND ABOUT 3 FEET HIGHER
HT0615'THAN THE ASPHALT.
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
HT0620 ***********************************************************************
HT0620  TIDAL BM    -  This is a Tidal Bench Mark.
HT0620  DESIGNATION -  HUNTER EAST
HT0620  PID         -  HT0620
HT0620  STATE/COUNTY-  CA/SAN FRANCISCO
HT0620  COUNTRY     -  US
HT0620  USGS QUAD   -  HUNTERS POINT (1993)
HT0620
HT0620                        *CURRENT SURVEY CONTROL
HT0620  ______________________________________________________________________
HT0620* NAD 83(1992) POSITION- 37 43 44.48133(N) 122 21 32.96786(W)   ADJUSTED
HT0620* NAD 83(1992) EPOCH   -  1991.35
HT0620* NAVD 88 ORTHO HEIGHT -     3.14   (+/-2cm)      10.3   (feet) VERTCON
HT0620  ______________________________________________________________________
HT0620  LAPLACE CORR    -          0.48  (seconds)                    DEFLEC12A
HT0620  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
HT0620  HORZ ORDER      -  SECOND
HT0620  VERT ORDER      -  FIRST     CLASS II (See Below)
HT0620
HT0620.The horizontal coordinates were established by classical geodetic methods
HT0620.and adjusted by the National Geodetic Survey in March 1994.
HT0620.
HT0620.The NAVD 88 height was computed by applying the VERTCON shift value to
HT0620.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
HT0620
HT0620.The vertical order pertains to the NGVD 29 superseded value.
HT0620
HT0620.This Tidal Bench Mark is designated as VM 8103
HT0620.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
HT0620
HT0620.The Laplace correction was computed from DEFLEC12A derived deflections.
HT0620
HT0620. The following values were computed from the NAD 83(1992) position.
HT0620
HT0620;                    North         East     Units Scale Factor Converg.
HT0620;SPC CA 3     -   638,025.745 1,836,128.943   MT  0.99992925   -1 08 17.6
HT0620;SPC CA 3     - 2,093,256.13  6,024,033.04   sFT  0.99992925   -1 08 17.6
HT0620;UTM  10      - 4,175,943.464   556,470.938   MT  0.99963928   +0 23 31.8
HT0620
HT0620!             -  Elev Factor  x  Scale Factor =   Combined Factor
HT0620!SPC CA 3     -   1.00000461  x   0.99992925  =   0.99993386
HT0620!UTM  10      -   1.00000461  x   0.99963928  =   0.99964389
HT0620
HT0620:                Primary Azimuth Mark                     Grid Az
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HT0620:SPC CA 3     -  POINT AVISADERO RESET                    229 58 39.8
HT0620:UTM  10      -  POINT AVISADERO RESET                    228 26 50.4
HT0620
HT0620|-----------------------------------------------------------------------|
HT0620| PID    Reference Object                     Distance      Geod. Az   |
HT0620|                                                           dddmmss.s  |
HT0620| HT2728 POINT AVISADERO RESET               APPROX. 0.6 KM 2285022.2  |
HT0620| HT0613 HUNTER WEST 1                       274.036 METERS 25321      |
HT0620|-----------------------------------------------------------------------|
HT0620
HT0620                          SUPERSEDED SURVEY CONTROL
HT0620
HT0620  NAD 83(1986)-  37 43 44.47515(N)    122 21 32.96631(W) AD(1984.00) 2
HT0620  NAD 27      -  37 43 44.71900(N)    122 21 29.06400(W) AD(       ) 2
HT0620  NGVD 29 (??/??/92)    2.311  (m)            7.58   (f) ADJ UNCH    1 2
HT0620
HT0620.Superseded values are not recommended for survey control.
HT0620
HT0620.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HT0620.See file dsdata.txt to determine how the superseded data were derived.
HT0620
HT0620_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG5647075943(NAD 83)
HT0620
HT0620_MARKER: DS = TRIANGULATION STATION DISK
HT0620_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
HT0620_SP_SET: SET IN TOP OF CONCRETE MONUMENT
HT0620_STAMPING: HUNTER EAST 1941
HT0620_MAGNETIC: R = STEEL ROD IMBEDDED IN MONUMENT
HT0620_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
HT0620+STABILITY: SURFACE MOTION
HT0620
HT0620  HISTORY     - Date     Condition        Report By
HT0620  HISTORY     - 1941     MONUMENTED       CGS
HT0620  HISTORY     - 1944     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1948     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1948     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1951     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1953     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1956     GOOD             CGS
HT0620  HISTORY     - 1958     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1965     SEE DESCRIPTION  CGS
HT0620  HISTORY     - 1979     GOOD             NOS
HT0620
HT0620                          STATION DESCRIPTION
HT0620
HT0620'DESCRIBED BY COAST AND GEODETIC SURVEY 1941 (WDP)
HT0620'STATION IS LOCATED AT U.S. NAVY SHIPYARD AT HUNTERS POINT.  ON
HT0620'THE S SIDE OF LARGE DRYDOCK, S OF THE TRACKS USED FOR THE
HT0620'CRANE.  AND APPROXIMATELY HALFWAY BETWEEN THE S EDGE OF DOCK
HT0620'AND THE BRICK BUILDING USED AS A SUPPLY ROOM, AND ABOUT 1000
HT0620'FEET FROM THE GATE AT THE ENTRANCE TO THE YARD.
HT0620'
HT0620'STATION MARK IS A BRONZE DISK SET IN CONCRETE, THAT WAS POURED
HT0620'INTO A HOLE ABOUT 12 INCHES IN DIAMETER CHISELED PAVEMENT.
HT0620
HT0620                          STATION RECOVERY (1944)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1944 (EHP)
HT0620'STATION IS AT THE U.S. NAVY DRYDOCK AT HUNTERS POINT, ON THE
HT0620'S SIDE OF DRYDOCK 3, AND APPROXIMATELY HALFWAY BETWEEN THE
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HT0620'S EDGE OF THE DOCK AND THE BRICK BUILDING USED AS A SUPPLY
HT0620'ROOM, AND ABOUT 100 FEET W OF THE CENTER LINE OF THE CAISSON
HT0620'OF DRYDOCK 3.  MARK IS ABOUT 8 INCHES BELOW SURFACE OF THE
HT0620'PAVEMENT AND HAS A REMOVABLE STEEL CAP OVER THE HOLE.
HT0620
HT0620                          STATION RECOVERY (1948)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1948 (WMG)
HT0620'RECOVERED AS DESCRIBED.  THE MARK APPEARS TO BE IN GOOD CONDITION.
HT0620
HT0620                          STATION RECOVERY (1948)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1948 (EHB)
HT0620'COPIED FROM TIDAL BENCH MARK RECORDS--
HT0620'
HT0620'STATION RECOVERED.  STAMPED HUNTER EAST 1941.  THE HAND HOLE
HT0620'COVER IS STAMPED SFWD.
HT0620
HT0620                          STATION RECOVERY (1951)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1951 (RAM)
HT0620'STATION WAS RECOVERED AS DESCRIBED.  IT IS 18 FT. S OF THE
HT0620'S SIDE OF THE DRYDOCK.
HT0620'
HT0620'STEEL HANDHOLE AND COVER PLATE IS APPROXIMATELY 10 IN. IN DIAMETER.
HT0620
HT0620                          STATION RECOVERY (1953)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1953 (FAR)
HT0620'STATION RECOVERED IN GOOD CONDITION AS DESCRIBED.  A COMPLETE
HT0620'DESCRIPTION FOLLOWS--
HT0620'
HT0620'AT THE SAN FRANCISCO NAVAL SHIPYARD, ON THE S SIDE OF DRYDOCK
HT0620'NO. 3, 18 FT. S OF THE S EDGE OF THE DRYDOCK, 93 FT. S OF THE
HT0620'CENTERLINE OF THE DRYDOCK, ABOUT 110 FT. W BY S OF THE S
HT0620'END OF THE DRYDOCK CAISSON, 64 FT. W BY N OF THE CENTER OF
HT0620'THE CAPSTAN AT THE SE END OF THE DRYDOCK, IN A CONCRETE WELL
HT0620'ABOUT 0.8 FT. BELOW THE PAVEMENT WITH A STEEL COVERPLATE STAMPED
HT0620'SFWD.  DISK COULD BE FELT AT TIME OF RECOVERY, AND IS
HT0620'APPARENTLY IN GOOD CONDITION, BUT COULD NOT BE CLOSELY EXAMINED
HT0620'BECAUSE OF SEVERAL INCHES OF WATER IN THE WELL.
HT0620
HT0620                          STATION RECOVERY (1956)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1956
HT0620'AT HUNTERS POINT.
HT0620'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARDS, BETWEEN
HT0620'DRY DOCKS 2 AND 3, ON THE SOUTH SIDE OF DRY DOCK 3, IN THE
HT0620'TOP OF THE SUBSURFACE OF A CONCRETE RETAINING WALL ABOUT 0.8
HT0620'FOOT LOWER THAN THE TOP OF AN ASPHALT DRIVEWAY, 95.9 FEET
HT0620'WEST OF THE SOUTHWEST CORNER OF THE SOUTH END OF THE DRY DOCK
HT0620'CAISSON, 35.1 FEET NORTH OF THE NORTH WALL OF A BRICK BUILDING
HT0620'(COMMANDING OFFICERS ROOM AND WASH HOUSE), 17.8 FEET SOUTH OF
HT0620'THE SOUTH SIDE OF DRY DOCK 3, 7.5 FEET SOUTH OF THE SOUTH RAIL
HT0620'OF A CRANE TRACK, AND ABOUT 0.8 FOOT LOWER THAN THE GROUND.
HT0620'NOTE-- ACCESS TO MARK HAD THROUGH A 10-INCH CAST IRON LID MARKED
HT0620'S.F.W.D.8.
HT0620
HT0620                          STATION RECOVERY (1958)
HT0620
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HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1958 (JCM)
HT0620'THE STATION MARK WAS RECOVERED IN GOOD CONDITION AS DESCRIBED
HT0620'IN 1941, 1944, 1938, 1951 AND 1953.
HT0620
HT0620                          STATION RECOVERY (1965)
HT0620
HT0620'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1965 (PAS)
HT0620'THE STATION WAS RECOVERED AS DESCRIBED BY F.A.R. IN 1953.
HT0620
HT0620                          STATION RECOVERY (1979)
HT0620
HT0620'RECOVERY NOTE BY NATIONAL OCEAN SERVICE 1979 (DRT)
HT0620'STATION WAS RECOVERED IN GOOD CONDITION AS DESCRIBED IN 1953.
HT0620'
HT0620'DESCRIBED BY F.L. ROSARIO
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
HT0613 ***********************************************************************
HT0613  HT_MOD      -  This is a Height Modernization Survey Station.
HT0613  TIDAL BM    -  This is a Tidal Bench Mark.
HT0613  DESIGNATION -  HUNTER WEST 1
HT0613  PID         -  HT0613
HT0613  STATE/COUNTY-  CA/SAN FRANCISCO
HT0613  COUNTRY     -  US
HT0613  USGS QUAD   -  HUNTERS POINT (1993)
HT0613
HT0613                        *CURRENT SURVEY CONTROL
HT0613  ___________________________________________________________________
HT0613* NAD 83(2011) POSITION- 37 43 41.95354(N) 122 21 43.70750(W)   ADJUSTED
HT0613* NAD 83(2011) ELLIP HT-   -29.216 (meters)        (06/27/12)   ADJUSTED
HT0613* NAD 83(2011) EPOCH   -  2010.00
HT0613* NAVD 88 ORTHO HEIGHT -     3.35   (meters)      11.0   (feet) GPS OBS
HT0613  ___________________________________________________________________
HT0613  NAVD 88 orthometric height was determined with geoid model    GEOIDXU
HT0613  GEOID HEIGHT    -        -32.50  (meters)                     GEOIDXU
HT0613  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
HT0613  NAD 83(2011) X  - -2,703,597.059 (meters)                     COMP
HT0613  NAD 83(2011) Y  - -4,266,415.908 (meters)                     COMP
HT0613  NAD 83(2011) Z  -  3,881,619.876 (meters)                     COMP
HT0613  LAPLACE CORR    -          0.47  (seconds)                   DEFLEC12A
HT0613
HT0613  FGDC Geospatial Positioning Accuracy Standards (95% confidence, cm)
HT0613  Type                                          Horiz  Ellip  Dist(km)
HT0613  ------------------------------------------------------------------
HT0613  NETWORK                                        0.70   1.22
HT0613  ------------------------------------------------------------------
HT0613  MEDIAN LOCAL ACCURACY AND DIST (004 points)   0.71   1.20     11.07
HT0613  ------------------------------------------------------------------
HT0613  NOTE: Click here for information on individual local accuracy
HT0613  values and other accuracy information.
HT0613
HT0613
HT0613.The horizontal coordinates were established by GPS observations
HT0613.and adjusted by the National Geodetic Survey in June 2012.
HT0613
HT0613.NAD 83(2011) refers to NAD 83 coordinates where the reference
HT0613.frame has been affixed to the stable North American tectonic plate. See
HT0613.www.ngs.noaa.gov/web/surveys/NA2011 for more information.
HT0613
HT0613.The horizontal coordinates are valid at the epoch date displayed above
HT0613.which is a decimal equivalence of Year/Month/Day.
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HT0613
HT0613.The orthometric height was determined by GPS observations and a
HT0613.high-resolution geoid model using precise GPS observation and
HT0613.processing techniques.
HT0613
HT0613.This Tidal Bench Mark is designated as VM 8102
HT0613.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
HT0613
HT0613.The X, Y, and Z were computed from the position and the ellipsoidal ht.
HT0613
HT0613.The Laplace correction was computed from DEFLEC12A derived deflections.
HT0613
HT0613.The ellipsoidal height was determined by GPS observations
HT0613.and is referenced to NAD 83.
HT0613
HT0613. The following values were computed from the NAD 83(2011) position.
HT0613
HT0613;                     North         East     Units Scale Factor Converg.
HT0613;SPC CA 3     -   637,953.060 1,835,864.477   MT  0.99992926   -1 08 24.2
HT0613;SPC CA 3     - 2,093,017.66  6,023,165.37   sFT  0.99992926   -1 08 24.2
HT0613;UTM  10      - 4,175,863.764   556,208.583   MT  0.99963891   +0 23 25.2
HT0613
HT0613!             -  Elev Factor  x  Scale Factor =   Combined Factor
HT0613!SPC CA 3     -   1.00000458  x   0.99992926  =   0.99993384
HT0613!UTM  10      -   1.00000458  x   0.99963891  =   0.99964349
HT0613
HT0613:                Primary Azimuth Mark                     Grid Az
HT0613:SPC CA 3     -  COLEMAN                                  262 08 55.9
HT0613:UTM  10      -  COLEMAN                                  260 37 06.5
HT0613
HT0613|---------------------------------------------------------------------|
HT0613| PID    Reference Object                     Distance      Geod. Az  |
HT0613|                                                           dddmmss.s |
HT0613| HT0620 HUNTER EAST                         274.036 METERS 07320     |
HT0613| HT2724 BLDG 253                            333.594 METERS 12358     |
HT0613| HT2720 COLEMAN                             APPROX. 0.6 KM 2610031.7 |
HT0613|---------------------------------------------------------------------|
HT0613
HT0613                          SUPERSEDED SURVEY CONTROL
HT0613
HT0613  NAD 83(2007)-  37 43 41.95022(N)    122 21 43.70610(W) AD(2007.00) 0
HT0613  ELLIP H (02/10/07)  -29.221  (m)                       GP(2007.00)
HT0613  NAD 83(1998)-  37 43 41.94615(N)    122 21 43.70174(W) AD(2002.75) B
HT0613  ELLIP H (08/23/04)  -29.147  (m)                       GP(2002.75) 4 1
HT0613  NAD 83(1992)-  37 43 41.93343(N)    122 21 43.68924(W) AD(1991.35) 3
HT0613  NAD 83(1986)-  37 43 41.92727(N)    122 21 43.68750(W) AD(1984.00) 3
HT0613  NAD 27      -  37 43 42.17100(N)    122 21 39.78600(W) AD(       ) 3
HT0613  NGVD 29 (??/??/92)    2.498  (m)            8.20   (f) ADJ UNCH    1 2
HT0613
HT0613.Superseded values are not recommended for survey control.
HT0613
HT0613.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
HT0613.See file dsdata.txt to determine how the superseded data were derived.
HT0613
HT0613_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG5620875863(NAD 83)
HT0613
HT0613_MARKER: DR = REFERENCE MARK DISK
HT0613_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
HT0613_SP_SET: SET IN TOP OF CONCRETE MONUMENT
HT0613_STAMPING: HUNTER WEST 1 1941
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HT0613_PROJECTION: RECESSED 12 CENTIMETERS
HT0613_MAGNETIC: N = NO MAGNETIC MATERIAL
HT0613_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
HT0613+STABILITY: SURFACE MOTION
HT0613_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
HT0613+SATELLITE: SATELLITE OBSERVATIONS - September , 2002
HT0613
HT0613  HISTORY     - Date     Condition        Report By
HT0613  HISTORY     - 1941     MONUMENTED       CGS
HT0613  HISTORY     - 1942     SEE DESCRIPTION  CGS
HT0613  HISTORY     - 1948     SEE DESCRIPTION  CGS
HT0613  HISTORY     - 1948     SEE DESCRIPTION  CGS
HT0613  HISTORY     - 1956     GOOD             CGS
HT0613  HISTORY     - 1958     SEE DESCRIPTION  CGS
HT0613  HISTORY     - 1964     SEE DESCRIPTION  CGS
HT0613  HISTORY     - 1979     GOOD             NOS
HT0613  HISTORY     - 200209   GOOD             JOHFRA
HT0613
HT0613                          STATION DESCRIPTION
HT0613
HT0613'DESCRIBED BY COAST AND GEODETIC SURVEY 1941 (WDP)
HT0613'STATION IS LOCATED AT THE U.S. NAVY SHIPYARD AT HUNTERS POINT.
HT0613'APPROXIMATELY 30 FEET E OF THE GATE AT THE MAIN ENTRANCE TO
HT0613'THE YARD.  APPROXIMATELY 125 FEET S OF THE DOCK MASTERS HOUSE.
HT0613'
HT0613'STATION MARK IS A BRONZE DISK SET IN CONCRETE THAT WAS POURED
HT0613'INTO A STEEL CYLINDER ABOUT 12 INCHES IN DIAMETER AND 27 INCHES
HT0613'DEEP, TOP OF MARK IS ABOUT 8 INCHES BELOW PRESENT GRADE IN THE
HT0613'YARD.  THERE IS TO BE A STEEL CAP PLACED OVER THE MARK TO
HT0613'PROTECT IT.  THE CAP IS TO BE REMOVABLE.
HT0613
HT0613                          STATION RECOVERY (1942)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1942 (GEB)
HT0613'DESTROYED BY CONTRACTOR.  REPLACED JUNE 19, 1942 BY A PRIVATE
HT0613'SURVEYING COMPANY IN WHAT WAS STATED TO BE THE SAME LOCATION
HT0613'BUT A DIFFERENT ELEVATION.
HT0613
HT0613                          STATION RECOVERY (1948)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1948 (WMG)
HT0613'STATION IS AT THE SAN FRANCISCO NAVAL SHIPYARD, HUNTERS POINT.
HT0613'IT IS NEAR THE SW END OF DRYDOCK NO. 3, ABOUT 50 FEET FROM
HT0613'THE EDGE OF THE DRYDOCK.
HT0613'
HT0613'STATION MARK IS A REFERENCE DISK STAMPED HUNTER WEST 1 1941.
HT0613'IT IS SET IN CONCRETE IN A CYLINDRICAL HOLE ABOUT 6 INCHES IN
HT0613'DIAMETER, WITH TOP OF THE MARK ABOUT 4 INCHES BELOW GRADE OF
HT0613'THE STREET.  THE HOLE IS COVERED BY A REMOVABLE STEEL CAP.
HT0613
HT0613                          STATION RECOVERY (1948)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1948 (EHB)
HT0613'COPIED FROM TIDAL BENCH MARK RECORDS--
HT0613'
HT0613'STATION RECOVERED AS DESCRIBED.  IT IS STAMPED HUNTER WEST
HT0613'1 1941.
HT0613'
HT0613'AN UNSTAMPED AZIMUTH MARK WAS RECOVERED IN THE SAME LOCALITY.
HT0613'IT IS A BRONZE AZIMUTH DISK, UNSTAMPED, SET IN SUBSURFACE
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HT0613'CONCRETE POST WHICH IS ABOUT 6 INCHES BELOW GROUND LEVEL AND
HT0613'HAVING A 10-INCH SQUARE HANDHOLD AROUND MARK.  COVER FOR
HT0613'HANDHOLD HAS ONE-INCH HOLE IN CENTER.  MARK IS LOCATED AT W
HT0613'END OF DRYDOCK NO. 3, 18 FEET S OF PROLONGATION OF S SIDE
HT0613'OF DRYDOCK NO. 3, 23 FEET W OF MOST W OF LINE OF SNUBBING POSTS
HT0613'ALONG S SIDE OF DRYDOCK NO. 3.
HT0613'
HT0613'NOTE--H.C. WARWICK USED AZIMUTH MARK AS A TIDAL BENCH MARK
HT0613'IN 1945.
HT0613
HT0613                          STATION RECOVERY (1956)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1956
HT0613'AT HUNTERS POINT.
HT0613'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARD, AT THE
HT0613'WEST END OF DRY DOCK 3, 93.0 FEET SOUTH OF THE CENTER OF THE
HT0613'WEST END OF DRY DOCK 3, 90 FEET NORTHWEST OF FIRE PLUG NO. 200
HT0613'ON THE SOUTH SIDE OF THE DOCK AND NEAR THE WEST END, 6.4 FEET
HT0613'WEST OF THE EAST RAIL OF A LARGE WIDE FIFTY TON CRANE TRACK,
HT0613'6.0 FEET EAST OF THE EAST RAIL OF A SMALL SET OF TRACKS INSIDE
HT0613'THE LARGE CRANE TRACKS, AND SET IN THE TOP OF A CONCRETE POST
HT0613'0.5 FOOT UNDERGROUND.  NOTE-- ACCESS TO MARK HAD THROUGH A
HT0613'METAL LID.
HT0613
HT0613                          STATION RECOVERY (1958)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1958 (JCM)
HT0613'THE STATION MARK WAS RECOVERED IN GOOD CONDITION AS DESCRIBED
HT0613'IN 1941 AND 1948.
HT0613
HT0613                          STATION RECOVERY (1964)
HT0613
HT0613'RECOVERY NOTE BY COAST AND GEODETIC SURVEY 1964 (PAS)
HT0613'THE STATION WAS RECOVERED AS DESCRIBED BY W.M.G. IN 1948.
HT0613
HT0613                          STATION RECOVERY (1979)
HT0613
HT0613'RECOVERY NOTE BY NATIONAL OCEAN SERVICE 1979 (DRT)
HT0613'STATION WAS RECOVERED IN GOOD CONDITION AS DESCRIBED IN 1948.
HT0613'
HT0613'DESCRIBED BY F.L. ROSARIO
HT0613
HT0613                          STATION RECOVERY (2002)
HT0613
HT0613'RECOVERY NOTE BY JOHNSON-FRANK 2002 (MSP)
HT0613'THE STATION IS AT HUNTERS POINT, AT A FORMER NAVAL SHIPYARD, IN THE
HT0613'SOUTHEAST PART OF  THE CITY AND COUNTY OF SAN FRANCISCO. FROM THE
HT0613'INTERSECTION OF HWY 101 AND 3RD ST, ABOUT 1.4 MI SOUTH OF THE
HT0613'INTERSECTION OF  HW 101 AND INTERSTATE 280, EXIT ON 3RD ST/BAYSHORE
HT0613'BLVD, IN THE VICINITY OF THE FORMER  CANDLESTICK PARK.  DRIVE NORTH ON
HT0613'3RD ST FOR ABOUT 2.0 MI TO EVANS AV.  TURN RIGHT (EAST)  ON EVANS AND
HT0613'DRIVE FOR ABOUT 0.7 MI TO THE INTERSECTION OF JENNINGS ST TO THE LEFT
HT0613'AND  MIDDLEPOINT TO THE RIGHT. FROM THIS INTERSECTION, WHERE EVANS
HT0613'BECOMES HUNTERS POINT  BLVD, CONTINUE ON HUNTERS PT BLVD WHICH CURVES
HT0613'TO THE RIGHT(SOUTHEAST) FOR 0.3 MI TO A  TRIANGULAR INTERSECTION WITH
HT0613'INNES AVE.  TURN LEFT (EAST) AND FOLLOW INNES FOR 0.4 MI TO  THE
HT0613'ENTRANCE INTERSECTION WITH A STREETLIGHT, AND THEN AN ABANDONED GUARD
HT0613'SHACK.   CONTINUE, BEARING LEFT WHEN THE ROAD TURNS/BEARS RIGHT, FOR
HT0613'ABOUT 0.1 MI,  THEN TURN  RIGHT ON GALVEZ.  DRIVE SOUTHEAST ON GALVEZ
HT0613'FOR 0.2 MI, THEN BEAR LEFT ON ROBINSON AND  DRIVE EASTERLY FOR ABOUT
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 HT0613'0.2 MI TO THE INTERSECTION OF FISHER AVE.  CONTINUE STRAIGHT (ON  SOME
 HT0613'MAPS, SOUTH OF FISHER AV ROBINSON TURNS INTO LOCKWOOD ST.  CONTINUE ON
 HT0613'THIS ROAD  AND ENTER THROUGH AN OPEN GATE MARKED 'OFFICERS QUARTERS'
 HT0613'ON A RUSTY SIGN.  AFTER  PASSING THE GATE, TURN LEFT DRIVING FOR ABOUT
 HT0613'0.2 MI  AND THEN RIGHT PAST A BOLLARD. THE STATION IS SET IN A
 HT0613'CONCRETE POST AT THE HEAD (WEST END) OF DRY DOCK 3, COVERED  WITH A
 HT0613'STEEL COVER PLATE.  THE STATION IS 33.2 M SE OF THE CAPSTAN AT THE
 HT0613'WEST END OF DRY  DOCK 3, 16.0 M W OF THE STANDPIPE AT THE 950' MARK ON
 HT0613'THE DRY DOCK, 11.9 M E OF A GATE IN  CHAIN LINK FENCE WHICH IS NEAR
 HT0613'THE INTERSECTION OF FISHER AV AND SPEAR AV (OUTSIDE THE  FENCE), AND
 HT0613'8.7 M E OF A SHORT BOLLARD, AND 1.8 M WEST OF THE INNER RAIL FOR A
 HT0613'DOCK CRANE. MARK IS AN 8.9 CM (3.5 IN) BRASS U.S. COAST AND GEODETIC
 HT0613'SURVEY REFERENCE MARK DISK  STAMPED 'HUNTER WEST 1 1941' SET IN
 HT0613'CONCRETE IN A 15 CM (6 IN)  DIAMETER WELL, DOWN 12 CM (0.4 FT) BELOW
 HT0613'THE ASPHALT.  THE LID OF THE  WELL IS 6 CM (0.2 FT) BELOW THE ASPHALT.
 HT0613'THIS STATION WAS OBSERVED AS PART OF THE SOUTH SAN FRANCISCO BAY
 HT0613'HEIGHT MODERNIZATION  PROJECT.
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
 HT0617 ***********************************************************************
 HT0617  DESIGNATION -  TIDAL 1
 HT0617  PID         -  HT0617
 HT0617  STATE/COUNTY-  CA/SAN FRANCISCO
 HT0617  COUNTRY     -  US
 HT0617  USGS QUAD   -  HUNTERS POINT (1993)
 HT0617
 HT0617                        *CURRENT SURVEY CONTROL
 HT0617  ______________________________________________________________________
 HT0617* NAD 83(1986) POSITION- 37 43 45.     (N) 122 21 30.     (W)   SCALED
 HT0617* NAVD 88 ORTHO HEIGHT -     3.38   (+/-2cm)      11.1   (feet) VERTCON
 HT0617  ______________________________________________________________________
 HT0617  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
 HT0617  VERT ORDER      -  FIRST     CLASS II (See Below)
 HT0617
 HT0617.The horizontal coordinates were scaled from a topographic map and have
 HT0617.an estimated accuracy of +/- 6 seconds.
 HT0617.
 HT0617.The NAVD 88 height was computed by applying the VERTCON shift value to
 HT0617.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 HT0617
 HT0617.The vertical order pertains to the NGVD 29 superseded value.
 HT0617
 HT0617;                    North         East    Units  Estimated Accuracy
 HT0617;SPC CA 3     -   638,040.    1,836,200.      MT  (+/- 180 meters Scaled)
 HT0617
 HT0617                          SUPERSEDED SURVEY CONTROL
 HT0617
 HT0617  NGVD 29 (??/??/92)    2.556  (m)            8.39   (f) ADJ UNCH    1 2
 HT0617
 HT0617.Superseded values are not recommended for survey control.
 HT0617
 HT0617.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HT0617.See file dsdata.txt to determine how the superseded data were derived.
 HT0617
 HT0617_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG565759(NAD 83)
 HT0617
 HT0617_MARKER: DB = BENCH MARK DISK
 HT0617_SETTING: 30 = SET IN A LIGHT STRUCTURE
 HT0617_SP_SET: WALL
 HT0617_STAMPING: HUNTERS PT BM 1 1917
 HT0617_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY
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 HT0617
 HT0617  HISTORY     - Date     Condition        Report By
 HT0617  HISTORY     - 1917     MONUMENTED       CGS
 HT0617  HISTORY     - 1956     GOOD             CGS
 HT0617
 HT0617                          STATION DESCRIPTION
 HT0617
 HT0617'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
 HT0617'AT HUNTERS POINT.
 HT0617'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARDS, AT THE
 HT0617'ENTRANCE TO DRY DOCK NO. 2, AT THE EAST END OF THE DOCK, IN
 HT0617'THE TOP OF THE NORTH GRANITE WALL, 24.0 FEET EAST OF THE CENTER
 HT0617'OF A CAISSON AT A CUT IN A WALL WHICH A FLOATING GATE OF THE
 HT0617'DRY DOCK REST, 18 1/2 FEET EAST OF THE WEST END OF A WOODEN
 HT0617'PIER WHICH EXTENDS OUT FROM THE END OF THE DRY DOCK.  NOTE-- ACCESS
 HT0617'TO MARK IS HAD THROUGH A 4-INCH HOLE IN A WOODEN PLANK.
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
 HT0619 ***********************************************************************
 HT0619  TIDAL BM    -  This is a Tidal Bench Mark.
 HT0619  DESIGNATION -  TIDAL 2
 HT0619  PID         -  HT0619
 HT0619  STATE/COUNTY-  CA/SAN FRANCISCO
 HT0619  COUNTRY     -  US
 HT0619  USGS QUAD   -  HUNTERS POINT (1993)
 HT0619
 HT0619                        *CURRENT SURVEY CONTROL
 HT0619  ______________________________________________________________________
 HT0619* NAD 83(1986) POSITION- 37 43 46.     (N) 122 21 29.     (W)   SCALED
 HT0619* NAVD 88 ORTHO HEIGHT -     3.49   (+/-2cm)      11.5   (feet) VERTCON
 HT0619  ______________________________________________________________________
 HT0619  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
 HT0619  VERT ORDER      -  FIRST     CLASS II (See Below)
 HT0619
 HT0619.The horizontal coordinates were scaled from a topographic map and have
 HT0619.an estimated accuracy of +/- 6 seconds.
 HT0619.
 HT0619.The NAVD 88 height was computed by applying the VERTCON shift value to
 HT0619.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 HT0619
 HT0619.The vertical order pertains to the NGVD 29 superseded value.
 HT0619
 HT0619.This Tidal Bench Mark is designated as VM 8098
 HT0619.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
 HT0619
 HT0619;                    North         East    Units  Estimated Accuracy
 HT0619;SPC CA 3     -   638,070.    1,836,230.      MT  (+/- 180 meters Scaled)
 HT0619
 HT0619                          SUPERSEDED SURVEY CONTROL
 HT0619
 HT0619  NGVD 29 (??/??/92)    2.670  (m)            8.76   (f) ADJ UNCH    1 2
 HT0619
 HT0619.Superseded values are not recommended for survey control.
 HT0619
 HT0619.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HT0619.See file dsdata.txt to determine how the superseded data were derived.
 HT0619
 HT0619_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG565759(NAD 83)
 HT0619
 HT0619_MARKER: DB = BENCH MARK DISK
 HT0619_SETTING: 30 = SET IN A LIGHT STRUCTURE
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 HT0619_SP_SET: WALL
 HT0619_STAMPING: HUNTERS PT BM 2 1917
 HT0619_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY
 HT0619
 HT0619  HISTORY     - Date     Condition        Report By
 HT0619  HISTORY     - 1917     MONUMENTED       CGS
 HT0619  HISTORY     - 1956     GOOD             CGS
 HT0619
 HT0619                          STATION DESCRIPTION
 HT0619
 HT0619'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
 HT0619'AT HUNTERS POINT.
 HT0619'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARD, AT THE
 HT0619'SMALL BRICK GATE AND PUMP HOUSE BUILDING (204) BETWEEN DRY
 HT0619'DOCKS NO. 2 AND 3, SET VERTICALLY IN THE WEST WALL AND BRICK
 HT0619'FOUNDATION OF THE PUMPHOUSE, 64.0 FEET SOUTHEAST OF THE SOUTHEAST
 HT0619'CORNER OF THE SOUTH END OF THE CAISSON OF DRY DOCK NO. 3, 0.7
 HT0619'FOOT SOUTH OF THE NORTHWEST CORNER OF THE PUMPHOUSE BUILDING
 HT0619'(204) 0.2 FOOT ABOVE THE ASPHALT DRIVEWAY, AND ABOUT LEVEL
 HT0619'WITH THE ASPHALT.
1        National Geodetic Survey,   Retrieval Date = OCTOBER 23, 2012
 HT0618 ***********************************************************************
 HT0618  TIDAL BM    -  This is a Tidal Bench Mark.
 HT0618  DESIGNATION -  TIDAL 3
 HT0618  PID         -  HT0618
 HT0618  STATE/COUNTY-  CA/SAN FRANCISCO
 HT0618  COUNTRY     -  US
 HT0618  USGS QUAD   -  HUNTERS POINT (1993)
 HT0618
 HT0618                        *CURRENT SURVEY CONTROL
 HT0618  ______________________________________________________________________
 HT0618* NAD 83(1986) POSITION- 37 43 46.     (N) 122 21 29.     (W)   SCALED
 HT0618* NAVD 88 ORTHO HEIGHT -     3.57   (+/-2cm)      11.7   (feet) VERTCON
 HT0618  ______________________________________________________________________
 HT0618  GEOID HEIGHT    -        -32.53  (meters)                     GEOID12A
 HT0618  VERT ORDER      -  FIRST     CLASS II (See Below)
 HT0618
 HT0618.The horizontal coordinates were scaled from a topographic map and have
 HT0618.an estimated accuracy of +/- 6 seconds.
 HT0618.
 HT0618.The NAVD 88 height was computed by applying the VERTCON shift value to
 HT0618.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 HT0618
 HT0618.The vertical order pertains to the NGVD 29 superseded value.
 HT0618
 HT0618.This Tidal Bench Mark is designated as VM 8099
 HT0618.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
 HT0618
 HT0618;                    North         East    Units  Estimated Accuracy
 HT0618;SPC CA 3     -   638,070.    1,836,230.      MT  (+/- 180 meters Scaled)
 HT0618
 HT0618                          SUPERSEDED SURVEY CONTROL
 HT0618
 HT0618  NGVD 29 (??/??/92)    2.750  (m)            9.02   (f) ADJ UNCH    1 2
 HT0618
 HT0618.Superseded values are not recommended for survey control.
 HT0618
 HT0618.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HT0618.See file dsdata.txt to determine how the superseded data were derived.
 HT0618
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HT0618_U.S. NATIONAL GRID SPATIAL ADDRESS: 10SEG565759(NAD 83)
HT0618
HT0618_MARKER: DB = BENCH MARK DISK
HT0618_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
HT0618_SP_SET: SET IN TOP OF CONCRETE MONUMENT
HT0618_STAMPING: HUNTERS PT BM 3 1917
HT0618_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
HT0618+STABILITY: SURFACE MOTION
HT0618
HT0618  HISTORY     - Date     Condition        Report By
HT0618  HISTORY     - 1917     MONUMENTED       CGS
HT0618  HISTORY     - 1956     GOOD             CGS
HT0618
HT0618                          STATION DESCRIPTION
HT0618
HT0618'DESCRIBED BY COAST AND GEODETIC SURVEY 1956
HT0618'AT HUNTERS POINT.
HT0618'AT HUNTERS POINT, AT THE SAN FRANCISCO NAVAL SHIPYARDS, BETWEEN
HT0618'DRY DOCKS 2 AND 3, SET VERTICALLY IN THE SOUTH FACE OF THE
HT0618'BRICK WALL AND FOUNDATION OF THE BOILER ROOM BUILDING NO. 205,
HT0618'AT ABOUT THE CENTER OF THE BUILDING, 35 FEET NORTH OF THE NORTH
HT0618'SIDE OF DRY DOCK NO. 2, 14.6 FEET EAST OF THE CENTER OF A SMALL
HT0618'DOOR LEADING INTO THE BOILER ROOM IN THE CENTER OF THE BUILDING,
HT0618'6.0 FEET NORHTWEST OF THE NORTHWEST CORNER OF A 4- BY 4-FOOT
HT0618'HIGH CONCRETE BOX OUTLET, AND 0.4 FOOT ABOVE THE ASPHALT.

*** retrieval complete.
Elapsed Time = 00:00:06
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Attachment 2. NOAA Tidal Datums for Tidal Epoch 1960 to 1978

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Datums Page

PUBLICATION DATE: 06/24/1983

Station ID: 9414358
Name: HUNTERS POINT, SAN FRANCISCO BAY CALIFORNIA
NOAA Chart: 18649
USGS Quad: HUNTERSPOINT

SUPERCEDED DATE: 04/21/2003

Latitude: 37° 43.8' N
Longitude: 122° 21.4' W

To reach the tidal bench marks from I-280 and U.S. Highway 101 interchange proceed 1.4 miles (2.2 km) south to Bayshore Blvd., Third Street exit, left onto Third Street, north 1.8 miles (2.9 km) to Evans Street, right turn on Evans Street, 0.7 mile (1.1 km) SE on Evans Street, one block south on Evans Street to Fairfax Street, right on Hunters Point Boulevard, 0.2 mile (0.3 km) after left turn on Innes Avenue and then 0.4 mile (0.6 km) to entrance to guard house with dry dock area at bottom of hill. The tide gage was located 50 feet (15.2 m) NW of NW corner of drydock No. 2 and the staff was located on an adjacent pier.

T I D A L B E N C H M A R K S

PRIMARY BENCH MARK STAMPING: HUNTERS POINT BM 2 1917

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Wall

VM#: 8098
PID#: HT0619

The bench mark is set vertically in west wall at the NW corner of the small brick pump house (Building No. 204), between drydocks No. 2 and 3, 100 feet (30.5 m) east of center of capstan at SE corner of drydock No. 3, 64 feet (19.5 m) east of SE corner of south end of caisson of drydock, No. 2, and 0.5 foot (0.2 m) above the paved ground.

BENCH MARK STAMPING: HUNTERS POINT BM 3 1917

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Wall

VM#: 8099
PID#: HT0618

The bench mark is set veritically on south wall of brick boiler room C building No. 205, between drydocks No. 2 and 3, 100 feet (30.5 m) east of SW corner of boiler room building, 35 feet (10.7 m) north of north edge of drydock No. 2 and 15 feet (4.6 m) east of the centerline of the door at center of the boiler room wall.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

PUBLICATION DATE: 06/24/1983
SUPERCEDED DATE: 04/21/2003

Station ID: 9414358
Name: HUNTERS POINT, SAN FRANCISCO BAY CALIFORNIA
NOAA Chart: 18649
USGS Quad: HUNTERSPOINT

Latitude: 37° 43.8' N
Longitude: 122° 21.4' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: 4 1941

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Concrete Platform

VM#: 8100
PID#: HT0616

The bench mark is set in top of SE corner of concrete loading platform at NE corner of large concrete machine shop Building No. 231, 96 feet (29.3 m) south of south side of drydock, No. 2, 0.5 foot (0.2 m) north of north wall of the building, and 3.4 feet (1.0 m) above the pavement.

BENCH MARK STAMPING: 5 1941

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Concrete Platform

VM#: 8101
PID#: HT0615

The bench mark is set on top of NW corner of concrete loading platform at the SW corner of the large concrete machine shop, Building No. 231, 260 feet (79.2 m) south of drydock No. 2, 0.5 foot (0.2 m) south of south wall of building, and 3 feet (0.9 m) above the pavement.

BENCH MARK STAMPING: HUNTER WEST 1 1941

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Concrete Post

VM#: 8102
PID#: HT0613

The bench mark is set in a concrete post at the head of drydock, No. 2, covered with a steel handhole and cover plate, 108 feet (32.9 m) south by east of center of capstan at head of drydock, 95 feet (29 m) west by north of fireplug on south side and near west end of drydock, 6 feet (1.8 m) west of inner rail of 50 ton crane, and 0.7 foot (0.2 m) below the pavement.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

PUBLICATION DATE: 06/24/1983

Station ID: 9414358
Name: HUNTERS POINT, SAN FRANCISCO BAY CALIFORNIA
NOAA Chart: 18649
USGS Quad: HUNTERSPOINT

SUPERCEDED DATE: 04/21/2003

Latitude: 37° 43.8' N
Longitude: 122° 21.4' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: HUNTER EAST 1941

MONUMENTATION: Survey Disk
AGENCY:
SETTING CLASSIFICATION: Retaining Wall

VM#: 8103
PID#: HT0620

The bench mark is set in the subsurface concrete retaining wall with a steel handhole and coverplate stamped SFWD over the mark at yard level, 96 feet (29.3 m) west of SW end of drydock caisson, 64 feet (19.5 m) west by north of center of capstan at SE end of drydock, 18 feet (5.5 m) south of south side of drydock, and 0.8 foot (0.2 m) below the pavement of yard.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

PUBLICATION DATE: 06/24/1983

Station ID: 9414358
Name: HUNTERS POINT, SAN FRANCISCO BAY CALIFORNIA
NOAA Chart: 18649
USGS Quad: HUNTERSPOINT

SUPERCEDED DATE: 04/21/2003

Latitude: 37° 43.8' N
Longitude: 122° 21.4' W

T I D A L D A T U M S

Tidal datums at HUNTERS POINT, SAN FRANCISCO BAY based on:

LENGTH OF SERIES: 13 MONTHS
TIME PERIOD: NOV 1974-FEB 1976
TIDAL EPOCH: 1960-1978
CONTROL TIDE STATION: 9414760 ALAMEDA, CA

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in FEET:

HIGHEST OBSERVED WATER LEVEL (12/27/1974)	=	8.16
MEAN HIGHER HIGH WATER (MHHW)	=	6.73
MEAN HIGH WATER (MHW)	=	6.10
MEAN TIDE LEVEL (MTL)	=	3.61
* NATIONAL GEODETIC VERTICAL DATUM-1929 (NGVD)	=	3.12
MEAN LOW WATER (MLW)	=	1.12
MEAN LOWER LOW WATER (MLLW)	=	0.00
LOWEST OBSERVED WATER LEVEL (12/01/1975)	=	-1.86

* NGVD reference based on adjustment of 1958 and NOS levels of1974-1976.
National Geodetic Vertical Datum (NGVD 29)

Bench Mark Elevation Information In FEET above:

Stamping or Designation	MLLW	MHW
HUNTERS POINT BM 2 1917	11.88	5.78
HUNTERS POINT BM 3 1917	12.14	6.04
4 1941	15.33	9.23
5 1941	15.38	9.28
HUNTER WEST 1 1941	11.32	5.22
HUNTER EAST 1941	10.65	4.55

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

PUBLICATION DATE: 06/24/1983

Station ID: 9414358 **SUPERCEDED DATE: 04/21/2003**
Name: HUNTERS POINT, SAN FRANCISCO BAY CALIFORNIA
NOAA Chart: 18649 **Latitude: 37° 43.8' N**
USGS Quad: HUNTERSPOINT **Longitude: 122° 21.4' W**

D E F I N I T I O N S

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88).

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at National Geodetic Survey.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level observed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at National Geodetic Survey.

NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

The Vertical Mark Number (VM#) and PID# shown on the bench mark sheet are unique identifiers for bench marks in the tidal and geodetic databases, respectively. Each bench mark in either database has a single, unique VM# and/or PID# assigned. Where both VM# and PID# are indicated, both tidal and geodetic elevations are available for the bench mark listed.

The NAVD 88 elevation is shown on the Elevations of Tidal Datums Table Referred to MLLW only when two or more of the bench marks listed have NAVD 88 elevations. The NAVD 88 elevation relationship shown in the table is derived from an average of several bench mark elevations relative to tide station datum. As a result of this averaging, NAVD 88 bench mark elevations computed indirectly from the tidal datums elevation table may differ slightly from NAVD 88 elevations listed for each bench mark in the NGS database.

Attachment 3. San Francisco Bay Tidal Stage vs. Frequency Study, Table 5

SAN FRANCISCO BAY

TIDAL STAGE vs. FREQUENCY STUDY

OCTOBER 1984

US Army Corps of Engineers
San Francisco District

TABLE 5

ADOPTED
100-YEAR TIDE ELEVATIONS

INDEX NO.	ADOPTED 100-YEAR TIDE ELEVATION (NGVD)	INDEX NO.	ADOPTED 100-YEAR TIDE ELEVATION (NGVD)
4290	6.0	4585	8.5
4305	6.2	4589	8.6
4317	6.5	4632	7.2
4358	6.7	4637	7.1
4391	6.9	4688	7.0
4392	6.9	4711	6.9
4413	6.9	4746	6.7
4449	7.0	4750	6.7
4458	7.1	4764	6.6
4483	7.1	4779	6.5
4486	7.2	4782	6.5
4501	7.3	4806	6.1
4505	7.3	4816	6.4
4506	7.6	4818	6.4
4507	7.4	4837	6.4
4509	7.5	4849	6.4
4513	7.3	4863	6.4
4519	7.9	4873	6.4
4521	8.5	4881	6.4
4523	7.3	5056	6.4
4525	7.8	5074	6.5
4537	7.7	5143	6.5
4548	8.1	5144	6.5
4549	8.5	5165	6.5
4551	8.6	5252	6.5
4561	8.6	5338	6.5
4575	8.2		

A8. Fetch Distances and Wind Parameters

Project	HPNS, Parcel E-2	Component/System:	Fetch Distances and Wind Parameters
Prepared by:	ALM	Checked by:	JS
Date	1-2013	Date	2-2013

PURPOSE

The purpose of this evaluation is to determine the fetch distances (the uninterrupted over-water distance where wind can influence the water surface) and the associated design wind speeds and directions that will be used to determine the design wave heights that will be the basis of the design of the shoreline protection structure (revetment) and the wetlands for Parcel E-2. The wave heights and periods of wind-generated waves are controlled by wind velocity, sustained wind duration, water depth, and fetch distance.

DATA

Wind Direction and Fetch Distances

Parcel E-2 is located within the South Basin, and therefore its shoreline is only partially exposed to waves. The proposed revetment area is directly exposed to waves generated by winds blowing from between 143 degrees (clockwise) from north and 176 degrees from north (Attachment 1). The proposed wetlands area is directly exposed to waves generated by winds blowing from between 119 degrees from north and 166 degrees from north (Attachment 1).

Wind Parameters (Velocity, Magnitude, Direction, and Duration)

Wind data from the San Francisco International Airport (SFIA) were evaluated to determine the wind parameters, including velocity, magnitude, and direction, that would generate waves along Parcel E-2 shoreline. The SFIA data include wind speed/direction readings for 2-minute sustained durations that were collected on an hourly basis between 1982 and 2011. These data were used to develop a wind rose, which is a radial plot that summarizes sustained wind velocity by direction. A 2-minute wind rose is shown in Figure 1 of Attachment 2 (GGWS, 2012). The 2-minute data were also converted to develop a 60-minute wind rose shown in Figure 2 of Attachment 2 (GGWS, 2012). The conversion method is described in the calculations section of this brief (below).

The SFIA wind data tables were queried to identify all significant wind velocity readings measured between 130-degrees and 170-degrees (clockwise) from north (Attachment 3). Readings less than 31 miles per hour were omitted from the analysis to focus the data presentation on the highest measured wind velocities. The maximum recorded 2-minute sustained wind speed is 49 miles per hour (mph) (measured at 160 degrees [clockwise] from north).

A Return-Period Analysis for 2-minute and 60-minute sustained durations was performed using the SFIA data. The return periods and corresponding wind speeds are shown on Table 4 of Attachment 2 (GGWS, 2012). It should be noted that the wind speeds shown on Table 4 of Attachment 2 may be biased high because the data set includes wind velocities from all directions, not just those that are directed towards the Parcel E-2 shoreline.

CALCULATIONS

Revetment Area

The maximum recorded 2-minute sustained wind speed of 49 mph from a direction of 160 degrees (clockwise) from north is converted to an average 60-minute speed using Figure II-2-1 (USACE, 2002) (Attachment 3).

From Figure II-2-1, for t = 120 seconds (2 minutes):

$$\frac{U_t}{U_{3600}} = 1.15$$

Therefore

$$U_{3600} = \frac{U_{120}}{1.15}$$

$$U_{3600} = \frac{49}{1.15}$$

$$= 42.6 mph$$

Where:

Ut	=	average sustained wind speed for duration t (m/sec)
U_{3600}	=	average 3,600-second (60-minute) sustained wind speed

The design wind speed should be appropriate to the design fetch distance. The fetch for winds blowing from 160 degrees (clockwise) from north extends from Coyote Point, which is over 10 kilometers from the Parcel E-2 shoreline. Figure II-2-3 (USACE, 2002) (Attachment 3) can be used to determine the

equivalent duration for wave generation as a function of fetch and wind speed. Using a maximum fetch distance of 10 km and an initial wind speed of 19.0 m/s (42.6 mph), Figure 11-2-3 estimates a duration of wave generation of approximately 87 minutes.

From Figure II-2-1, for t = 5,220 sec (87 minutes):

$$\frac{U_t}{U_{3600}} = 0.96$$

$$Therefore$$
$$U_{5220} = 0.96(U_{3600})$$

$$U_{5220} = 0.96(42.6)$$

$$= 40.9mph = 18.3m/s$$

Using the maximum fetch distance of 10 km and an initial wind speed of 18.3 m/s (40.9 mph), Figure 11-2-3 estimates a duration of wave generation of approximately 88 minutes.

Wetlands Area

The maximum recorded 2-minute sustained wind speed of 40 mph from a direction of 150 degrees (clockwise) from north is converted to an average 60-minute speed using Figure II-2-1 (USACE, 2002) (Attachment 3).

From Figure II-2-1, for t = 120 seconds (2 minutes):

$$\frac{U_t}{U_{3600}} = 1.15$$

Therefore

$$U_{3600} = \frac{U_{120}}{1.15}$$

$$U_{3600} = \frac{40}{1.15}$$

$$= 34.8mph$$

The fetch distance for winds blowing from 150 degrees (clockwise) from north extends uninterrupted from the San Mateo Bridge, which is more than 10 km from the Parcel E-2 shoreline. Using the maximum fetch of 10 km and an initial wind speed of 34.8 mph (15.6 m/s), Figure 11-2-3 estimates a duration of wave generation of approximately 95 minutes.

From Figure II-2-1, for t = 5,700 seconds (95 minutes):

$$\frac{U_t}{U_{3600}} = 0.95$$

Therefore

$$U_{5700} = 0.95(U_{3600})$$

$$U_{5700} = 0.95(34.8)$$

$$= 33.1mph = 14.8m/s$$

REFERENCES

Golden Gate Weather Services. 2012. "San Francisco International Airport Wind Analysis 1982-2011." December.

U.S. Army Corps of Engineers. 2002. "Coastal Engineering Manual - Part II." April.

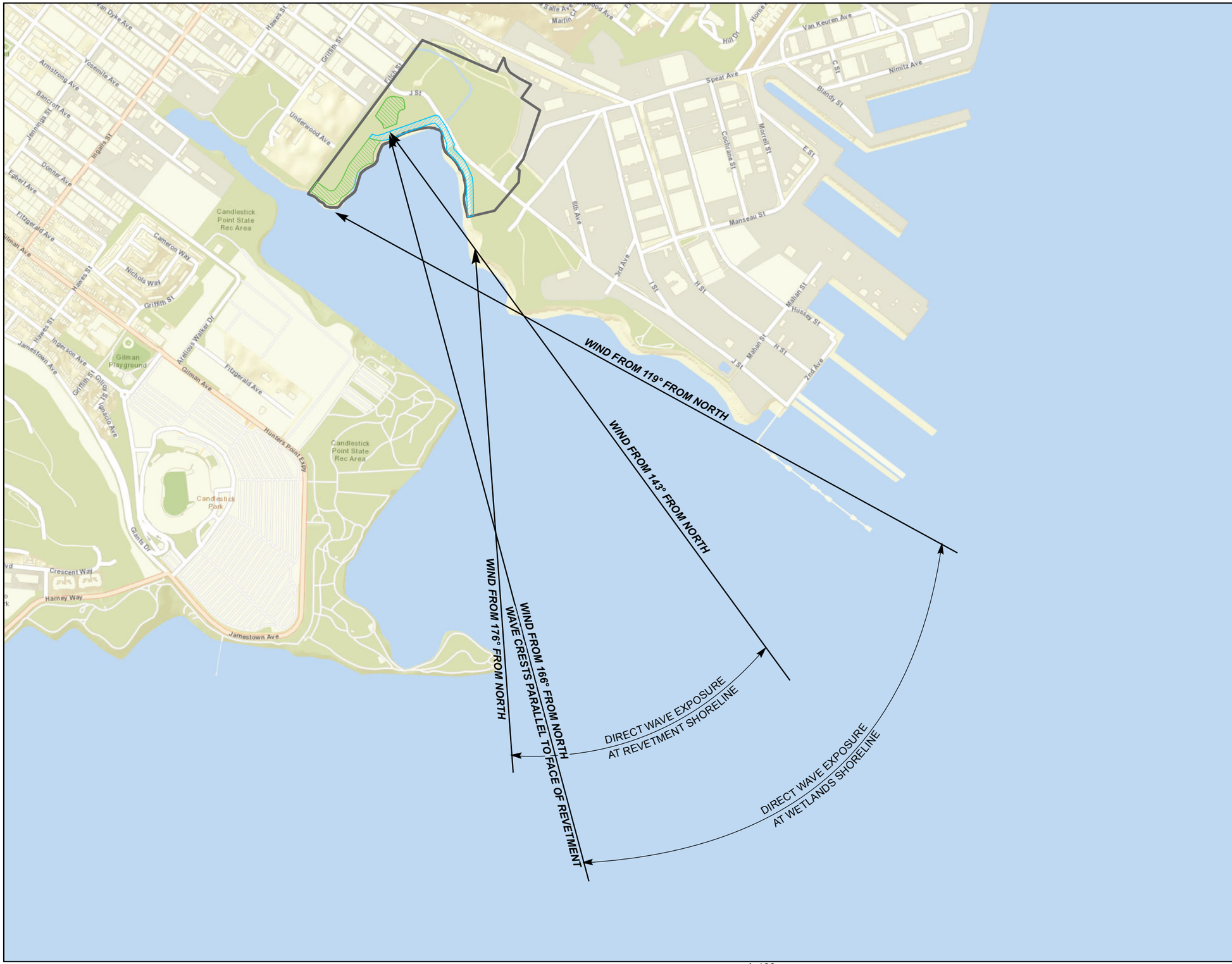
ATTACHMENTS

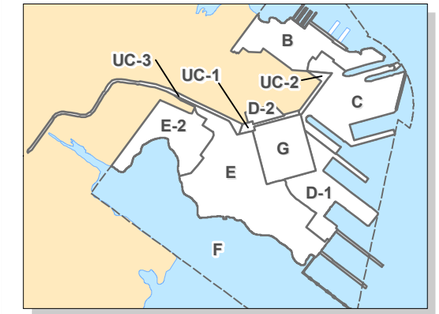
Attachment 1. Exposure to Wind-Generated Waves, Parcel E-2 Shoreline

Attachment 2. San Francisco International Airport Wind Data Analysis

Attachment 3. Figures II-2-1 and II-2-3 from the USACE Coastal Engineering Manual – Part II

Attachment 1. Exposure to Wind-Generated Waves, Parcel E-2 Shoreline





LEGEND:

- Wind-Generated Wave Direction
- Parcel E-2 Shoreline Revetment
- Parcel E-2 Wetlands
- Parcel E-2 Boundary

N

1,000 0 1,000

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Naval Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE WG-1

EXPOSURE TO WIND-GENERATED WAVES, PARCEL E-2 SHORELINE

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\Shoreline Revetment\Wave_Directions.mxd Last updated: 10/30/2012 at 10:36:30 AM

Attachment 2. San Francisco International Airport Wind Data Analysis

Figure 1.

Wind Rose

San Francisco International Airport (SFO)

2-minute – 1982-2011

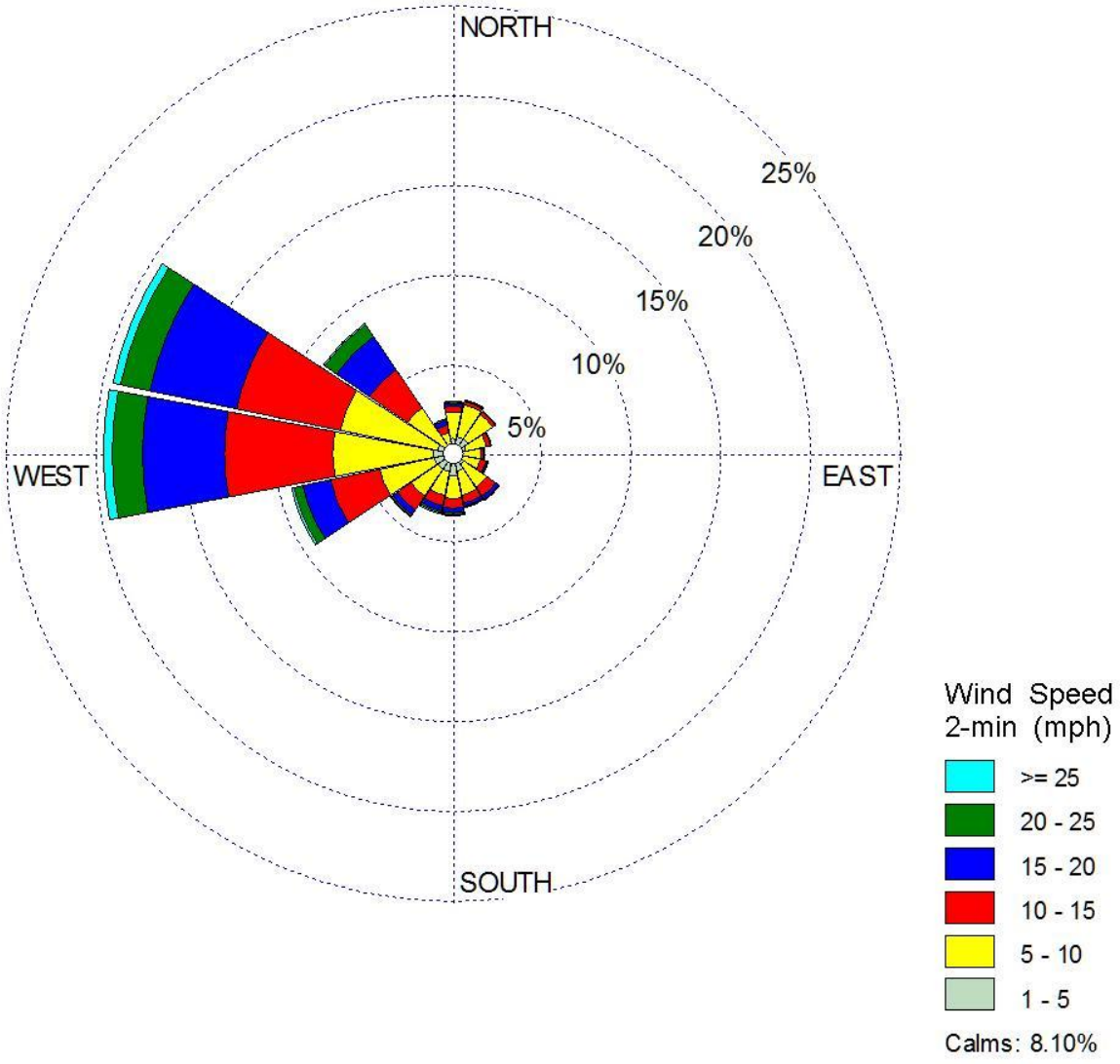


Table 1.

Station ID: SFO **2-min**
Start Date: 1/1/1982 - 00:00
End Date: 12/31/2011 - 23:00

Wind Speed/Direction Frequency Distribution

			Wind Speed (mph)						
Direction (deg)			**1-5**	**5-10**	**10-15**	**15 - 20**	**20 - 25**	**>= 25**	**Total**
349	-	11	0.009	0.015	0.003	0.002	0.001	0.000	0.030
11	-	34	0.010	0.018	0.002	0.001	0.000	0.000	0.031
34	-	56	0.011	0.016	0.002	0.000	0.000	0.000	0.029
56	-	79	0.008	0.012	0.002	0.001	0.000	0.000	0.022
79	-	101	0.006	0.010	0.002	0.000	0.000	0.000	0.018
101	-	124	0.005	0.011	0.003	0.001	0.000	0.000	0.021
124	-	146	0.008	0.016	0.006	0.002	0.001	0.000	0.032
146	-	169	0.011	0.014	0.004	0.002	0.001	0.000	0.031
169	-	191	0.013	0.013	0.005	0.003	0.001	0.001	0.035
191	-	214	0.011	0.013	0.006	0.003	0.001	0.001	0.035
214	-	236	0.011	0.018	0.009	0.003	0.001	0.000	0.043
236	-	259	0.012	0.031	0.028	0.016	0.005	0.001	0.093
259	-	281	0.012	0.056	0.060	0.046	0.017	0.005	0.195
281	-	304	0.010	0.055	0.059	0.049	0.017	0.004	0.194
304	-	326	0.006	0.026	0.026	0.022	0.008	0.001	0.088
326	-	349	0.004	0.009	0.004	0.003	0.001	0.000	0.021
		SubTotals:	0.146	0.332	0.221	0.153	0.053	0.014	0.919
	Calms:								0.081
	Missing/Incomplete:								0.000
	Total:								1.000

Frequency of Calm Winds: 8.10%
Average Wind Speed: 9.46 mph

Figure 2.

Wind Rose

San Francisco International Airport (SFO)

60-minute – 1982-2011

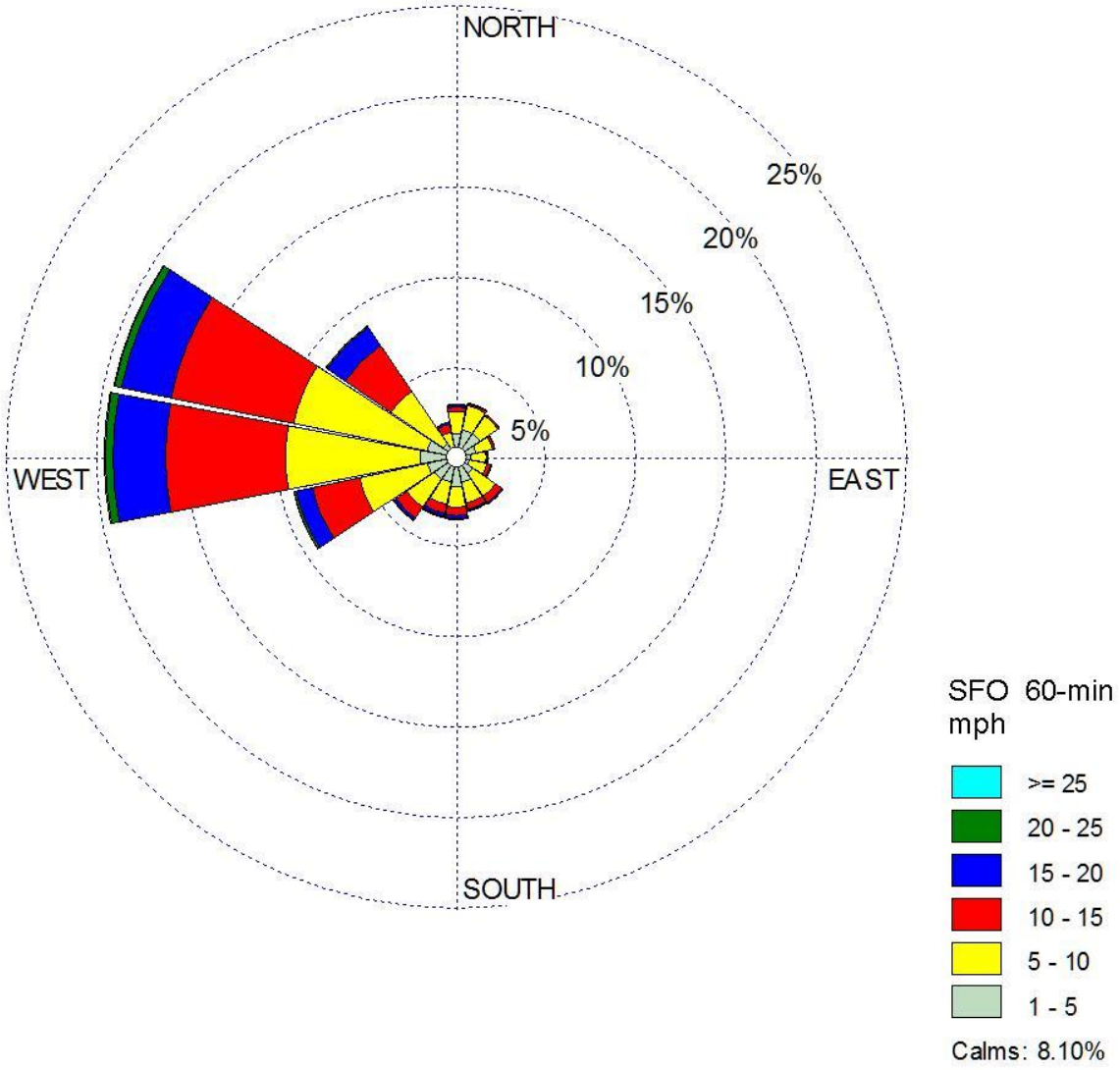


Table 2.

Station ID: SFO **60-min**

Start Date: 1/1/1982 - 00:00

End Date: 12/31/2011 - 23:00

Wind Speed/Direction Frequency Distribution

			Wind Speed (mph)						
Direction (deg)			**1-5**	**5-10**	**10-15**	**15 - 20**	**20 - 25**	**>= 25**	**Total**
349	-	11	0.014	0.012	0.002	0.001	0.000	0.000	0.030
11	-	34	0.016	0.013	0.001	0.000	0.000	0.000	0.031
34	-	56	0.017	0.012	0.001	0.000	0.000	0.000	0.029
56	-	79	0.012	0.009	0.001	0.000	0.000	0.000	0.022
79	-	101	0.009	0.008	0.001	0.000	0.000	0.000	0.018
101	-	124	0.008	0.010	0.002	0.000	0.000	0.000	0.021
124	-	146	0.012	0.015	0.004	0.001	0.000	0.000	0.032
146	-	169	0.015	0.012	0.003	0.001	0.000	0.000	0.031
169	-	191	0.017	0.011	0.004	0.002	0.001	0.000	0.035
191	-	214	0.015	0.012	0.005	0.002	0.000	0.000	0.035
214	-	236	0.016	0.018	0.007	0.002	0.000	0.000	0.043
236	-	259	0.017	0.038	0.026	0.009	0.001	0.000	0.093
259	-	281	0.021	0.074	0.066	0.029	0.004	0.001	0.195
281	-	304	0.017	0.075	0.069	0.028	0.004	0.001	0.194
304	-	326	0.010	0.035	0.030	0.012	0.001	0.000	0.088
326	-	349	0.006	0.009	0.004	0.001	0.000	0.000	0.021
		SubTotals:	0.222	0.364	0.229	0.089	0.012	0.002	0.919
	Calms:								0.081
	Missing/Incomplete:								0.000
	Total:								1.000

Frequency of Calm Winds: 8.10%

Average Wind Speed: 7.66 mph

Table 3
Highest Recorded Wind Speeds and Associated Directions
San Francisco International Airport Wind Data: 1982 - 2011

Date/Time	Year	Speed (mph)	Direction (deg)
0212152300	2002	49	160
0801040800	2008	48	170
0801040900	2008	48	170
0211071900	2002	46	170
0212160200	2002	43	170
9503090400	1995	41	170
0212160100	2002	40	150
0002140200	2000	38	170
0111240700	2001	38	170
9612291000	1996	38	170
0212160000	2002	37	150
0112020400	2001	36	160
0112020500	2001	36	160
9503090100	1995	36	170
9503090500	1995	36	160
9902090000	1999	36	170
0001160000	2000	35	170
0111240600	2001	35	160
0212141200	2002	35	160
0212152100	2002	35	150
0212281200	2002	35	160
0801040600	2008	35	150
0801040700	2008	35	160
1103192300	2011	35	170
8204101800	1982	35	170
9612291200	1996	35	170
9612291400	1996	35	160
9701010300	1997	35	160

Date/Time	Year	Speed (mph)	Direction (deg)
0002140100	2000	33	170
0212141400	2002	33	160
0910131200	2009	33	170
8301261200	1983	33	170
9501081300	1995	33	170
9612291300	1996	33	160
9701010100	1997	33	170
9701010200	1997	33	170
0002140400	2000	32	170
0101251300	2001	32	170
0212141300	2002	32	150
0212152200	2002	32	160
0402171000	2004	32	160
9501091200	1995	32	170
9612100300	1996	32	160
9612261900	1996	32	170
9902061300	1999	32	150
0002140300	2000	31	170
0002262100	2000	31	160
0002262200	2000	31	160
0212141100	2002	31	150
0401010800	2004	31	170
0402250700	2004	31	130
0412062100	2004	31	160
0412062200	2004	31	170
0412070000	2004	31	170
1102152000	2011	31	170
1103181000	2011	31	170

Table 4.

Return Period Analysis

2-min and 60-min Wind Speed
San Francisco International Airport

	2-min	**60-min**
RP *	mph	mph
2	38	30
3	40	32
4	41	33
5	42	34
6	43	35
7	43	35
8	44	36
9	44	36
10	45	36
15	46	38
20	48	39
25	48	39
30	49	40
35	50	40
40	50	41
45	51	41
50	51	41
60	52	42
70	52	42
80	53	43
90	53	43
100	54	44

* Example: A return period (RP) of 50 years means that in any given year there is a 1-in-50 chance of the event occurring.

Attachment 3. Figures II-2-1 and II-2-3 from the USACE Coastal Engineering Manual – Part II

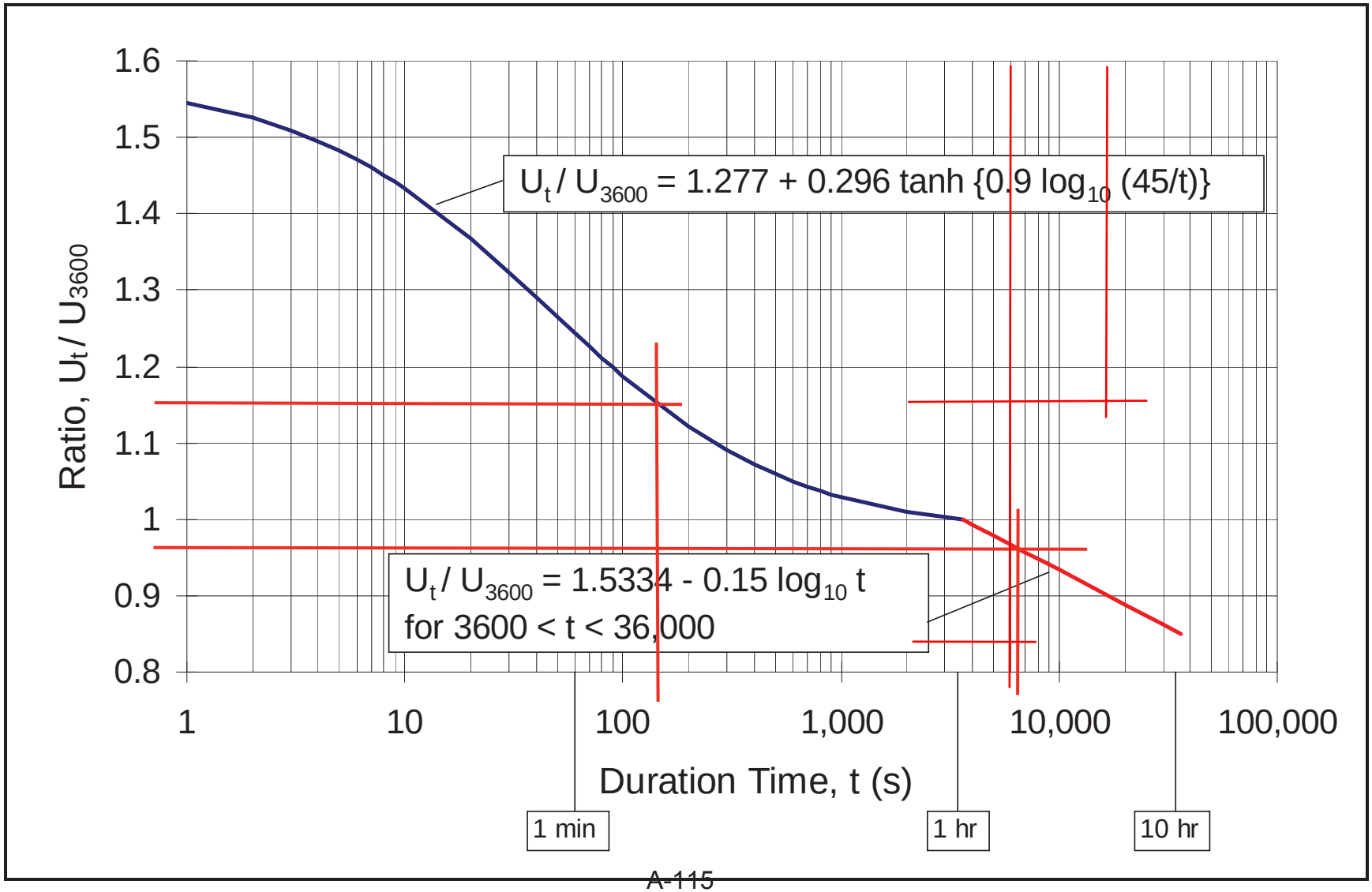


Figure II-2-1. Ratio of wind speed of any duration U_t to the 1-hr wind speed U_{3600}

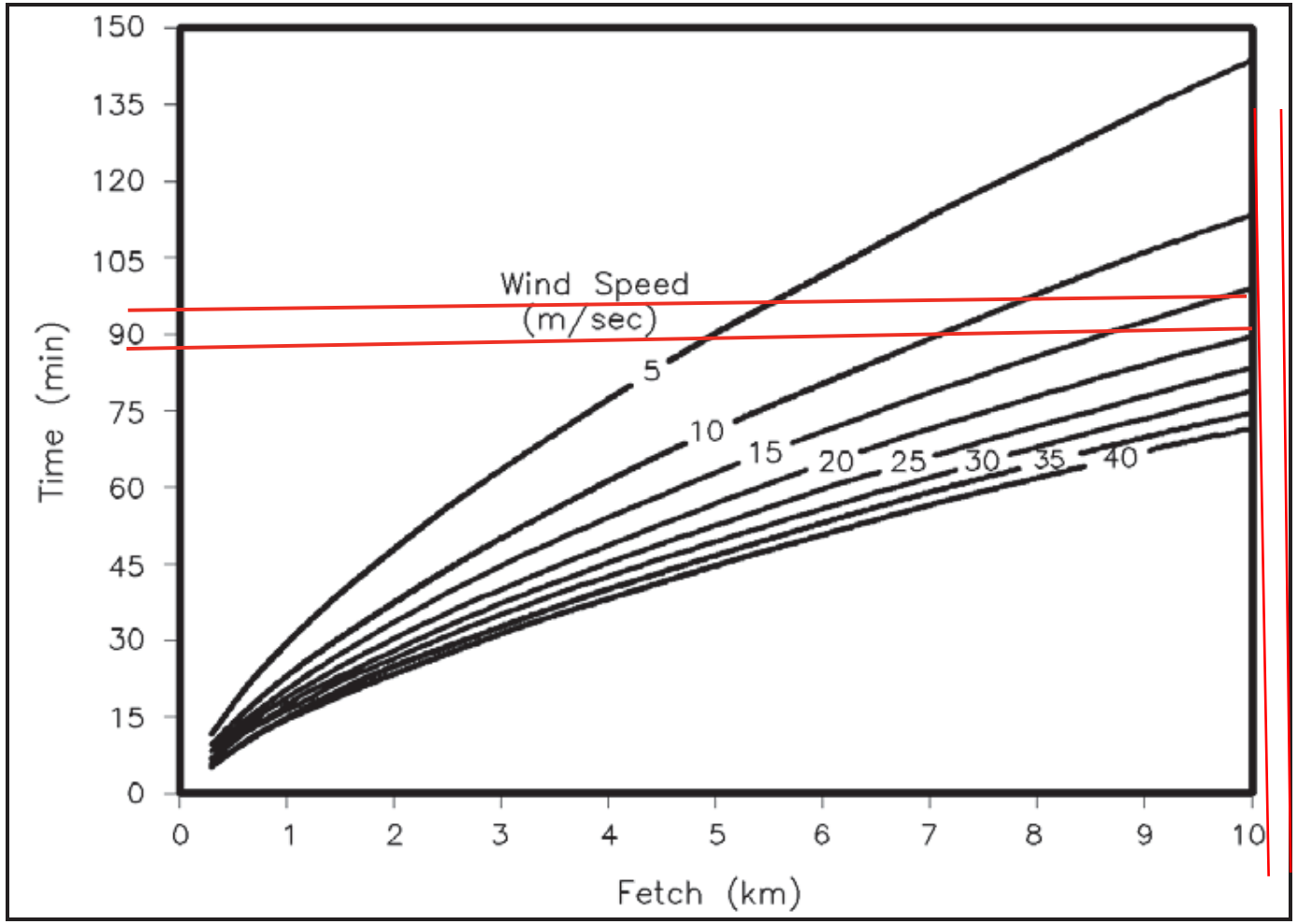


Figure II-2-3. Equivalent duration for wave generation as a function of fetch and wind speed

A9. Wave Generation

Project	HPNS, Parcel E-2	Component/System:	Wave Generation
Prepared by:	ALM	Checked by:	DB
Date	1-2013	Date	3-2013

PURPOSE

The purpose of this evaluation is to determine the fetch-controlled wave height (i.e., the height of the design wave for this RD). The significant wave height will be used to support the design of the shoreline protection structure for Parcel E-2.

METHODOLOGY

Three methods were used to calculate fetch-controlled wave heights, and the most conservative results were adopted to support this RD:

- Method 1 is as presented in the U.S. Army Corps of Engineers (USACE) publication "Low Cost Shore Protection…A Guide for Engineers and Contractors," (USACE, 2004).
- Method 2 uses Equation II-2-36 from the USACE Coastal Engineering Manual (USACE, 2006); and
- Method 3 uses a nomogram from the USACE Coastal Engineering Manual (USACE, 2006).

CALCULATIONS

Method 1

Fetch baselines were drawn on NOAA Chart 18651 (Figure 1). Each baseline was divided into a series of equal segments (Attachment 1). The depth at each segment division point was estimated from the chart and tabulated (see Tables 1 and 2). The average depth measurement was then calculated for each fetch baseline. The average measurements were then adjusted to account for the water depth between MLLW and MSL (+3.12 feet) and the water depth between MSL and the top of the extreme tide (100 year return interval) (+ 6.7 feet) (Tables 1 and 2).

A table corresponding to the converted/adjusted average depth is selected. The selected table shows wave height for fetch length and wind speed. Next, tables of wind-generated wave heights (for varying fetch lengths, wind speeds, and average depths (USACE, 2004; Attachment 2) were evaluated to determine the most appropriate table to use in this evaluation. It should be noted that the wave estimation tables account for the thresholds beyond which there is no further wave growth unless wind speed increases. The estimated wind-generated wave heights, based on Table 9 from USACE, 2004 (i.e. "Wind-Generated Wave Heights and (Periods) for Fetch Lengths with Average Depths = 25 feet") are presented in Tables 1 and 2 for each fetch baseline.

Table 1. Method 1 Results, Wind Direction from 150 Degrees (From North), Wind Speed 33 mph

Depth Station	Depth Below MLLW (feet)	Station Length (feet)	Station Length (miles)
0	5	0	0
1	6	4737	0.9
2	23	9474	1.8
3	25	14211	2.7
4	25	18948	3.6
5	23	23685	4.5
6	27	28422	5.4
7	31	33159	6.3
8	32	37896	7.2
9	30	42633	8.1
10	8	47370	9.0
11	7	52107	9.9
12	2	56844	10.8
Average	18.8 feet		
Adjusted[1]	29.1 feet		
Estimated Wind-Generated Wave Height[2]	**3.3 feet**		

Notes:

1. Adjusted = Average Depth Below MLLW + 3.12 ft[a] + 6.7 ft[b]
   a) Added 3.12 ft to adjust for depth of water between MLLW and MSL[c]
   b) Added 6.7 ft to adjust for height of extreme tide (100 year return interval)[c]
   c) Refer to "Tidal Datums" brief for adjustment factors
2. From *Table 9. Wind-Generated Wave Heights and (Periods) for Fetch Lengths with Average Depths = 25 feet* (USACE, 2004)

Table 2. Method 1 Results, Wind Direction from 160 Degrees (From North), Wind Speed 41 mph

Depth Station	Depth Below MLLW	Station Length (ft)	Station Length (mi)
0	5	0	0
1	5	4737	0.9
2	19	9474	1.8
3	21	14211	2.7
4	23	18948	3.6
5	20	23685	4.5
6	15	28422	5.4
7	13	33159	6.3
8	11	37896	7.2
9	8	42633	8.1
10	5	47370	9.0
Avg	13.2		
Adjusted[1]	23.5		
Estimated Wind-Generated Wave Height[2]	**4.1 feet**		

Notes:

1. Adjusted = Average Depth Below MLLW + 3.12 ft[a] + 6.7 ft[b]
   a) Added 3.12 ft to adjust for depth of water between MLLW and MSL[c]
   b) Added 6.7 ft to adjust for height of extreme tide (100 year return interval)[c]
   c) Refer to "Tidal Datums" brief for adjustment factors
2. From *Table 9. Wind-Generated Wave Heights and (Periods) for Fetch Lengths with Average Depths = 25 feet* (USACE, 2004)

Method 2

The equations that govern wave growth with fetch are as follows (Equation II-2-36, USACE, 2006):

$$\frac{gH_{m_0}}{u_*^2} = 4.13\times10^{-2} * \left(\frac{gX}{u_*^2}\right)^{\frac{1}{2}}$$

and

$$\frac{gT_p}{u_*} = 0.751\left(\frac{gX}{u_*^2}\right)^{\frac{1}{3}}$$

$$C_D = \frac{u_*^2}{U_{10}^2}$$

$$C_D = 0.001(1.1 + 0.035U_{10})$$

Where:

X	=	straight line fetch distance over which wind blows (m)
H_{m0}	=	energy-based significant wave height (m)
C_D	=	drag coefficient
U_{10}	=	wind speed at 10 m elevation (m/sec)
u_*	=	friction velocity (m/sec)
g	=	gravitational acceleration (m/sec/sec)
T_p	=	wave period (sec)

The fetch distances and wind speeds analyzed above (using Method 1) were analyzed by Method 2. The results of the calculations are summarized in Table 3, below.

Table 3. Method 2 Results Using Equation II-2-36

Wind Direction (Deg from N)	Fetch (mi)	Fetch (km)	Design Wind (mph)	Design Wind (m/sec)	Drag Coef (C_D)	Friction Velocity (u_*)	Wave Height (m)	Wave Height (ft)	Wave Period (sec)
150	10.8	17.4	33	14.8	0.00162	0.593	1.0	3.4	3.6
160	9.0	14.5	41	18.3	0.00174	0.765	1.2	4.0	3.6

Method 3

Fetch length and wind speed are used to determine wave height using a nomogram (Figure II-2-23, USACE, 2006; Attachment 3). The fetch distances and wind speeds analyzed above (using Method 1) were analyzed by Method 3. The results of the analysis are summarized below.

- **Wind Direction from 150 Degrees (From North), Wind Speed 33 mph:** Using a fetch length of 17.4 km (10.8 mi) and wind speed of 14.8 m/sec (33 mph), the resultant wave height is 1.0 m (3.3 feet).
- **Wind Direction from 160 Degrees (From North), Wind Speed 41 mph:** Using a fetch length of 14.5 km (9.0 mi) and wind speed of 18.3 m/sec (41 mph), the resultant wave height is 1.25 m (4.1 feet).

CONCLUSIONS

Wave heights determined by each of the three methods described above are in general agreement. The most conservative (highest) wave height (and period) for each of the wind directions is as follows:

- Wind Direction from 150 Degrees (From North), Wind Speed 33 mph: Height = **3.4 feet (Period = 3.6 seconds)**
- Wind Direction from 160 Degrees (From North), Wind Speed 41 mph: Height = **4.1 feet (Period = 3.6 seconds)**

REFERENCES

U.S. Army Corps of Engineers. 2004. "Low Cost Shore Protection…A Guide for Engineers and Contractors." July.

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

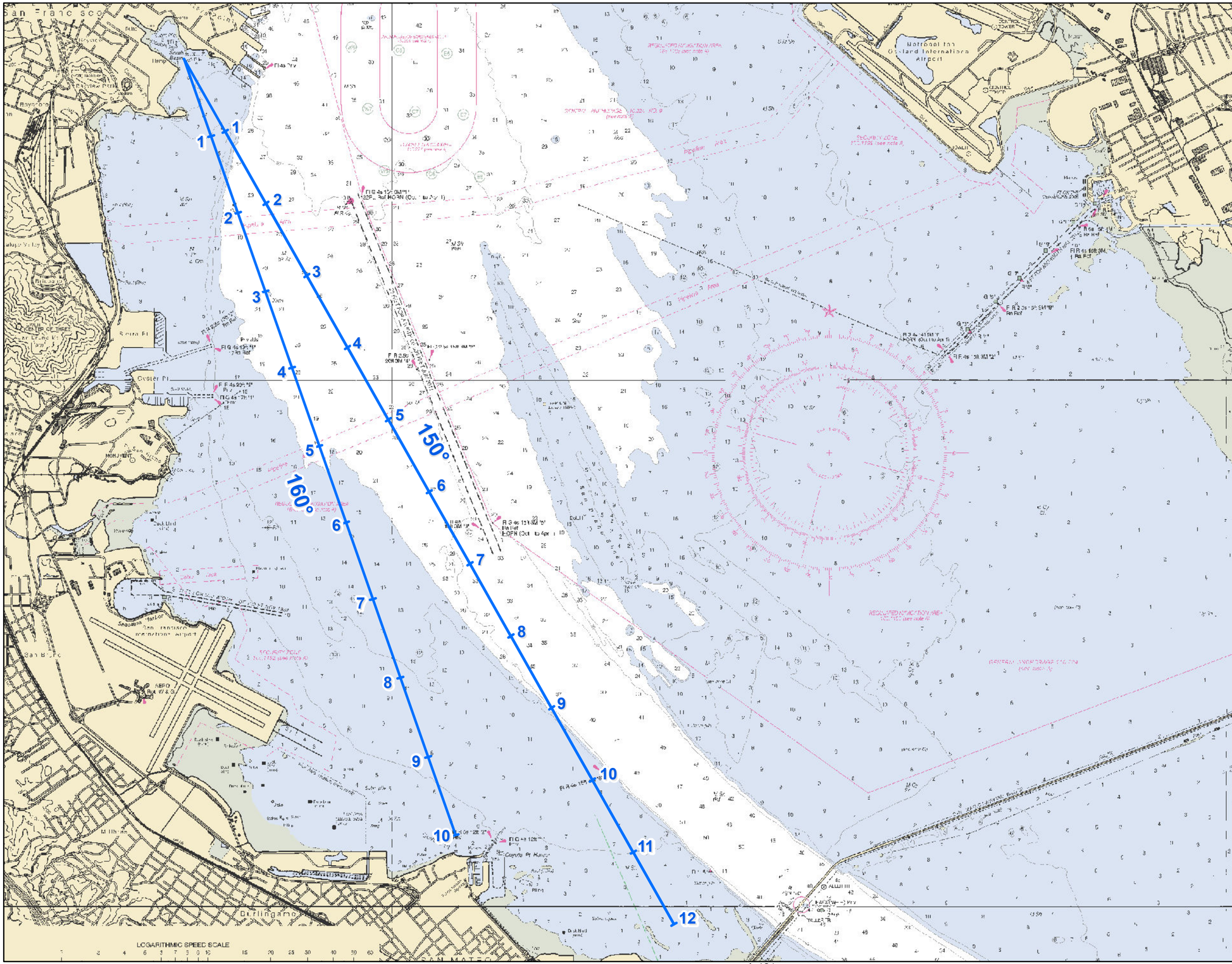
ATTACHMENTS

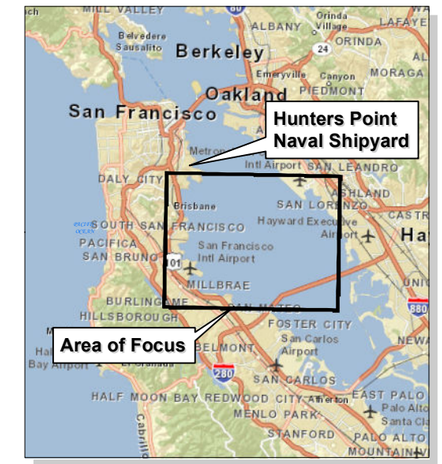
Attachment 1. Fetch Baselines

Attachment 2. Wind-Generated Wave Height Tables

Attachment 3. Fetch Limited Wave Heights Nomogram

Attachment 1. Fetch Baselines





LEGEND:

Fetch Base Line

Source:
NOAA chart 18651 "San Francisco Bay, Southern Part"

N

7,000 0 7,000

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Naval Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE WG-2

FETCH BASELINES

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\Shoreline Revetment\Fetch_Baselines.mxd Last updated: 1/9/2013 at 11:33:41 AM

Attachment 2. Wind-Generated Wave Height Tables

Table 5

WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 5 FEET

Wind Speed (mph)	Fetch Length (miles) 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
10	0.5 (1.0)	0.5 (1.0)	0.5 (1.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)
20	0.5 (1.0)	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)
30	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)
40	1.0 (2.0	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)
50	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)
55	1.5 (2.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)
60	1.5 (2.0	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)
65	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)
70	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)
75	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)	2.0 (4.0)
80	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)

Table 6

WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 10 FEET

Wind Speed (mph)	Fetch Length (miles) 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
10	0.5 (1.0)	0.5 (1.0)	0.5 (1.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)
20	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)
30	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)
40	1.5 (2.0)	1.5 (2.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (4.0)	2.5 (4.0)	2.5 (4.0)
50	1.5 (2.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)
55	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)
60	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)
65	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)
70	2.5 (3.0)	3.0 (3.0)	3.0 (3.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)
75	2.5 (3.0)	3.0 (3.0)	3.0 (3.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)
80	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (5.0)	4.0 (5.0)	4.0 (5.0)	4.0 (5.0)	4.0 (5.0)	4.0 (5.0)	4.0 (5.0)

Table 7

WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 15 FEET

Wind Speed (mph)	Fetch Length (miles) 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
10	0.5 (1.0)	0.5 (1.0)	0.5 (1.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)
20	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)
30	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)
40	1.5 (2.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)
50	2.0 (2.0)	2.0 (3.0)	2.5 (3.0)	2.5 (4.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)
55	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)
60	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (5.0)	4.5 (5.0)
65	2.5 (3.0)	3.0 (3.0)	3.5 (3.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	4.5 (5.0)
70	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	4.5 (5.0)	4.5 (5.0)	4.5 (5.0)	4.5 (5.0)
75	2.5 (3.0)	3.5 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)
80	3.0 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)

Table 8

WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 20 FEET

Wind Speed (mph)	Fetch Length (miles) 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
10	0.5 (1.0)	0.5 (1.0)	0.5 (1.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)
20	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)
30	1.0 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)
40	1.5 (2.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)
50	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)
55	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	4.5 (5.0)	4.5 (5.0)
60	2.0 (3.0)	3.0 (3.0)	3.0 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)
65	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)
70	2.5 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)
75	3.0 (3.0)	3.5 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (4.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.0 (5.0)
80	3.0 (3.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (4.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.0 (5.0)	6.0 (5.0)	6.0 (5.0)

Table 9

WIND-GENERATED WAVE HEIGHTS AND (PERIODS)
FETCH LENGTHS WITH AVERAGE DEPTHS = 25 FEET

3.3

4.1

Wind Speed (mph)	Fetch Length (miles) 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
10	0.5 (1.0)	0.5 (1.0)	0.5 (1.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)
20	0.5 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	1.5 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)
30	1.0 (2.0)	1.5 (2.0)	1.5 (2.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (4.0)	3.0 (4.0)	3.0 (4.0)
40	1.5 (2.0)	2.0 (3.0)	2.0 (3.0)	2.5 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (3.0)	3.0 (4.0)	3.0 (4.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)
50	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.0 (3.0)	3.5 (4.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (5.0)	5.0 (5.0)
55	2.0 (3.0)	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)
60	2.0 (3.0)	3.0 (3.0)	3.5 (3.0)	3.5 (4.0)	4.0 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (4.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)
65	2.5 (3.0)	3.0 (3.0)	3.5 (4.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.[illegible] (5.[illegible])
70	2.5 (3.0)	3.5 (3.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (4.0)	5.0 (4.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.0 (5.0)	6.0 (5.0)	6.5 (5.0)
75	3.0 (3.0)	3.5 (3.0)	4.0 (4.0)	4.5 (4.0)	4.5 (4.0)	5.0 (4.0)	5.5 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.0 (5.0)	6.0 (5.0)	6.5 (5.0)	6.5 (5.0)	6.5 (5.0)
80	3.0 (3.0)	4.0 (4.0)	4.5 (5.0)	5.0 (5.0)	5.0 (5.0)	5.5 (5.0)	5.5 (5.0)	6.0 (5.0)	6.0 (5.0)	6.0 (5.0)	6.5 (5.0)	6.5 (5.0)	6.5 (5.0)	7.0 (6.0)	7.0 (6.0)

4.1

3.3

Attachment 3. Fetch Limited Wave Heights Nomogram

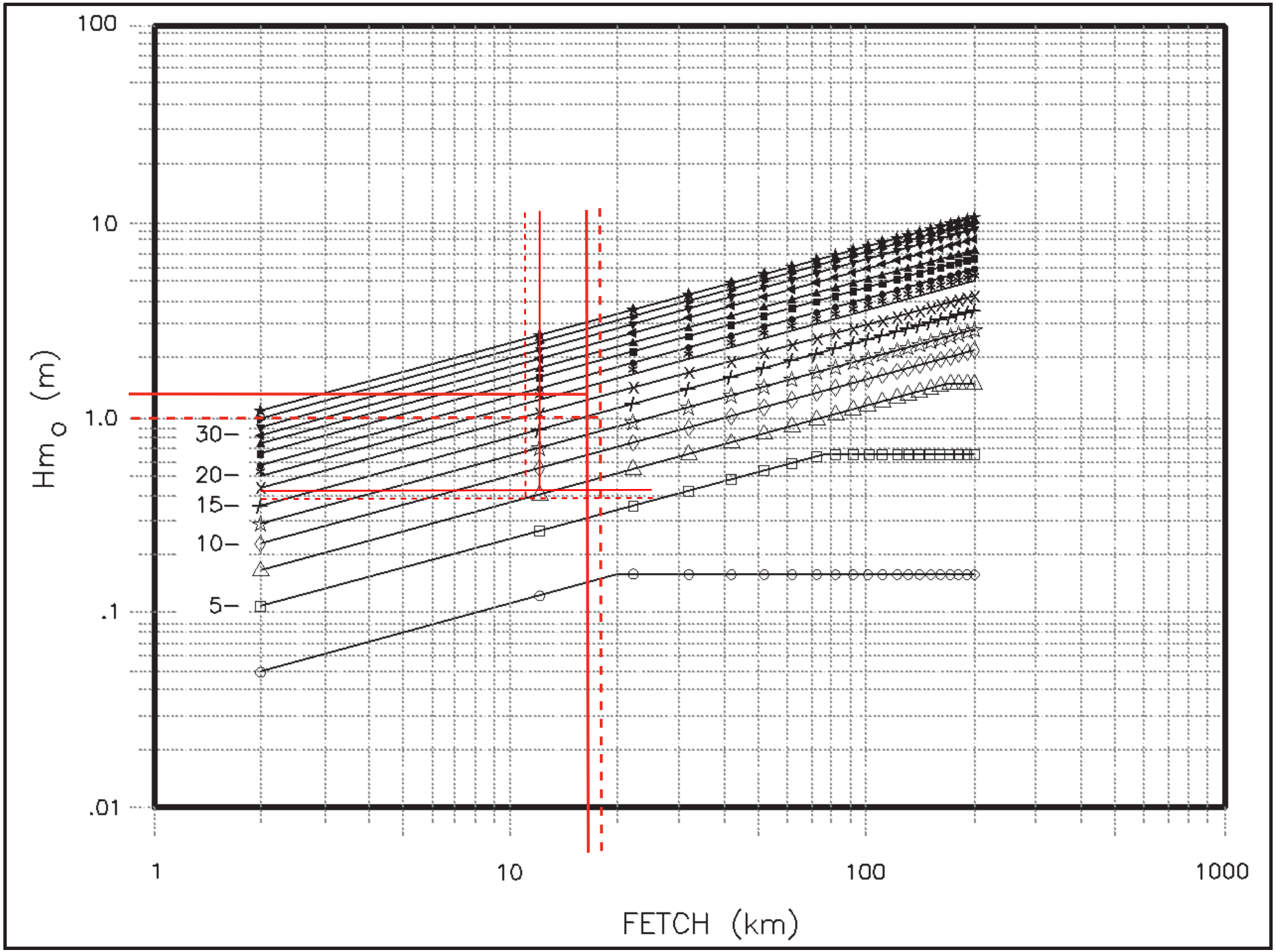


Figure II-2-23. Fetch-limited wave heights

A10. Armor Stone Size

Project	HPNS, Parcel E-2	Component/System:	Armor Stone Size
Prepared by:	ALM	Checked by:	JS
Date	1-2013	Date	3-2013

PURPOSE

The purpose of this calculation is to determine the size of the revetment armor stone.

DATA

- Maximum wind-generated wave height (direction normal to face of revetment): 4.1 feet
- Specific weight of armoring stone: 165 pounds per cubic foot
- Design slope of revetment face = 3H:1V (18.4 degrees from horizontal)

METHODOLOGY

The Hudson Formula (Equation 2-15 from the USACE Design of Coastal Revetments, Seawalls, and Bulkheads, 1995) is used to determine the size of the revetment armor stone.

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1 \right)^3 \cot\theta}$$

Where:

W	=	*required individual armor unit weight, lb (or W_{50} for graded riprap)*
γ_r	=	*specific weight of the armor unit = 165 lb/ft^3*
H	=	*wave height = 4.1 ft*
K_D	=	*stability coefficient = 2.2 for randomly placed riprap at slopes from 2.0 to 6.0. (from USACE Table 2-3, see Attachment 1)*
θ	=	*structure slope from horizontal = 18.4 degrees (0.32098 radians)*
γ_w	=	*specific weight of saltwater = 64 lbs/ft^3*

CALCULATION

$$W = \frac{\gamma_r H^3}{K_D\left(\frac{\gamma_r}{\gamma_w}-1\right)^3 \cot\theta} = \frac{(165)(4.1)^3}{2.2\left(\frac{165}{64}-1\right)^3 \cot(0.32098)} = 437 lbs.$$

CONCLUSIONS

The Hudson Formula gives a median stone weight (minimum W_{50} size) of 437 pounds. This is equivalent to a spherical shape with a diameter of 1.7 feet, and a cubical shape with a dimension of 1.4 feet.

The USACE (2006) states that stones comprising the primary cover layer can range from 4.0 W_{50} to 0.125 W_{50}.

The USACE (1995) suggests the following guidelines for establishing gradation limits:

- The lower limit of the W_{50} stone ($W_{50\ min}$) should be based on stability requirements using Hudson's Formula
- The upper limit of the W_{100} stone ($W_{100\ max}$) should not exceed 4 times $W_{50\ min}$
- The lower limit of the W_{100} stone ($W_{100\ min}$) should not be less than twice $W_{50\ min}$
- The upper limit of the W_{50} stone ($W_{50\ max}$) should be about 1.5 times $W_{50\ min}$
- The lower limit of the W_{15} stone ($W_{15\ min}$) should be about 0.4 times $W_{50\ min}$
- The upper limit of the W_{15} stone ($W_{15\ max}$) should be about based on filter requirements per EM 1110-2-1901 (USACE , 1994), and should slightly exceed $W_{50\ min}$

On projects with a high degree of public access, the USACE (1985) recommends a stone size of at least 400 to 500 pounds to prevent vandalism. Therefore, a stone weight of 450 pounds was selected as the median stone weight for the revetment design.

Given the design criteria listed above, the riprap gradation recommended for this project is as follows:

Percent Lighter Limits of Stone by Weight	Weight (pounds)
95-100%	900
0-50-%	450
0-15%	180
0-5%	75

REFERENCES

U.S. Army Corps of Engineers. 1995. "Design of Coastal Revetments, Seawalls, and Bulkheads." June.

U.S. Army Corps of Engineers. 1985. "Coastal Engineering Technical Note, Riprap Revetment Design." June.

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

A11. Armor Layer Thickness

Project	HPNS, Parcel E-2	Component/System:	Armor Layer Thickness
Prepared by:	ALM	Checked by:	DB
Date	1-2013	Date	3-2013

PURPOSE

The purpose of this calculation is used to determine the thickness of the layer of revetment armor stone.

DATA

- Median weight of stone (Hudson Formula) = 450 pounds
- Maximum weight of stone = 900 pounds
- Specific weight of armoring stone = 165 pounds per cubic foot

METHODOLOGY

In accordance with USACE recommendations (USACE, 1995), the layer thickness for graded riprap should be:

- At least twice the nominal diameter of the W_{50} stone $\left[D = \left(\frac{W}{\gamma_r} \right)^{1/3} \right]$
- At least 25% greater than the nominal diameter of the largest stone
- Greater than a minimum thickness of 1 foot

The following equation summarizes these design criteria:

$$r_{\min} = \max\left[2.0\left(\frac{W_{50}}{\gamma_r} \right)^{1/3} ; 1.25\left(\frac{W_{100}}{\gamma_r} \right)^{1/3} ; 1\,ft \right]$$

Where:

W	=	*weight of individual riprap stone (W_{50} or W_{100})*
γ_r	=	*specific weight of the armor unit = 165 lb/ft^3*
$r_{\min}$	=	*minimum layer thickness perpendicular to the slope*

CALCULATIONS

The minimum layer thickness was evaluated for the W_{50} stone size determined by Hudson's Formula.

$$r_{\min} = \max\left[2.0\left(\frac{450}{165}\right)^{1/3};1.25\left(\frac{900}{165}\right)^{1/3};1\,ft\right]$$

$$r_{\min} = \max\left[2.75\,ft;2.20\,ft;1\,ft\right]$$

The results show that for the Hudson's Formula derived W_{50} stone, a 2.75-foot thick layer (minimum) is required. Given that the cubical dimension of a W_{50} stone weighing 450 lbs is 1.4 feet, a layer thickness of 2.8 feet will be used in the design (i.e., twice the dimensions of a W_{50} stone weighing 450 lbs).

REFERENCES

U.S. Army Corps of Engineers. 1995. "Design of Coastal Revetments, Seawalls, and Bulkheads." June.

U.S. Army Corps of Engineers. 1977. "Shore Protection Manual." June.

A12. Wave Runup

Project	HPNS, Parcel E-2	Component/System:	Wave Runup
Prepared by:	ALM	Checked by:	DB
Date	1-2013	Date	3-2013

PURPOSE

This calculation examines the design wind-generated wave runup on the face of the revetment. Runup is the vertical height above the still water level to which the uprush of a wave will rise on a structure. This calculation brief determines the wave runup based on two conditions: (1) an extreme tide (100-year return period), and (2) Mean Higher High Water (MHHW) that also accounts for 3 feet of sea level rise.

ASSUMPTIONS

- Extreme tide (100-year return period) = 6.7 feet NGVD 1929.
- Mean Higher High Water (MHHW) = 3.61 feet NGVD 1929
- Mean Sea Level (MSL) = 0.00 feet NGVD
- Sea level rise = 3 feet
- Maximum wind-generated wave height (direction normal to face of revetment) = 4.1 feet
- Wave period of maximum wind-generated wave height (direction normal to face of revetment) = 3.6 seconds
- Design elevation of proposed toe of revetment = 0.00 feet NGVD
- Design slope of revetment face = 3H:1V

METHODOLGY

The maximum wave runup on a rip-rap covered revetment may be estimated by Equation 2-6 from the USACE Design of Coastal Revetments, Seawalls, and Bulkheads, 1995 (as developed by Ahrens and Heimbaugh, 1988).

$$\frac{R_{\max}}{H_{mo}} = \frac{a\xi}{1+b\xi}$$

Where:

R_{max} = *maximum vertical height (in feet) of the runup wave on the revetment*

H_{mo} = *energy-based wave height (in feet) at the zeroth moment of the wave spectrum*

a, b = *regression coefficients determined as 1.022 and 0.247, respectively (constants)*

ξ = *surf zone parameter defined by Equation 2-7 from the USACE Design of Coastal Revetments, Seawalls, and Bulkheads, 1995, defined as:*

$$\xi = \frac{\tan\theta}{\left(\frac{2\pi H_{mo}}{gT_p^2}\right)^{1/2}}$$

Where:

θ	=	*the angle (in radians) of the revetment slope with the horizontal = 0.32098 radians*
T_p	=	*wave period (in seconds) of the design wave = 3.6 sec*

And

$$\frac{H_s}{H_{mo}} = \exp\left[C_0\left(\frac{d}{gT_p^2}\right)^{-C_1}\right]$$

Where:

H_s	=	*design wave height (in feet) = 4.1 ft*
C_0, C_1	=	*regression coefficients given as 0.00089 and 0.834, respectively*
g	=	*gravitational acceleration (in feet per squared seconds) = 32.2 ft/sec^2*
d	=	*water depth at the structure (in feet)*

CALCULATIONS

Calculation 1: Wave runup based on an extreme tide (100-year return period)

Wave Height (H_{mo})

$$\frac{4.1}{H_{mo}} = \exp\left[0.00089\left(\frac{6.7}{32.2*3.6^2}\right)^{-0.834}\right]$$

H_{mo} = 3.99 ft

Surf Parameter

$$\xi = \frac{\tan\theta}{\left(\frac{2\pi H_{mo}}{gT_p^2}\right)^{1/2}} = \frac{\tan(0.32098)}{\left(\frac{2\pi 3.99}{32.2*3.6^2}\right)^{1/2}} = 1.36$$

Maximum Runup

$$\frac{R_{\max}}{H_{mo}} = \frac{a\xi}{1+b\xi} \qquad = \qquad \frac{R_{\max}}{3.99} = \frac{1.022*1.36}{1+0.247*1.36}$$

R_{max} = 4.14 ft

Therefore, maximum elevation of wave runup = 6.7 ft (extreme tide) + 4.14 ft (R_{max})

= <u>10.84 feet NGVD 1929</u>

<u>Calculation 2: Wave runup condition based on MHHW + 3 feet of sea level rise</u>

Wave Height (H_{mo})

$$\frac{4.1}{H_{mo}} = \exp\left[0.00089\left(\frac{3.61+3.0}{32.2*3.6^2}\right)^{-0.834}\right]$$

H_{mo} = 3.99 ft

Surf Parameter

$$\xi = \frac{\tan\theta}{\left(\frac{2\pi H_{mo}}{gT_p^2}\right)^{1/2}} = \frac{\tan(0.32098)}{\left(\frac{2\pi 3.99}{32.2*3.6^2}\right)^{1/2}} = 1.36$$

Maximum Runup

$$\frac{R_{\max}}{H_{mo}} = \frac{a\xi}{1+b\xi} \qquad = \qquad \frac{R_{\max}}{3.99} = \frac{1.022*1.36}{1+0.247*1.36}$$

R_{max} = 4.1 ft

Therefore, maximum elevation of wave runup = 3.61 ft (MHHW) + 3.0 ft (SLR) + 4.14 ft (R_{max})

= <u>10.75 feet NGVD 1929</u>

CONCLUSIONS

Based on the results of the calculations herein, the crest elevation of the revetment structure (or alternative crest design element) must be higher than **10.84 feet NGVD 1929** to accommodate the maximum wave runup from:

1. An extreme tide (100-year return period)
2. MHHW + 3 feet of sea level rise

REFERENCE

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

A13. Wave Breaking Depth

Project	HPS, Parcel E-2	**Component/System:**	Wave Breaking Depth
Prepared by:	ALM	**Checked by:**	DB
Date	1-2013	**Date**	3-2013

PURPOSE

This calculation examines the depth at which the design wind-generated wave will break, and the locations of the break point at various tidal datums.

DATA

The following design data is being used for this calculation:

- 100-Year Tide: 6.7 ft NGVD
- Highest Observed Water Level (HOWL): 5.04 ft NGVD
- Mean Higher High Water (MHHW): 3.61 ft NGVD
- Mean Sea Level (MSL): 0.00 ft NGVD
- Mean Lower Low Water (MLLW): -3.56 ft NGVD
- Maximum wind-generated wave height (direction normal to face of revetment): 4.1 ft
- Toe of revetment is at 0.00 ft NGVD (0.00 ft MSL)
- Slope of revetment face is 3:1

METHODOLGY

The relationship between wave height and breaking depth is given by Equation II-1-97 from the USACE Coastal Engineering Manual (USACE, 2006) as follows:

$$\left(\frac{H}{d}\right)_{\max} = 0.78$$

Where:

H	=	*wave height*
d	=	*water depth at wave break*

CALCULATIONS

The water depth at which a 4.1 ft wave will break is determined using Equation II-1-97.

$$\left(\frac{H}{d}\right)_{\max} = 0.78$$

$$d = \frac{4.1}{0.78}$$

$$d = 5.3\,ft$$

For the 100-Year Tide depth of 6.7 ft NGVD, the wave will break at an elevation of 1.4 ft NGVD.

$$6.7 - 5.3 = 1.4\,ft$$

Since the slope of the revetment section is 3H:1V, this corresponds to a break point location of 4.2 ft shoreward from the toe of the revetment.

$$1.4 \times 3 = 4.2\,ft$$

For the 100-Year Tide depth of 6.7 ft NGVD, plus a sea level rise of 3.0 ft (SWL =9.7 ft NGVD), the wave will break at an elevation of 4.4 ft NGVD.

$$9.7 - 5.3 = 4.4\,ft$$

Since the slope of the revetment section is 3H:1V, this corresponds to a break point location of 13.2 ft shoreward from the toe of the revetment.

$$4.4 \times 3 = 13.2\,ft$$

CONCLUSIONS:

- A 4.1 feet high wave will break at a water depth of 5.3 feet
- At the 100-Year Tide depth of 6.7 ft NGVD, the wave will break at an elevation of 1.4 ft NGVD, which is 4.2 feet shoreward from the toe of the revetment
- At the 100 Year Tide depth 6.7 ft NGVD, plus a sea level rise of 3.0 ft (SWL =9.7 ft NGVD), the wave will break at an elevation of 4.4 ft NGVD, which is 13.2 feet shoreward from the toe of the revetment
- The structure will be subjected to breakers equal to the design wave height

REFERENCES

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

A14. Revetment Wall Design Criteria

Project	HPNS, Parcel E-2	Component/System:	Revetment Wall Design Criteria
Prepared by:	MJG	Checked by:	PDL
Date	3-2013	Date	3-2013

PURPOSE

This calculation brief presents the evaluation of short wind-waves and wave-induced runup upon the revetment structure. The evaluation was performed by Noble Consultants, Inc. (NCI) in their Draft Project Memorandum (Noble, 2013). The purpose of this evaluation is to determine oceanographic design criteria and computed wave loading conditions on the proposed wall along the top of the revetment structure. The addition of a sea wall at the top of the revetment would allow for a reduction in the height of the revetment and the overall loading along the shoreline which had raised slope stability concerns. NCI evaluated wave runup and resulting forces on the revetment structure considering with- and without- wall conditions.

DATA

Data from the following calculation briefs were used by NCI for the estimation of the wave-induced forces:

- Wave Runup
- Fetch Distances and Wind Parameters
- Wave Generation

METHODOLOGY

NCI first reviewed and confirmed ERRG's initial input parameters and calculations on wind wave generation and wave runup for the without-wall condition and then analyzed these parameters considering a with-wall condition. NCI then determined the wave forces acting against the wall in the with-wall condition looking at both the wave-induced hydrostatic and dynamic forces.

For all of these analyses, NCI considered the following two scenarios:

- Scenario I: Broken wave condition under 100-yr tide
- Scenario II: Broken wave condition under 100-yr tide with a 3-ft sea level rise

CALCULATIONS

The calculations performed by NCI are described in the Memorandum and the results summarized in Tables 1 and 2. (Noble, 2013)

CONCLUSIONS

The Memorandum presents design criteria for the proposed wall based on the computed wind and wave conditions at the site. The addition of a seawall at the top of the revetment structure will allow the height of the shoreline area to be reduced to an elevation of 9 ft MSL, improving the overall slope stability of the area. In the 3-foot sea level rise scenario there is chance for waves overtopping the wall in the 100-year tide condition, but not under current conditions.

REFERENCES

Noble Consultants, Inc. 2013. "Project Memorandum, Oceanographic Design Criteria, DRAFT." March.

ATTACHMENTS

Attachment 1. Noble Project Memorandum

Attachment 1. Noble Project Memorandum

NOBLE
CONSULTANTS, INC.

PROJECT MEMORANDUM

2201 DUPONT DRIVE, SUITE 620, IRVINE, CA 92612 (949) 752-1530
FACSIMILE (949) 752- 8381

To:

From: Ronald M. Noble

Date: March 22, 2013

RE: Oceanographic Design Criteria

DRAFT

This project memorandum briefly presents our evaluation of estimation of short wind-waves and wave-induced runup along the proposed revetment that was performed by Engineering/Remediation Resources Group, Inc. (ERRG). In addition, the wave runup analysis under the with-wall condition and wave force calculations that were prepared by Noble Consultants Inc. (NCI) are also presented.

1) Wind Wave Generation

Short-period wind waves were estimated by ERRG[1], based on the historical wind data that was recorded at San Francisco Airport and Coastal Engineering Manual (CEM) that was prepared by US Army, Corps of Engineers (USACE)[2]. Wind wave exposure at the project site ranges approximately between 143 and 176 degrees from the north. Design waves were estimated from three different methods. Estimated short-period wind waves with a height of 4.1 feet and a period of 3.6 seconds appear to be reasonable.

2) Wave Runup

Wave uprush along the proposed revetment without the presence of the flood wall was estimated by ERRG[3]. Two scenarios were considered: 1) 100-year tide without sea level rise and 2) 100-year tide with a 3-foot sea level rise. Figure 1 illustrates the preliminarily proposed cross section of the revetment structure that was used in the analysis. NCI also performed wave runup calculations based on the composite slope method[4] for the with- and without- wall conditions. Table 1 presents the comparison of the wave runup calculations. The design wave has a height of 4.1 feet and a period of 3.6 second. The results estimated by ERRG and NCI are comparable for the without-wall condition. It is expected that wave runup would be higher with the presence of the flood wall, particularly for the condition

[1] Summary of Engineering Analysis of Wind Waves by ERRG, 2013.
[2] USACE, 2006. "Coastal Engineering Manual".
[3] Summary of Engineering Analysis of Wave Runup by ERRG, 2013
[4] USACE, 1984. "Shore Protection Manual".

DRAFT

including the effect of sea level rise since the still water level (SWL) at +9.7 feet, MSL is higher than the crest of the revetment structure at +9 feet, MSL.

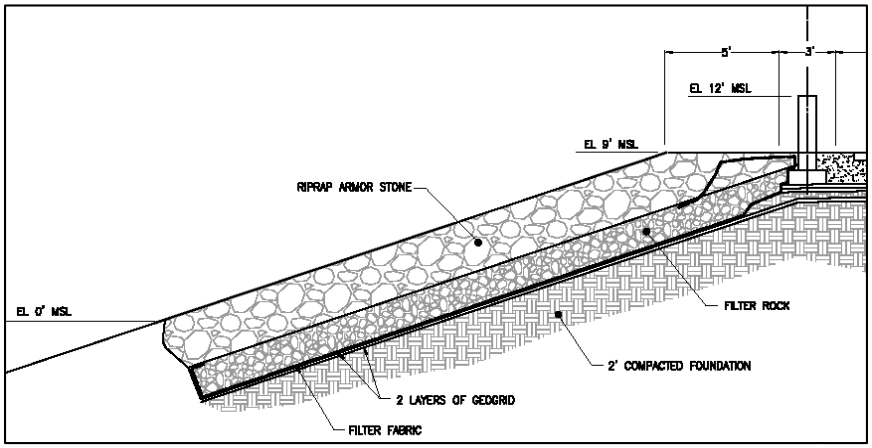


Figure 1. Preliminary Cross Section of Revetment & Flood Wall

Table 1. Estimated Wave Runups

SWL	ERRG w/o wall	NCI w/o wall	NCI w/wall
6.7', msl	+10.8', msl	+10.8', msl	10.9', msl
9.7', msl	+14.9, msl	+15.4', msl	16.8', msl

3) Wave Force Against Flood Wall

Since the flood wall that is exposed to wave impingement is above the crest of the revetment structure at +9 feet, MSL, waves will break prior to propagating to the wall. Thus, the broken wave force against the wall is to be expected. The same two scenarios with and without inclusion of sea level rise were analyzed for the wall design. Table 2 presents the computed wave-induce hydrostatic and dynamic forces.

<u>Scenario I: Broken wave condition under 100-yr tide</u>

The estimated elevation of wave uprush is only at +10.9 feet, MSL. Therefore, the bore depth is only 1.9 feet (10.9-9.0=1.9). Based on the guideline presented in the Shore Protection Manual[4], the hydrostatic and dynamic forces were estimated from the following formulae:

Hydrostatic force (P_s) = $\frac{W}{2}\ d^2$

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Dynamic force (P_m) = $\frac{w d_b h'}{2} \left(1 - \frac{x_1}{x_2}\right)^2$

Where:
w is the weight per unit volume of sea water (=64 lbs/ft^3),
d is the bore depth at the seawall,
d_b is the wave breaking depth,
h' is the equivalent broken wave height at wall,
x_1 is the distance from the stillwater line to the seawall structure, and
x_2 is the imaginary distance from the stillwater line to the limit of wave uprush.

<u>Scenario II: Broken wave condition under 100-yr tide with a 3-ft sea level rise</u>

It is noted that the preliminary design for the top of the wall footing is at +6.75 feet, MSL. The hydrostatic and dynamic forces were estimated from the following formulae:

Hydrostatic force (P_s) = $\frac{W}{2} (R_2 + R_1)(h_W - h_f)$

Dynamic force (P_m) = $\frac{w d_b}{2} (h_w - h_s)$

Where:
w is the weight per unit volume of sea water (=64 lbs/ft^3),
R_1 is the vertical distance from the top of structure footing to the crest of wave uprush,
R_2 is the vertical distance from the top of the wall to the crest of wave uprush,
h_w is the top elevation of the wall at +12 feet, MSL,
h_f is the top of the structure footing at +6.75 feet, MSL, and
h_s is the still water level +9.7 feet, MSL.

Table 2. Oceanographic Design Criteria and Computed Wave Loadings

Parameters	Design Criteria	
	Scenario 1	Scenario 2
Stillwater level	+6.7 feet, MSL	+9.7 feet, MSL
Breaking wave Height	4.5 feet	4.5 feet
Breaking water depth	4.3 feet	4.3 feet
Wave-induced bore depth at the seawall	1.9 feet	3.0 feet*
Hydrostatic Pressure at the bore bottom	121.6 lbs/sf	-
Hydrostatic Pressure at the crest of wall	-	307.2 lbs/sf
Hydrostatic Pressure at the wall footing	-	643.2 lbs/sf
Resultant Hydrostatic Force	115 lbs/lf	2,494 lbs/lf
Dynamic Pressure	13.9 lbs/sf	137.6 lbs/sf
Resultant Dynamic Force	17.9 lbs/lf	316.5 lbs/lf

*: waves overtop the wall

A15. Revetment Wall Structural Calculations

NOBLE CONSULTANTS INC.

PROJECT:

Project No.:

DRAFT

STRUCTURAL CALCULATIONS

FOR: HUNTER'S POINT SEAWALL

ENGINEERING REMEDIATION RESOURCES GROUP, INC.

BY: NOBLE CONSULTANTS INC.
THOMAS FISCHETTI, PE
PROJECT NO. 1052-01

MARCH 27, 2013
(35% SUBMITTAL)

CONTENTS:

LOADING DIAGRAMS ——— 1-2
WALL ANALYSIS FOR RETAINING SOIL — 3-21
WALL ANALYSIS FOR WAVE RUN UP — 22-

By: T. FISCHETTI	Checker:	Sheet: —
Date: 3-27-2013	Date:	of

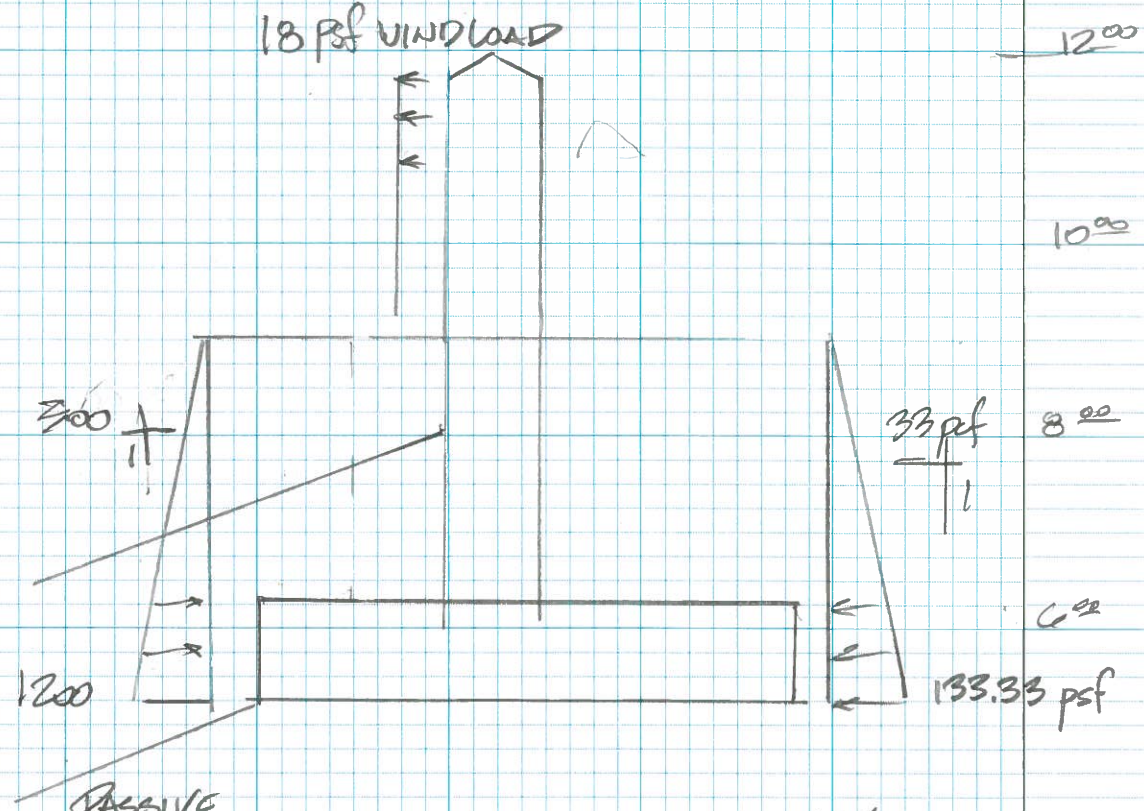
NOBLE CONSULTANTS INC.

PROJECT: HUNTERS POINT SEAWALL DESIGN

Project No.: 1052-01

PRESSURE DIAGRAM (LC1 - SOILS)

NOTE: QUICK R-WALL ANALYSIS INCLUDES SEISMIC LOADING.



PASSIVE SOIL PRESSURE

$\gamma = 100$ pcf
$\phi = 30°$
$C = 0$ psf

ACTIVE SOIL PRESSURE

$\gamma = 100$ pcf
$\phi = 30°$
$C = 0$ psf
$K_h = 0.20$
$K_v = 0.00$
} SEISMIC

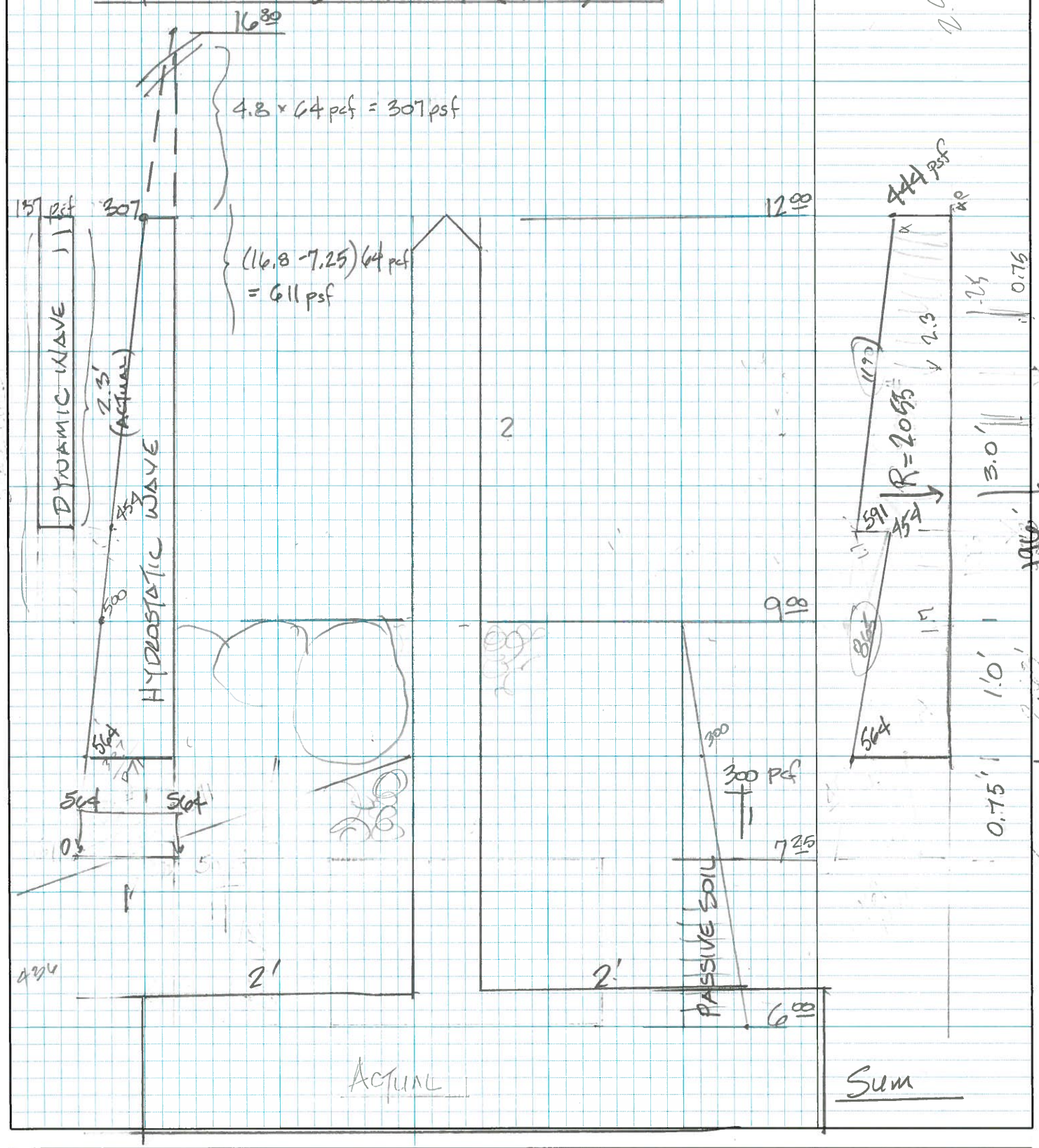
By: T. FISCHETTI	Checker:	Sheet: 1
Date: 3-27-2013	Date:	of

NOBLE CONSULTANTS INC.

PROJECT: Hunters Point Seawall Design

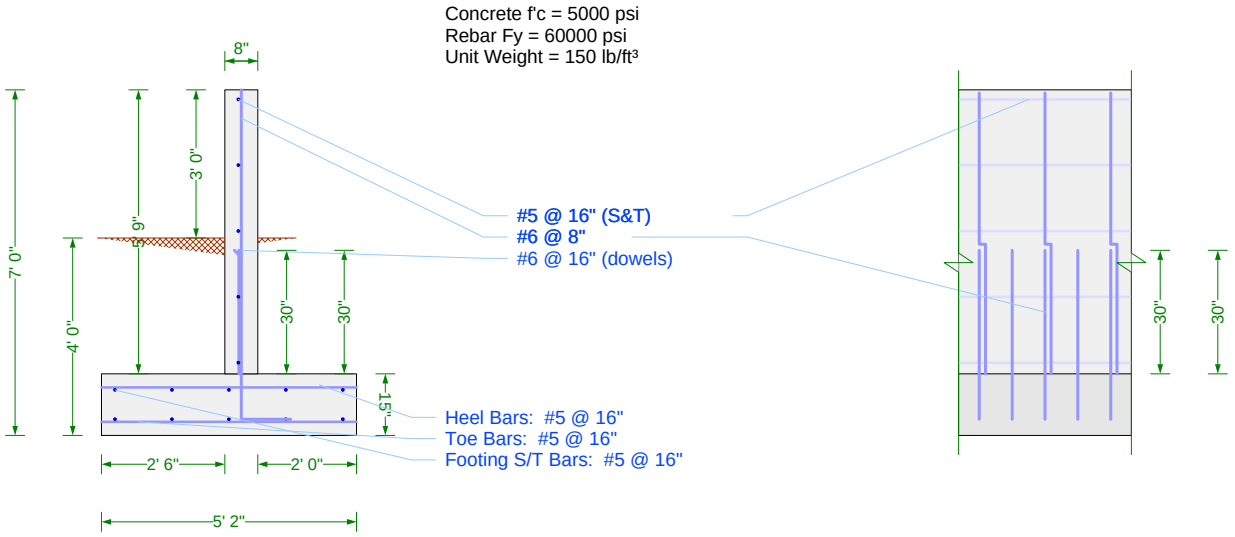
Project No.: 1052-01

PRESSURE DIAGRAM (LC2)



By: T. Fischetti	Checker:	Sheet: 2
Date: 3-27-2013	Date:	of

Design Detail



Check Summary

Ratio	Check	Provided	Required	Combination
----- Stability Checks -----				
✓ 0.939	Overturning	1.28	1.20	Stability
✓ 0.578	Sliding	2.08	1.20	Stability
✓ 0.902	Bearing Pressure	2500 psf	2255 psf	Stability
✓ 0.650	Bearing Eccentricity	20.2"	31"	Stability
----- Toe Checks -----				
✓ 0.166	Shear	14.88 k/ft	2.47 k/ft	1.4D + 1.4F
✓ 0.398	Moment	12.08 ft·k/ft	4.81 ft·k/ft	1.4D + 1.4F
✓ 0.003	Min Strain	1.1507	0.0040	1.4D + 1.4F
✓ 0.000	Min Steel	0.02 in²	0 in²	1.4D + 1.4F
✓ 0.414	Development	29"	12"	1.4D + 1.4F
✓ 0.889	S&T Max Spacing	16"	18"	1.4D + 1.4F
✓ 0.697	S&T Min Rho	0.0026	0.0018	1.4D + 1.4F
----- Heel Checks -----				
✓ 0.113	Shear	14.88 k/ft	1.68 k/ft	1.4D + 1.4F
✓ 0.139	Moment	12.08 ft·k/ft	1.68 ft·k/ft	1.4D + 1.4F
✓ 0.003	Min Strain	1.1507	0.0040	1.4D + 1.4F
✓ 0.000	Min Steel	0.02 in²	0 in²	1.4D + 1.4F
✓ 0.343	Development	35"	12"	1.4D + 1.4F
✓ 0.889	S&T Max Spacing	16"	18"	1.4D + 1.4F
✓ 0.697	S&T Min Rho	0.0026	0.0018	1.4D + 1.4F
----- Stem Checks -----				
✓ 0.826	Horz Bar Rho	0.0024	0.0020	Load Case 1: 1.4D + 1.4F
✓ 0.889	Horz Bar Spacing	16"	18"	Load Case 1: 1.4D + 1.4F
✓ 0.961	Moment	10.73 ft·k/ft	10.31 ft·k/ft	Load Case 1: 1.4D + 1.4F
✓ 0.565	Shear	5.09 k/ft	2.88 k/ft	Load Case 1: 1.4D + 1.4F
✓ 0.015	Max Steel	0.2752	0.0040	Load Case 1: 1.4D + 1.4F
✓ 0.257	Min Steel	0.06 in²/in	0.01 in²/in	Load Case 1: 1.4D + 1.4F
✓ 0.714	Base Development	12"	8.6"	Load Case 1: 1.4D + 1.4F
✓ 0.662	Lap Splice Length	30"	19.9"	Load Case 1: 1.4D + 1.4F
✓ 0.000	Lap Splice Spacing	0"	4"	Load Case 1: 1.4D + 1.4F
✓ 0.851	Bar Cutoff Extension	10.6"	9"	Load Case 1: 1.4D + 1.4F
✓ 0.565	Bar Cutoff Shear	5.09 k/ft	2.88 k/ft	Load Case 1: 1.4D + 1.4F

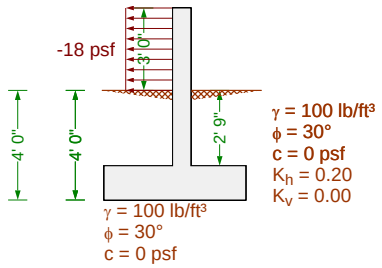
Criteria

Building Code	IBC 2009
Concrete Load Combs	IBC 2009 (Strength)
Masonry Load Combs	ASCE 7-05 (ASD)
Stability Load Comb	Stability
Restrained Against Sliding	No
Neglect Bearing At Heel	Yes
Use Vert. Comp. for OT	Yes
Use Vert. Comp. for Sliding	Yes
Use Vert. Comp. for Bearing	Yes
Use Surcharge for Sliding & OT	No
Use Surcharge for Bearing	Yes
Neglect Soil Over Toe	No
Neglect Backfill Wt. for Coulomb	No
Factor Soil Weight As Dead	Yes
Use Passive Force for OT	Yes
Assume Pressure To Top	Yes
Extend Backfill Pressure To Key Bottom	No
Use Toe Passive Pressure for Bearing	Yes
Required F.S. for OT	1.20
Required F.S. for Sliding	1.20
Has Different Safety Factors for Seismic	Yes
Seismic F.S. for OT	1.20
Seismic F.S. for Sliding	1.20
Allowable Bearing Pressure	2500 psf
Req'd Bearing Location	Over footing
Wall Friction Angle	25°
Friction Coefficent	0.35
Soil Reaction Modulus	100 lb/in³

Loads

Loading Options/Assumptions

Passive pressure neglects top 0' 0" of soil.

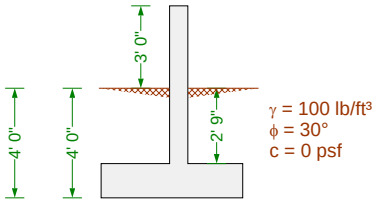


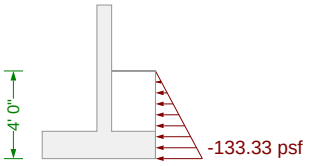
Load Combinations

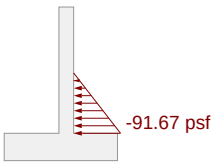
IBC 2009 (Strength)

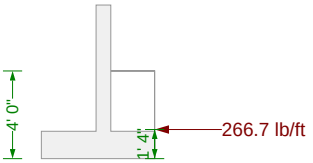
1.4D + 1.4F
1.2D + 1.6H + 1.2F
0.9D + 1.6H
1.2D
1.2D + 1.6H
1.2D + 0.8W
1.2D + 1.6W
1.2D + 1.0E
0.9D + 1.6H + 1.0E
0.9D + 1.6H + 1.6W
1.4D
1.2D
1.2D + 1.6H + 1.6L
1.2D + 0.5L
0.9D + 1.6H
1.4D
1.2D

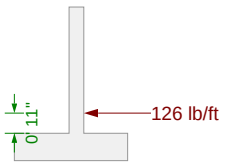
Backfill Pressure











Lateral Earth Pressure

Rankine Active Earth Pressure Theory

$$K_a = \tan^2\left[45° - \frac{\phi}{2}\right] = \tan^2\left[45° - \frac{(30°)}{2}\right] = 0.3333$$

$$\sigma_a = \gamma H K_a - 2c\sqrt{K_a} = (100\ lb/ft^3)(4'\ 0")(0.3333) - 2(0\ psf)\sqrt{0.3333} = 133.3\ psf$$

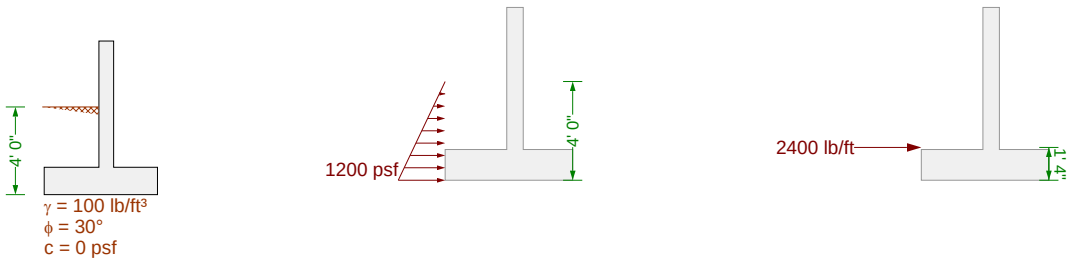
$$\alpha_P = \alpha = (0°) = 0° \quad \text{(resultant force angle with horizontal)}$$

Lateral Earth Pressure (stem only)

$$\sigma_a = \gamma H K_a - 2c\sqrt{K_a} = (100\ lb/ft^3)(2'\ 9")(0.3333) - 2(0\ psf)\sqrt{0.3333} = 91.67\ psf$$

$$\alpha_P = \alpha = (0°) = 0° \quad \text{(resultant force angle with horizontal)}$$

Passive Pressure



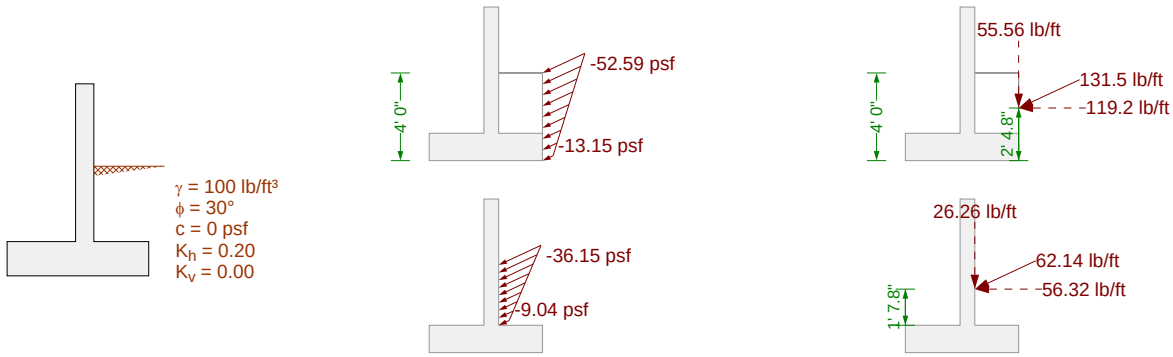
Lateral Earth Pressure

Rankine Passive Earth Pressure Theory

$$K_p = \tan^2\left[45° + \frac{\phi}{2}\right] = \tan^2\left[45° + \frac{(30°)}{2}\right] = 3.0$$

$$\sigma_p = \gamma H K_p + 2 c \sqrt{K_p} = (100 \text{ lb / ft}^3)(4' 0")(3.0) + 2 (0 \text{ psf}) \sqrt{3.0} = 1200 \text{ psf}$$

Seismic Pressure



Seismic Pressure

Dynamic + static force (Mononobe - Okabe equation)

$$\theta' = \arctan\left[\frac{k_h}{1 - k_v}\right] = \arctan\left[\frac{(0.20)}{1 - (0.0)}\right] = 11.31°$$

$$K_{ae} = \frac{\sin^2[\beta + \phi - \theta']}{\cos(\theta')\sin^2(\beta)\sin[\beta - \theta' - \delta]\left[1 + \sqrt{\frac{\sin[\phi + \delta]\sin[\phi - \theta' - \alpha]}{\sin[\beta - \delta - \theta']\sin[\alpha + \beta]}}\right]^2}$$

$$= \frac{\sin^2[(90°) + (30°) - (11.31°)]}{\cos((11.31°))\sin^2((90°))\sin[(90°) - (11.31°) - (25°)]\left[1 + \sqrt{\frac{\sin[(30°) + (25°)]\sin[(30°) - (11.31°) - (0°)]}{\sin[(90°) - (25°) - (11.31°)]\sin[(0°) + (90°)]}}\right]^2}$$

$$= 0.4603$$

$$P_{ae} = \frac{1}{2}K_{ae}\gamma H^2[1 - k_v] = \frac{1}{2}(0.4603)(100\ lb/ft^3)(4'\ 0'')^2[1 - (0.0)] = 368.2\ lb/ft$$

Static - only force (Coulomb equation)

$$K_a = \frac{\sin^2[\beta + \phi]}{\sin^2(\beta)\sin[\beta - \delta]\left[1 + \sqrt{\frac{\sin[\phi + \delta]\sin[\phi - \alpha]}{\sin[\beta - \delta]\sin[\alpha + \beta]}}\right]^2}$$

$$= \frac{\sin^2[(90°) + (30°)]}{\sin^2((90°))\sin[(90°) - (25°)]\left[1 + \sqrt{\frac{\sin[(30°) + (25°)]\sin[(30°) - (0°)]}{\sin[(90°) - (25°)]\sin[(0°) + (90°)]}}\right]^2}$$

$$= 0.2959$$

$$P_a = \frac{1}{2}K_a\gamma H^2 = \frac{1}{2}(0.2959)(100\ lb/ft^3)(4'\ 0'')^2 = 236.7\ lb/ft$$

Net dynamic force

$$\Delta P_{ae} = P_{ae} - P_a = (368.2\ lb/ft) - (236.7\ lb/ft) = 131.5\ lb/ft$$

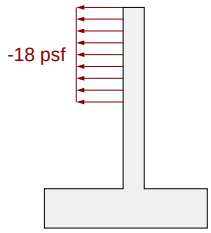
$\alpha_P = 90° - \beta + \delta = 90° - (90°) + (25°) = 25°$ (resultant force angle with horizontal)

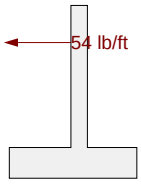
To arrive at the pressure distribution illustrated above (used to determine stem moments), apply inverted triangular pressure plus a uniform portion to bring resultant to 0.6H

$$\sigma_{e_top} = \frac{8}{5}\frac{\Delta P_{ae}}{H} = \frac{8}{5}\frac{(131.5\ lb/ft)}{(4'\ 0'')} = 52.59\ psf$$

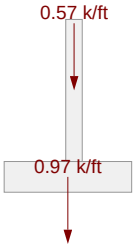
$$\sigma_{e_bot} = \frac{2}{5}\frac{\Delta P_{ae}}{H} = \frac{2}{5}\frac{(131.5\ lb/ft)}{(4'\ 0'')} = 13.15\ psf$$

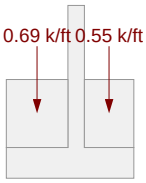
Manually Specified Lateral Stem Pressure



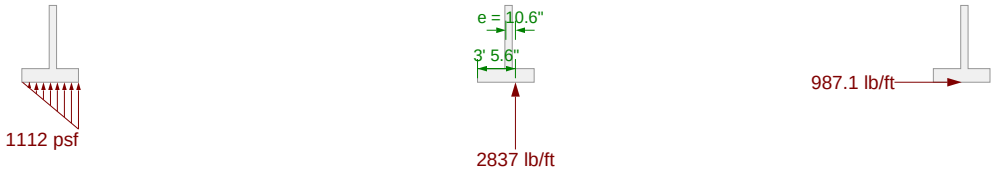


Wall/Soil Weights





Bearing Pressure



Friction

$F = \mu R = (0.350)(2837 \text{ lb / ft}) = 992.9 \text{ lb / ft}$

Bearing Pressure Calculation

Contributing Forces

	Vert Force	...offset	Horz Force	...offset	OT Moment
Backfill Pressure	-0 lb/ft	-	-266.67 lb/ft	1' 4"	4267 in·lb/ft
Passive Pressure (user option)	0 lb/ft	-	2400 lb/ft	1' 4"	-38400 in·lb/ft
Manual Lateral Pressure	-0 lb/ft	-	-54 lb/ft	5' 6"	3564 in·lb/ft
Seismic Force	-55.56 lb/ft	5' 2"	-119.15 lb/ft	2' 4.8"	-13.23 in·lb/ft
Footing Weight	-968.75 lb/ft	2' 7"	0 lb/ft	-	-30031.25 in·lb/ft
Stem Weight	-575 lb/ft	2' 10"	0 lb/ft	-	-19550 in·lb/ft
Backfill Weight	-550 lb/ft	4' 2"	0 lb/ft	-	-27500 in·lb/ft
Soil over toe Weight	-687.5 lb/ft	1' 3"	0 lb/ft	-	-10312.5 in·lb/ft
	-2836.81 lb/ft				-117976.32 in·lb/ft

$$\frac{-117976.32 \text{ in·lb / ft}}{-2836.81 \text{ lb / ft}} = 3' \ 5.6''$$

Stability Checks

Overturning Check

Overturning Moments

	Force	Distance	Moment
Backfill pressure (horz)	266.7 lb/ft	1' 4"	4267 in·lb/ft
Manual lateral pressure	54 lb/ft	5' 6"	3564 in·lb/ft
Seismic force	83.41 lb/ft	2' 4.8"	2402 in·lb/ft
		Total:	10233 in·lb/ft

Resisting Moments

	Force	Distance	Moment
Backfill pressure (vert)	0 lb/ft	5' 2"	0 in·lb/ft
Passive pressure @ toe	2400 lb/ft	1' 4"	38400 in·lb/ft
Footing Weight	-968.75 lb/ft	2' 7"	30031 in·lb/ft
Stem Weight	-575 lb/ft	2' 10"	19550 in·lb/ft
Backfill Weight	-550 lb/ft	4' 2"	27500 in·lb/ft
Soil over toe Weight	-687.5 lb/ft	1' 3"	10313 in·lb/ft
		Total:	125794 in·lb/ft

Without seismic loads:

$$F.S. = \frac{RM}{OTM} = \frac{125794 \text{ in·lb / ft}}{7831 \text{ in·lb / ft}} = 16.064 > 1.20 \text{ (OK)}$$

Including seismic loads:

$$F.S. = \frac{RM}{OTM} = \frac{125794 \text{ in·lb / ft}}{10233 \text{ in·lb / ft}} = 12.293 > 1.20 \text{ (OK)}$$

Sliding Check

Sliding Force(s)

Backfill pressure	266.7 lb/ft
Manual lateral pressure	54 lb/ft
Seismic force	83.41 lb/ft
Total:	404.1 lb/ft

Resisting Force(s)

Passive pressure @ toe	2400 lb/ft
Friction	987.1 lb/ft
Total:	3387 lb/ft

Without seismic loads:

$$F.S. = \frac{RF}{SF} = \frac{3387 \text{ lb / ft}}{320.7 \text{ lb / ft}} = 10.563 > 1.20 \text{ (OK)}$$

Including seismic loads:

$$F.S. = \frac{RF}{SF} = \frac{3387 \text{ lb / ft}}{404.1 \text{ lb / ft}} = 8.382 > 1.20 \text{ (OK)}$$

Bearing Check

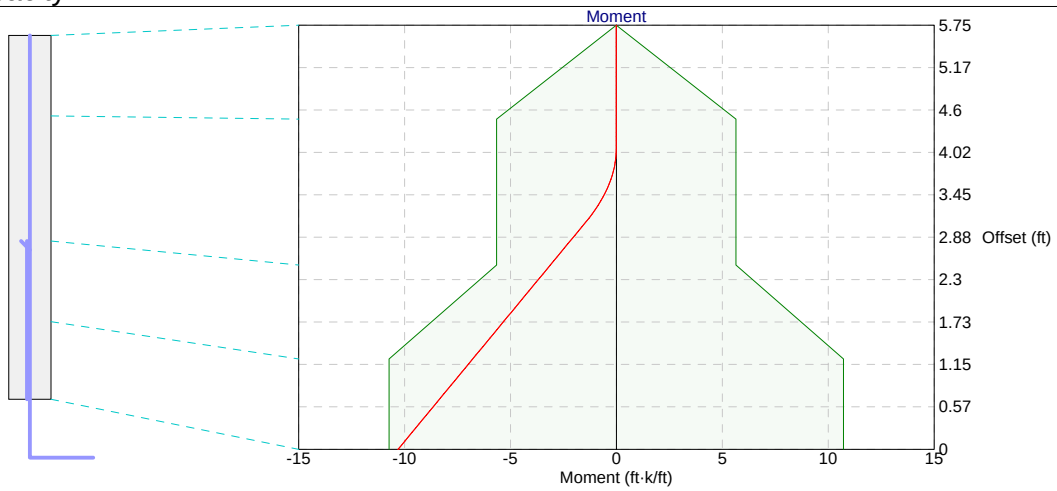
Bearing pressure < allowable (1105 psf < 2500 psf) - OK
Bearing resultant eccentricity < allowable (10.6" < 31") - OK

Wall Top Displacement

(based on unfactored service loads)

Deflection due to stem flexural displacement	0"
Deflection due to rotation from settlement	-0.1"
Total deflection at top of wall (positive towards toe)	-0.1"

Stem Flexural Capacity



Capacity (ACI 318-08 10.2) @ 0' 0" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 0' 0" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 1' 2.7" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 1' 2.7" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 2' 6" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 2' 6" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 4' 5.7" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Stem Flexural Capacity (continued)

Capacity (ACI 318-08 10.2) @ 4' 5.7" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4''$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0.4'') / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 5' 9" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0''$$

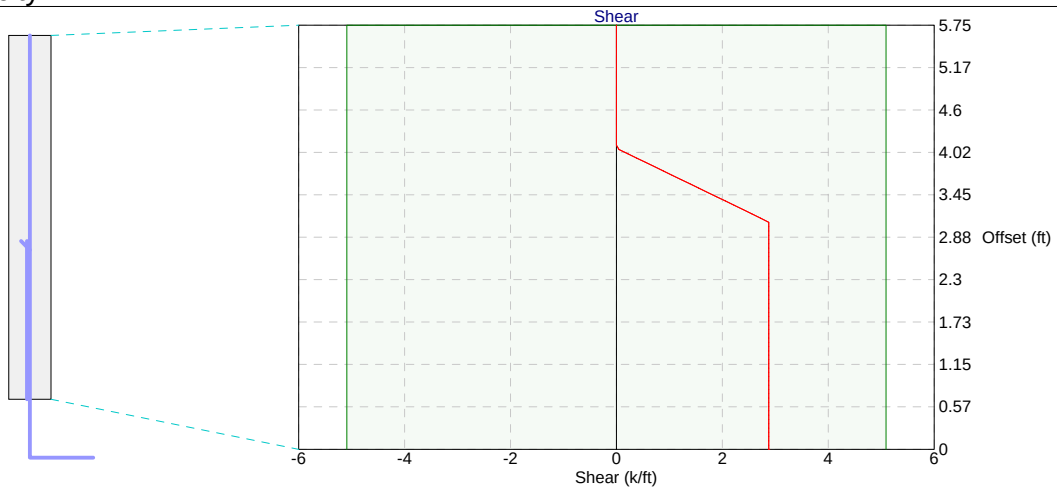
$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0'') / 2] = 0 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 5' 9" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0''$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0'') / 2] = 0 \text{ ft·k / ft}$$

Stem Shear Capacity



Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 0' 0" from base [Positive shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 0' 0" from base [Negative shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 5' 9" from base [Positive shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

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Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 5' 9" from base [Negative shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Stem Development/Lap Length Calculations

Main vertical stem bars (bottom end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b$$

$$= \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8")$$

$= 12.7"$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$8\,d_b = 8\,(0.8") = 6.0$

Main vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16") / 2 = 8"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Cutoff vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (8") / 2 = 4"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Dowels for vertical stem bars (bottom end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b$$

$$= \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8")$$

$= 12.7"$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$8\,d_b = 8\,(0.8") = 6.0$

Stem Development/Lap Length Calculations (continued)

Dowels for vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

ψ_e = 1.0 (bar not epoxy - coated)

ψ_s = 0.80 (bars are #6 or smaller)

s / 2 = (8") / 2 = 4"

cover + d_b / 2 = (2") + (0.8") / 2 = 2.4"

c = 2.4" (lesser of half spacing, ctr to surface)

ψ_t = 1.0 (bars are not horizontal)

λ = 1.0 (normal weight concrete)

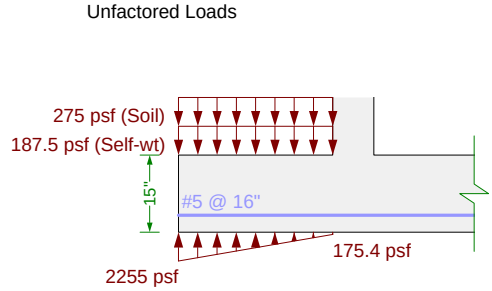
K_{tr} = 0" (no transverse reinforcement)

c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667

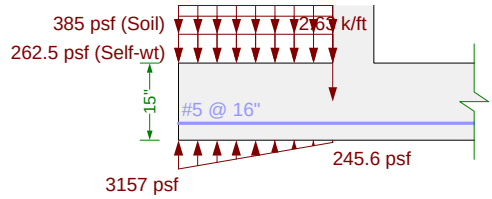
$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right]d_b = \left[\frac{3.}{40}\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\frac{(1.0)(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Toe Checks [combination Load Case 1: 1.4D + 1.4F]

Toe Unfactored Loads



Toe Factored Loads



Controlling Moment

Design moment M_u for toe need not exceed moment at stem base:

$M_{toe} = 4.81\ ft{\cdot}k/ft < M_{stem} = 10.31\ ft{\cdot}k/ft$

$M_u = 4.81\ ft{\cdot}k/ft$ (stem moment does not control)

Flexure Check (ACI 318-08 10.2)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2/in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\phi M_n = \phi A_s f_y [d - a/2] = (0.90)(0.02\ in^2/in)(60000\ psi)[(11.7'') - (0.3'')/2] = 12.08\ ft{\cdot}k/ft$$

$\phi M_n = 12.08\ ft{\cdot}k/ft \geq M_u = 4.81\ ft{\cdot}k/ft$ ✓

Shear Check (ACI 318-08 11.1.1, 11.2.1)

$$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\ psi}(11.7'') = 19.83\ k/ft$$

$$\phi V_n = \phi V_c = (0.750)(19.83\ k/ft) = 14.88\ k/ft$$

$\phi V_n = 14.88\ k/ft \geq V_u = 2.47\ k/ft$ ✓

Minimum Strain Check (ACI 318-08 10.3.5)

$$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$$

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2/in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\varepsilon_t = 0.003\left[\frac{d}{a/\beta_1} - 1\right] = 0.003\left[\frac{(11.7'')}{(0.3'')/(0.9)} - 1\right] = 1.1507$$

$\varepsilon_t = 1.1507 \geq 0.004$ ✓

Minimum Steel Check (ACI 318-08 10.5.1)

$\phi M_n = 12.08\ ft{\cdot}k/ft \geq (4/3)M_u = [4/3](4.81\ ft{\cdot}k/ft) = 6.41\ ft{\cdot}k/ft$

Check is waived per ACI 10.5.3 ✓

Shrinkage _Temperature Steel (ACI 318-08 7.12.2)

$$\rho_{ST_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(0.62\ in^2)}{(15'')(16'')} = 0.0026$$

$$\rho_{ST_min} = \frac{0.0018(60000)}{f_y} = \frac{0.0018(60000)}{(60000\ psi)} = 0.0018$$

$\rho_{ST_min} = 0.0018$

$\rho_{ST_prov} = 0.0026 \geq \rho_{ST_min} = 0.0018$ ✓

18 inch limit governs

$s_{ST_max} = 18''$

$s_{ST} = 16'' \leq s_{ST_max} = 18''$ ✓

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s/2 = (16'')/2 = 8''$

cover + $d_b/2 = (3'') + (0.6'')/2 = 3.3''$

$c = 3.3''$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (12 inches or less cast below - 3.00 inches)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0''$ (no transverse reinforcement)

$c + K_{tr}/d_b = (3.3'') + (0'')/(0.6'') = 5.30$

$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\psi_e\psi_s}{2.5}\right]d_b = \left[\frac{3.}{40}\frac{(60000\ psi)}{(1.0)\sqrt{5000\ psi}}\frac{(1.0)(0.80)}{2.5}\right](0.6'') = 12.7''$$ (term 'c plus Ktr over db' limited to 2.5)

$M_u/\phi M_n = (4.81\ ft{\cdot}k/ft)/(12.08\ ft{\cdot}k/ft) = 0.3979$

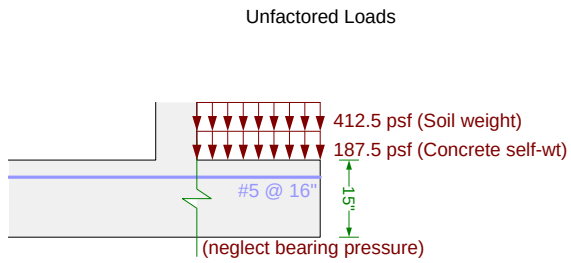
Excess reinforcement reduction of 12.3.3 (a) applies: $l_d = 5.1''$

12 inch minimum controls

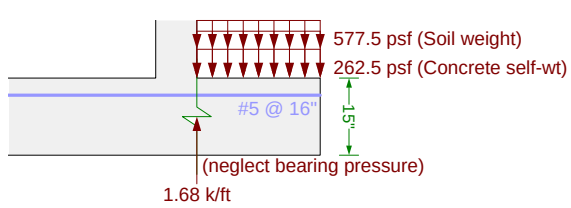
$l_{d_prov} = 29'' \geq l_d = 12''$ ✓

Heel Checks [combination Load Case 1: 1.4D + 1.4F]

Heel Unfactored Loads



Heel Factored Loads



Controlling Moment

Design moment M_u for heel need not exceed moment at stem base:

$M_{heel} = 1.68\ ft{\cdot}k / ft \quad < \quad M_{stem} = 10.31\ ft{\cdot}k / ft$

$M_u = 1.68\ ft{\cdot}k / ft$ (stem moment does not control)

Flexure Check (ACI 318-08 10.2)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2 / in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\phi M_n = \phi A_s f_y [d - a / 2]$$
$$= (0.90)(0.02\ in^2 / in)(60000\ psi)[(11.7'') - (0.3'') / 2]$$
$$= 12.08\ ft{\cdot}k / ft$$

$\phi M_n = 12.08\ ft{\cdot}k / ft \quad \geq \quad M_u = 1.68\ ft{\cdot}k / ft$ ✓

Shear Check (ACI 318-08 11.1.1, 11.2.1)

$$V_c = 2 \lambda \sqrt{f'_c}\, d = 2(1.0)\sqrt{5000\ psi}(11.7'') = 19.83\ k / ft$$

$$\phi V_n = \phi V_c = (0.750)(19.83\ k / ft) = 14.88\ k / ft$$

$\phi V_n = 14.88\ k / ft \quad \geq \quad V_u = 1.68\ k / ft$ ✓

Minimum Strain Check (ACI 318-08 10.3.5)

$$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$$

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2 / in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(11.7'')}{(0.3'') / (0.9)} - 1\right] = 1.1507$$

$\varepsilon_t = 1.1507 \quad \geq \quad 0.004$ ✓

Minimum Steel Check (ACI 318-08 10.5.1)

$\phi M_n = 12.08\ ft{\cdot}k / ft \quad \geq \quad (4 / 3) M_u = [4 / 3](1.68\ ft{\cdot}k / ft) = 2.24\ ft{\cdot}k / ft$

Check is waived per ACI 10.5.3 ✓

Shrinkage _Temperature Steel (ACI 318-08 7.12.2)

$$\rho_{ST_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(0.62\ in^2)}{(15'')(16'')} = 0.0026$$

$$\rho_{ST_min} = \frac{0.0018(60000)}{f_y} = \frac{0.0018(60000)}{(60000\ psi)} = 0.0018$$

$\rho_{ST_min} = 0.0018$

$\rho_{ST_prov} = 0.0026 \quad \geq \quad \rho_{ST_min} = 0.0018$ ✓

18 inch limit governs

$s_{ST_max} = 18''$

$s_{ST} = 16'' \quad \leq \quad s_{ST_max} = 18''$ ✓

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16'') / 2 = 8''$

cover + $d_b / 2 = (3'') + (0.6'') / 2 = 3.3''$

$c = 3.3''$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (12 inches or less cast below - 11.38 inches)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0''$ (no transverse reinforcement)

$c + K_{tr} / d_b = (3.3'') + (0'') / (0.6'') = 5.30$

$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t \psi_e \psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\frac{(60000\ psi)}{(1.0)\sqrt{5000\ psi}}\frac{(1.0)(0.80)}{2.5}\right](0.6'') = 12.7''$$ (term 'c plus Ktr over db' limited to 2.5)

$M_u / \phi M_n = (1.68\ ft{\cdot}k / ft) / (12.08\ ft{\cdot}k / ft) = 0.1390$

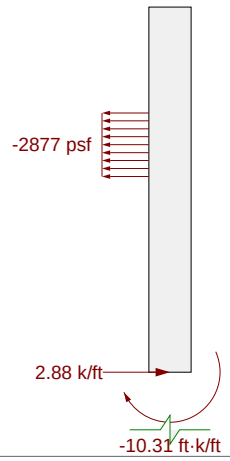
Excess reinforcement reduction of 12.3.3 (a) applies: $l_d = 1.8''$

12 inch minimum controls

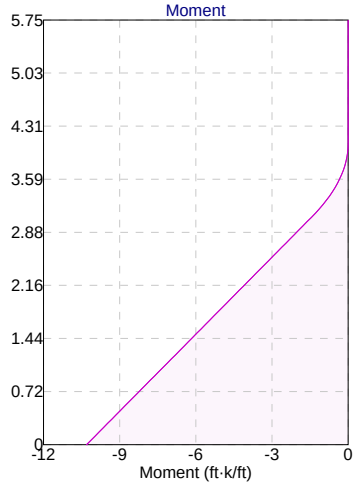
$l_{d_prov} = 35'' \quad \geq \quad l_d = 12''$ ✓

Stem Forces [combination Load Case 1: 1.4D + 1.4F]

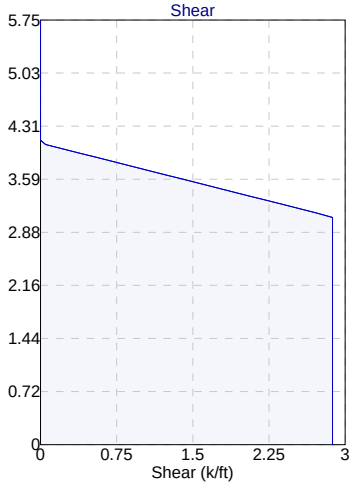
Stem Internal Forces



Stem Internal Forces



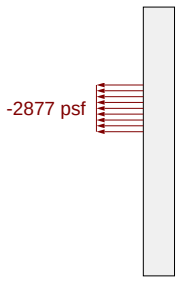
Stem Internal Forces



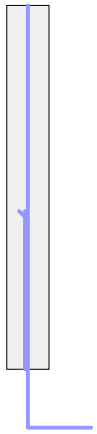
Stem Joint Force Transfer

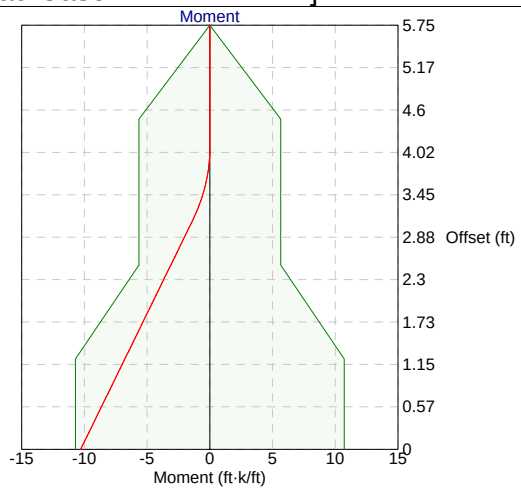
Location	Force
@ stem base	2.88 k/ft

Stem Internal Forces



Stem Moment Checks [combination Load Case 1: 1.4D + 1.4F]





Check (ACI 318-08 Ch 10) @ 0' 0" from base

ϕM_n = 10.73 ft·k / ft ≥ M_u = 10.31 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 1' 2.7" from base

ϕM_n = 10.73 ft·k / ft ≥ M_u = 6.8 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 1' 3.3" from base

ϕM_n = 10.53 ft·k / ft ≥ M_u = 6.63 ft·k / ft ✓

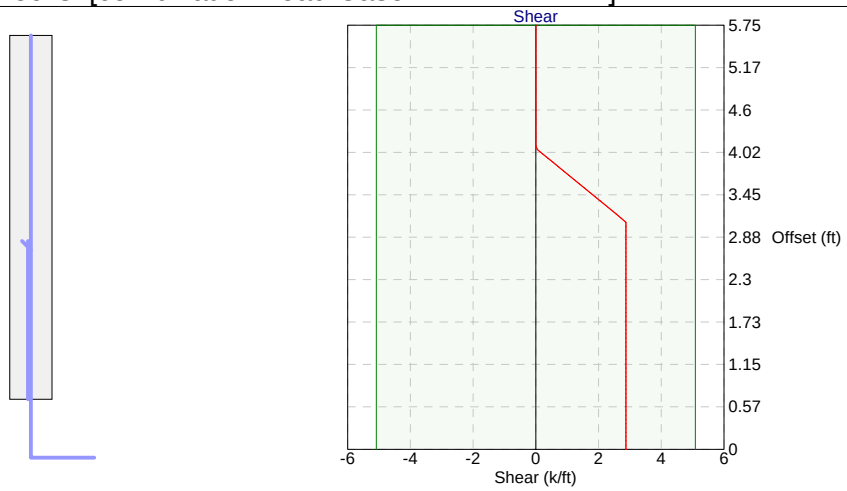
Check (ACI 318-08 Ch 10) @ 2' 6" from base

ϕM_n = 5.65 ft·k / ft ≥ M_u = 3.12 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 2' 6.7" from base

ϕM_n = 5.65 ft·k / ft ≥ M_u = 2.96 ft·k / ft ✓

Stem Shear Checks [combination Load Case 1: 1.4D + 1.4F]



Shear Check (ACI 318-08 Ch 11.1.1) @ 0' 0" from base

ϕV_n = 5.09 k / ft ≥ V_u = 2.88 k / ft ✓

Stem Miscellaneous Checks [combination Load Case 1: 1.4D + 1.4F]

Minimum Steel Check (ACI 318-08 10.5.1) @ 0' 0" from base [Stem in negative flexure]

$\phi M_n = 10.73\ \text{ft·k / ft} < (4/3)\,M_u = [4/3](10.31\ \text{ft·k / ft}) = 13.75\ \text{ft·k / ft}$

$A_{s_min} = \frac{3\sqrt{f'_c}}{f_y} d = \frac{3\sqrt{5000\ \text{psi}}}{(60000\ \text{psi})}(4") = 0.01\ \text{in}^2 / \text{in}$

$200\ d / f_y = 200\ (4") / (60000\ \text{psi}) = 0.01\ \text{in}^2 / \text{in}$

$A_s = 0.06\ \text{in}^2 / \text{in} \geq A_{s_min} = 0.01\ \text{in}^2 / \text{in}$ ✓

Minimum Steel Check (ACI 318-08 10.5.1) @ 2' 6" from base [Stem in negative flexure]

$\phi M_n = 5.65\ \text{ft·k / ft} \geq (4/3)\,M_u = [4/3](3.12\ \text{ft·k / ft}) = 4.17\ \text{ft·k / ft}$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-08 10.5.1) @ 5' 9" from base [Stem in negative flexure]

$\phi M_n = 0\ \text{ft·k / ft} \geq (4/3)\,M_u = [4/3](0\ \text{ft·k / ft}) = 0\ \text{ft·k / ft}$

Check is waived per ACI 10.5.3 ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 0' 0" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ \text{psi}) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06\ \text{in}^2 / \text{in})(60000\ \text{psi})}{0.85\ (5000\ \text{psi})} = 0.8"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.8") / (9.0)} - 1\right] = 0.1361$

$\varepsilon_t = 0.1361 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 2' 6" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ \text{psi}) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03\ \text{in}^2 / \text{in})(60000\ \text{psi})}{0.85\ (5000\ \text{psi})} = 0.4"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.4") / (9.0)} - 1\right] = 0.2752$

$\varepsilon_t = 0.2752 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 5' 9" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ \text{psi}) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03\ \text{in}^2 / \text{in})(60000\ \text{psi})}{0.85\ (5000\ \text{psi})} = 0.4"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.4") / (9.0)} - 1\right] = 0.2752$

$\varepsilon_t = 0.2752 \geq 0.004$ ✓

Wall Horizontal Steel (ACI 318-08 14.3.3, 14.3.5)

$\rho_t = \frac{A_{s_horz} / s_{horz}}{t} = \frac{(0.31\ \text{in}^2) / (16")}{(8")} = 0.0024$

$\rho_t = 0.0024 \geq \rho_{t_min} = 0.0020$ ✓

$3\,t = 3\,(8") = 24"$

18 inch limit governs

$s_{horz_max} = 18"$

$s_{horz} = 16" \leq s_{horz_max} = 18"$ ✓

Stem Miscellaneous Checks [combination Load Case 1: 1.4D + 1.4F] (continued)

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b$$

$$= \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8")$$

$= 12.7"$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$$\frac{M_u}{\phi M_n} = \frac{(10.31\text{ ft}\cdot\text{k / ft})}{(10.73\text{ ft}\cdot\text{k / ft})} = 0.9611$$

Factor l_{dh} by this ratio (excess reinforcement) per 12.5.3 (d): $l_{dh} = 8.6"$

$8\,d_b = 8\,(0.8") = 6.0$

$l_{dh_prov} = 12" \geq l_{dh} = 8.6"$ ✓

Lap Splice Checks (ACI 318-05 12.14.2.3, 12.15.1, 12.15.2) - #6 lap with #6, from 0' 0" to 2' 6" (from stem base)

$1 / 5\,l_{lap} = 1 / 5\,(19.9") = 3.9711 \leq 6.0$

$s_{trans} = 0" \leq 1 / 5\,l_{lap}$
$= 1 / 5\,(19.9")$ ✓
$= 3.9711$

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16") / 2 = 8"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

$l_{lap} = 1.3\,l_d$
$= 1.3\,(15.3")$
$= 19.9"$ (class B splice assumed)

$l_{lap_prov} = 30" \geq l_{lap}$ ✓
$= 19.9"$

Cutoff Checks (ACI 318-05 12.10.3, 12.10.5) - #6 cut off at 2' 6"

$d = 5.6" < 12\,d_b = 12\,(0.8") = 9.0$

$l_{ext} = 10.6" \geq 12\,d_b = 12\,(0.8") = 9.0$ ✓

$\frac{2}{3}\phi V_n = \frac{2}{3}(5.09\text{ k / ft}) = 3.39\text{ k / ft} \geq V_u = 2.88\text{ k / ft}$ ✓

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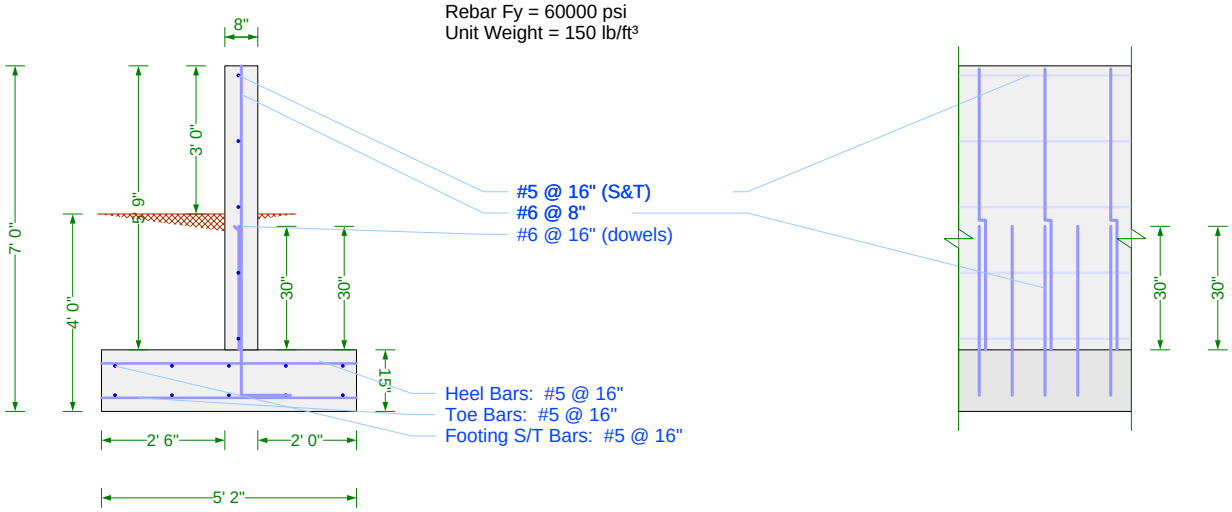
HUNTERS POINT - REVETMENT SEAWALL

Analysis for:
1. Wave Runup Against Wall
2. Soil Retaining Wall

Job # 1052-01

Design Detail

Concrete f'c = 5000 psi
Rebar Fy = 60000 psi
Unit Weight = 150 lb/ft³



Check Summary

Ratio	Check	Provided	Required	Combination
----- Stability Checks -----				
✓ 0.939	Overturning	1.28	1.20	Stability
✓ 0.578	Sliding	2.08	1.20	Stability
✓ 0.902	Bearing Pressure	2500 psf	2255 psf	Stability
✓ 0.650	Bearing Eccentricity	20.2"	31"	Stability
----- Toe Checks -----				
✓ 0.166	Shear	14.88 k/ft	2.47 k/ft	1.4D + 1.4F
✓ 0.398	Moment	12.08 ft·k/ft	4.81 ft·k/ft	1.4D + 1.4F
✓ 0.003	Min Strain	1.1507	0.0040	1.4D + 1.4F
✓ 0.000	Min Steel	0.02 in²	0 in²	1.4D + 1.4F
✓ 0.414	Development	29"	12"	1.4D + 1.4F
✓ 0.889	S&T Max Spacing	16"	18"	1.4D + 1.4F
✓ 0.697	S&T Min Rho	0.0026	0.0018	1.4D + 1.4F
----- Heel Checks -----				
✓ 0.113	Shear	14.88 k/ft	1.68 k/ft	1.4D + 1.4F
✓ 0.139	Moment	12.08 ft·k/ft	1.68 ft·k/ft	1.4D + 1.4F
✓ 0.003	Min Strain	1.1507	0.0040	1.4D + 1.4F
✓ 0.000	Min Steel	0.02 in²	0 in²	1.4D + 1.4F
✓ 0.343	Development	35"	12"	1.4D + 1.4F
✓ 0.889	S&T Max Spacing	16"	18"	1.4D + 1.4F
✓ 0.697	S&T Min Rho	0.0026	0.0018	1.4D + 1.4F
----- Stem Checks -----				
✓ 0.826	Horz Bar Rho	0.0024	0.0020	Load Case 1: 1.4D + 1.4F
✓ 0.889	Horz Bar Spacing	16"	18"	Load Case 1: 1.4D + 1.4F
✓ 0.961	Moment	10.73 ft·k/ft	10.31 ft·k/ft	Load Case 1: 1.4D + 1.4F
✓ 0.565	Shear	5.09 k/ft	2.88 k/ft	Load Case 1: 1.4D + 1.4F
✓ 0.015	Max Steel	0.2752	0.0040	Load Case 1: 1.4D + 1.4F
✓ 0.257	Min Steel	0.06 in²/in	0.01 in²/in	Load Case 1: 1.4D + 1.4F
✓ 0.714	Base Development	12"	8.6"	Load Case 1: 1.4D + 1.4F
✓ 0.662	Lap Splice Length	30"	19.9"	Load Case 1: 1.4D + 1.4F
✓ 0.000	Lap Splice Spacing	0"	4"	Load Case 1: 1.4D + 1.4F
✓ 0.851	Bar Cutoff Extension	10.6"	9"	Load Case 1: 1.4D + 1.4F
✓ 0.565	Bar Cutoff Shear	5.09 k/ft	2.88 k/ft	Load Case 1: 1.4D + 1.4F

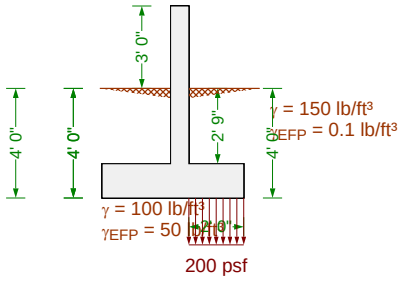
Criteria

Building Code	IBC 2009
Concrete Load Combs	IBC 2009 (Strength)
Masonry Load Combs	ASCE 7-05 (ASD)
Stability Load Comb	Stability
Restrained Against Sliding	No
Neglect Bearing At Heel	Yes
Use Vert. Comp. for OT	Yes
Use Vert. Comp. for Sliding	Yes
Use Vert. Comp. for Bearing	Yes
Use Surcharge for Sliding & OT	No
Use Surcharge for Bearing	Yes
Neglect Soil Over Toe	No
Neglect Backfill Wt. for Coulomb	No
Factor Soil Weight As Dead	Yes
Use Passive Force for OT	Yes
Assume Pressure To Top	Yes
Extend Backfill Pressure To Key Bottom	No
Use Toe Passive Pressure for Bearing	Yes
Required F.S. for OT	1.20
Required F.S. for Sliding	1.20
Has Different Safety Factors for Seismic	Yes
Seismic F.S. for OT	1.20
Seismic F.S. for Sliding	1.20
Allowable Bearing Pressure	2500 psf
Req'd Bearing Location	Over footing
Wall Friction Angle	25°
Friction Coefficent	0.35
Soil Reaction Modulus	100 lb/in³

Loads

Loading Options/Assumptions

Passive pressure neglects top 0' 0" of soil.

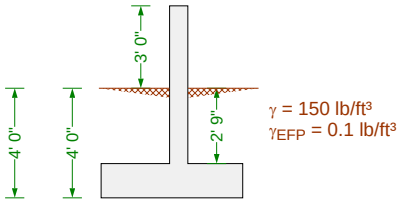


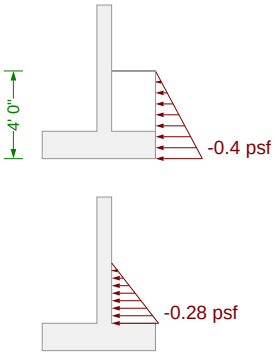
Load Combinations

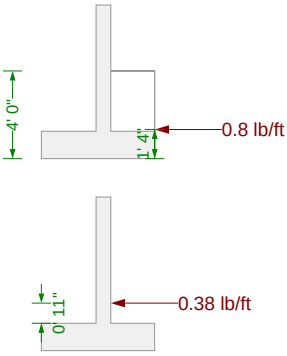
IBC 2009 (Strength)

1.4D + 1.4F
1.2D + 1.6H + 1.2F
0.9D + 1.6H
1.2D
1.2D + 1.6H
1.2D + 0.8W
1.2D + 1.6W
0.9D + 1.6H
0.9D + 1.6H + 1.6W
1.4D
1.2D
1.2D + 1.6H + 1.6L
1.2D + 0.5L
0.9D + 1.6H
1.4D
1.2D

Backfill Pressure







Lateral Earth Pressure

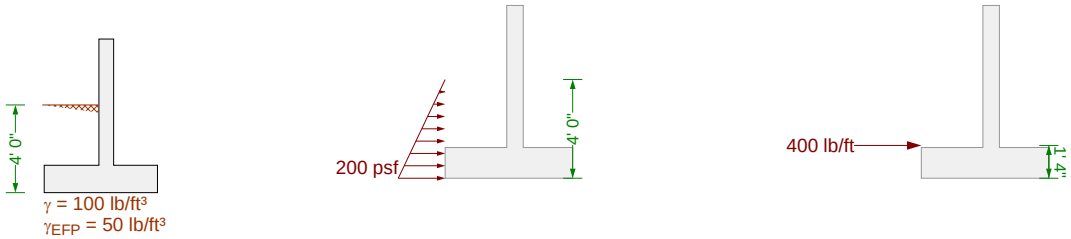
Equivalent Fluid Pressure

$\sigma_h = H\,\gamma_{fluid} = (4'\ 0")(0.1\ lb/ft^3) = 0.4\ psf$

Lateral Earth Pressure (stem only)

$\sigma_h = H\,\gamma_{fluid} = (2'\ 9")(0.1\ lb/ft^3) = 0.28\ psf$

Passive Pressure

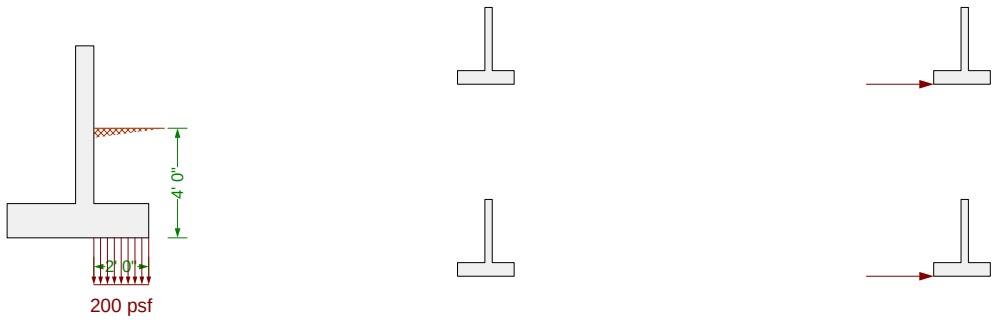


Lateral Earth Pressure

Equivalent Fluid Pressure

$\sigma_h = H\,\gamma_{fluid} = (4'\ 0'')(50\ lb/ft^3) = 200\ psf$

Line/Strip Pressure



Lateral Pressure Due To Strip Surcharge

The horizontal stress σ at depth z is given by:

$$\frac{2\,q}{\pi}(\beta - \sin\beta\cos 2\alpha)$$

where α and β are given by:

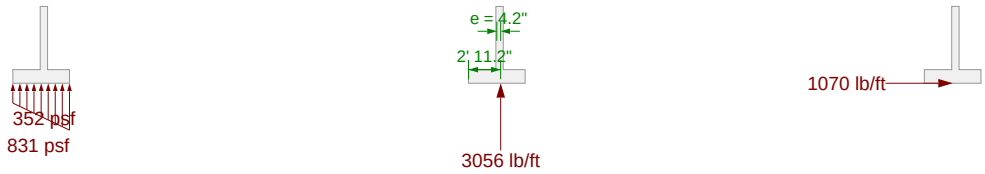
$$\alpha = \frac{1}{2}\,\mathrm{atan}\left(\frac{b' + a'}{z}\right) + \mathrm{atan}\left(\frac{b'}{z}\right)$$

$$\beta = \mathrm{atan}\left(\frac{b' + a'}{z}\right) - \mathrm{atan}\left(\frac{b'}{z}\right)$$

Integrating this over the height of the backfill gives the pressure distribution shown above.

Wall/Soil Weights

Bearing Pressure



Friction

$F = \mu R = (0.350)(3056 \text{ lb / ft}) = 1070 \text{ lb / ft}$

Bearing Pressure Calculation

Contributing Forces

	Vert Force	...offset	Horz Force	...offset	OT Moment
Backfill Pressure	-0 lb/ft	-	-0.8 lb/ft	1' 4"	12.8 in·lb/ft
Passive Pressure (user option)	0 lb/ft	-	400 lb/ft	1' 4"	-6400 in·lb/ft
Footing Weight	-968.75 lb/ft	2' 7"	0 lb/ft	-	-30031.25 in·lb/ft
Stem Weight	-575 lb/ft	2' 10"	0 lb/ft	-	-19550 in·lb/ft
Backfill Weight	-825 lb/ft	4' 2"	0 lb/ft	-	-41250 in·lb/ft
Soil over toe Weight	-687.5 lb/ft	1' 3"	0 lb/ft	-	-10312.5 in·lb/ft
	-3056.25 lb/ft				-107530.95 in·lb/ft

$$\frac{-107530.95 \text{ in·lb / ft}}{-3056.25 \text{ lb / ft}} = 2' \ 11.2''$$

Stability Checks

Overturning Check

Overturning Moments

	Force	Distance	Moment
Backfill pressure (horz)	0.8 lb/ft	1' 4"	12.8 in·lb/ft
		Total:	12.8 in·lb/ft

Resisting Moments

	Force	Distance	Moment
Backfill pressure (vert)	0 lb/ft	5' 2"	0 in·lb/ft
Passive pressure @ toe	400 lb/ft	1' 4"	6400 in·lb/ft
Footing Weight	-968.75 lb/ft	2' 7"	30031 in·lb/ft
Stem Weight	-575 lb/ft	2' 10"	19550 in·lb/ft
Backfill Weight	-825 lb/ft	4' 2"	41250 in·lb/ft
Soil over toe Weight	-687.5 lb/ft	1' 3"	10312 in·lb/ft
		Total:	107544 in·lb/ft

$$F.S. = \frac{RM}{OTM} = \frac{107544 \text{ in·lb / ft}}{12.8 \text{ in·lb / ft}} = 8401.855 > 1.20 \text{ (OK)}$$

Sliding Check

Sliding Force(s)

Backfill pressure	0.8 lb/ft
Total:	0.8 lb/ft

Resisting Force(s)

Passive pressure @ toe	400 lb/ft
Friction	1070 lb/ft
Total:	1470 lb/ft

$$F.S. = \frac{RF}{SF} = \frac{1470 \text{ lb / ft}}{0.8 \text{ lb / ft}} = 1837.109 > 1.20 \text{ (OK)}$$

Bearing Check

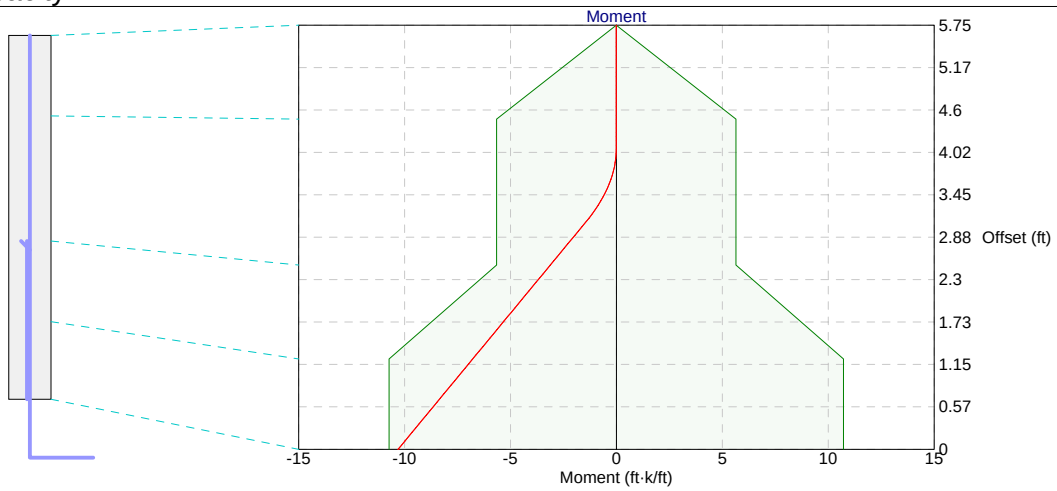
Bearing pressure < allowable (831 psf < 2500 psf) - OK
Bearing resultant eccentricity < allowable (4.2" < 31") - OK

Wall Top Displacement

(based on unfactored service loads)

Deflection due to stem flexural displacement	0"
Deflection due to rotation from settlement	-0"
Total deflection at top of wall (positive towards toe)	-0"

Stem Flexural Capacity



Capacity (ACI 318-08 10.2) @ 0' 0" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 0' 0" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 1' 2.7" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 1' 2.7" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.8"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.06 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.8") / 2] = 10.73 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 2' 6" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 2' 6" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 4' 5.7" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4"$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4") - (0.4") / 2] = 5.65 \text{ ft·k / ft}$$

Stem Flexural Capacity (continued)

Capacity (ACI 318-08 10.2) @ 4' 5.7" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0.4''$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0.03 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0.4'') / 2] = 5.65 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 5' 9" from base [Negative bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0''$$

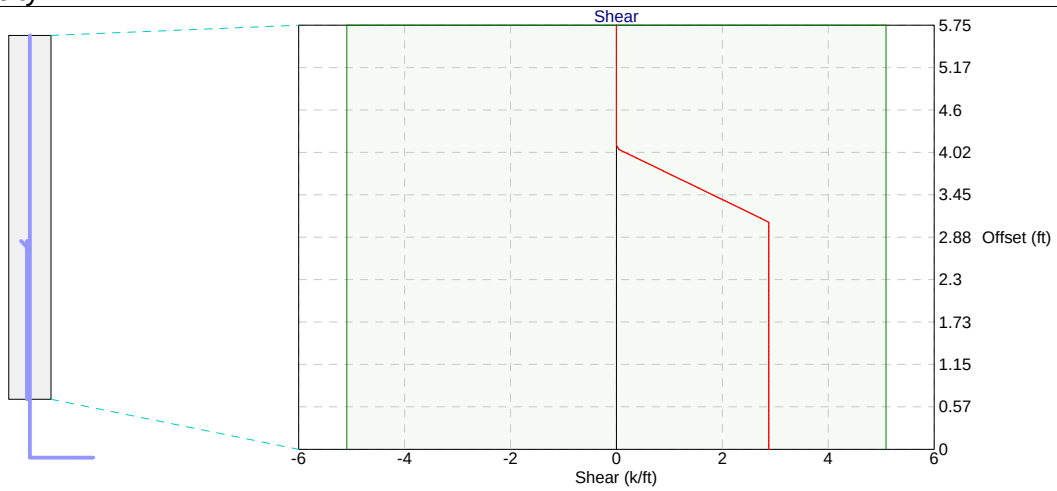
$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0'') / 2] = 0 \text{ ft·k / ft}$$

Capacity (ACI 318-08 10.2) @ 5' 9" from base [Positive bending]

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0 \text{ in}^2 / \text{in})(60000 \text{ psi})}{0.85 (5000 \text{ psi})} = 0''$$

$$\phi M_n = \phi A_s f_y [d - a / 2] = (0.90)(0 \text{ in}^2 / \text{in})(60000 \text{ psi})[(4'') - (0'') / 2] = 0 \text{ ft·k / ft}$$

Stem Shear Capacity



Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 0' 0" from base [Positive shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 0' 0" from base [Negative shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 5' 9" from base [Positive shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Shear Capacity (ACI 318-08 11.1.1, 11.2.1) @ 5' 9" from base [Negative shear]

$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\text{ psi}}(4") = 6.79\text{ k / ft}$

$\phi V_n = \phi V_c = (0.750)(6.79\text{ k / ft}) = 5.09\text{ k / ft}$

Stem Development/Lap Length Calculations

Main vertical stem bars (bottom end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b$$

$$= \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8")$$

$= 12.7"$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$8\,d_b = 8\,(0.8") = 6.0$

Main vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16") / 2 = 8"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Cutoff vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (8") / 2 = 4"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Dowels for vertical stem bars (bottom end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b$$

$$= \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8")$$

$= 12.7"$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$8\,d_b = 8\,(0.8") = 6.0$

Stem Development/Lap Length Calculations (continued)

Dowels for vertical stem bars (top end) - Development Length Calculation (ACI 318-08 12.2.3, 12.5)

ψ_e = 1.0 (bar not epoxy - coated)

ψ_s = 0.80 (bars are #6 or smaller)

s / 2 = (8") / 2 = 4"

cover + d_b / 2 = (2") + (0.8") / 2 = 2.4"

c = 2.4" (lesser of half spacing, ctr to surface)

ψ_t = 1.0 (bars are not horizontal)

λ = 1.0 (normal weight concrete)

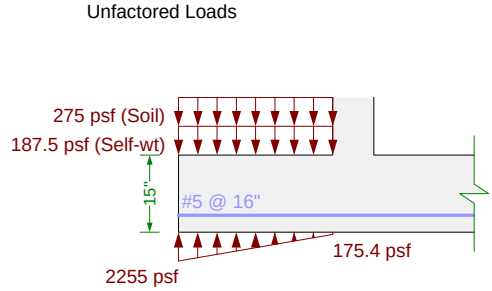
K_{tr} = 0" (no transverse reinforcement)

c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667

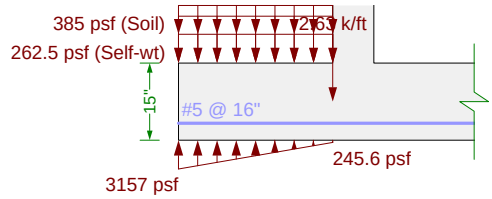
$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right]d_b = \left[\frac{3.}{40}\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\frac{(1.0)(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

Toe Checks [combination Load Case 1: 1.4D + 1.4F]

Toe Unfactored Loads



Toe Factored Loads



Controlling Moment

Design moment M_u for toe need not exceed moment at stem base:

$M_{toe} = 4.81\ ft{\cdot}k/ft < M_{stem} = 10.31\ ft{\cdot}k/ft$

$M_u = 4.81\ ft{\cdot}k/ft$ (stem moment does not control)

Flexure Check (ACI 318-08 10.2)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2/in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\phi M_n = \phi A_s f_y [d - a/2] = (0.90)(0.02\ in^2/in)(60000\ psi)[(11.7'') - (0.3'')/2] = 12.08\ ft{\cdot}k/ft$$

$\phi M_n = 12.08\ ft{\cdot}k/ft \geq M_u = 4.81\ ft{\cdot}k/ft$ ✓

Shear Check (ACI 318-08 11.1.1, 11.2.1)

$$V_c = 2\lambda\sqrt{f'_c}\,d = 2(1.0)\sqrt{5000\ psi}(11.7'') = 19.83\ k/ft$$

$$\phi V_n = \phi V_c = (0.750)(19.83\ k/ft) = 14.88\ k/ft$$

$\phi V_n = 14.88\ k/ft \geq V_u = 2.47\ k/ft$ ✓

Minimum Strain Check (ACI 318-08 10.3.5)

$$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$$

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2/in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\varepsilon_t = 0.003\left[\frac{d}{a/\beta_1} - 1\right] = 0.003\left[\frac{(11.7'')}{(0.3'')/(0.9)} - 1\right] = 1.1507$$

$\varepsilon_t = 1.1507 \geq 0.004$ ✓

Minimum Steel Check (ACI 318-08 10.5.1)

$\phi M_n = 12.08\ ft{\cdot}k/ft \geq (4/3)M_u = [4/3](4.81\ ft{\cdot}k/ft) = 6.41\ ft{\cdot}k/ft$

Check is waived per ACI 10.5.3 ✓

Shrinkage _Temperature Steel (ACI 318-08 7.12.2)

$$\rho_{ST_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(0.62\ in^2)}{(15'')(16'')} = 0.0026$$

$$\rho_{ST_min} = \frac{0.0018(60000)}{f_y} = \frac{0.0018(60000)}{(60000\ psi)} = 0.0018$$

$\rho_{ST_min} = 0.0018$

$\rho_{ST_prov} = 0.0026 \geq \rho_{ST_min} = 0.0018$ ✓

18 inch limit governs

$s_{ST_max} = 18''$

$s_{ST} = 16'' \leq s_{ST_max} = 18''$ ✓

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s/2 = (16'')/2 = 8''$

cover + $d_b/2 = (3'') + (0.6'')/2 = 3.3''$

$c = 3.3''$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (12 inches or less cast below - 3.00 inches)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0''$ (no transverse reinforcement)

$c + K_{tr}/d_b = (3.3'') + (0'')/(0.6'') = 5.30$

$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t\psi_e\psi_s}{2.5}\right]d_b = \left[\frac{3.}{40}\frac{(60000\ psi)}{(1.0)\sqrt{5000\ psi}}\frac{(1.0)(0.80)}{2.5}\right](0.6'') = 12.7''$$ (term 'c plus Ktr over db' limited to 2.5)

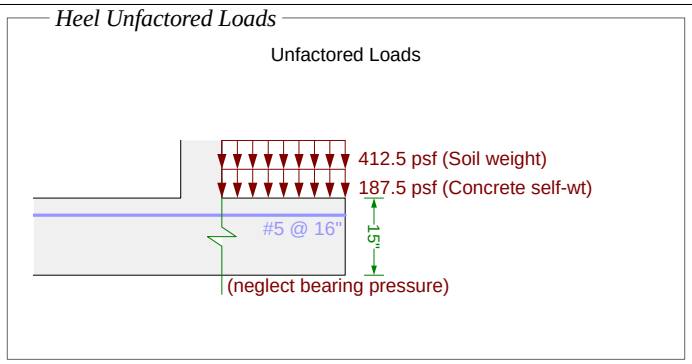
$M_u/\phi M_n = (4.81\ ft{\cdot}k/ft)/(12.08\ ft{\cdot}k/ft) = 0.3979$

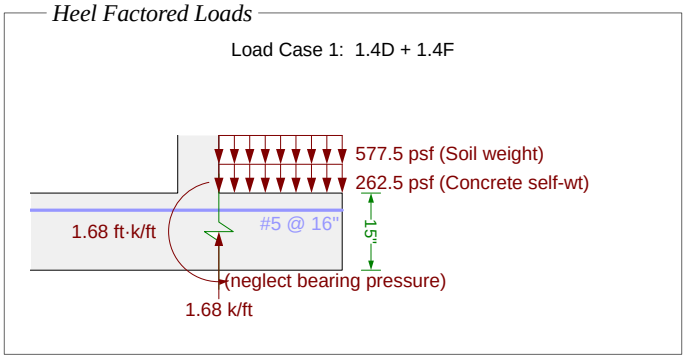
Excess reinforcement reduction of 12.3.3 (a) applies: $l_d = 5.1''$

12 inch minimum controls

$l_{d_prov} = 29'' \geq l_d = 12''$ ✓

Heel Checks [combination Load Case 1: 1.4D + 1.4F]





Controlling Moment

Design moment M_u for heel need not exceed moment at stem base:

$M_{heel} = 1.68\ ft{\cdot}k / ft \quad < \quad M_{stem} = 10.31\ ft{\cdot}k / ft$

$M_u = 1.68\ ft{\cdot}k / ft$ (stem moment does not control)

Flexure Check (ACI 318-08 10.2)

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2 / in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\phi M_n = \phi A_s f_y [d - a / 2]$$
$$= (0.90)(0.02\ in^2 / in)(60000\ psi)[(11.7'') - (0.3'') / 2]$$
$$= 12.08\ ft{\cdot}k / ft$$

$\phi M_n = 12.08\ ft{\cdot}k / ft \quad \geq \quad M_u = 1.68\ ft{\cdot}k / ft$ ✓

Shear Check (ACI 318-08 11.1.1, 11.2.1)

$$V_c = 2 \lambda \sqrt{f'_c}\, d = 2(1.0)\sqrt{5000\ psi}(11.7'') = 19.83\ k / ft$$

$$\phi V_n = \phi V_c = (0.750)(19.83\ k / ft) = 14.88\ k / ft$$

$\phi V_n = 14.88\ k / ft \quad \geq \quad V_u = 1.68\ k / ft$ ✓

Minimum Strain Check (ACI 318-08 10.3.5)

$$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$$

$$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.02\ in^2 / in)(60000\ psi)}{0.85(5000\ psi)} = 0.3''$$

$$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(11.7'')}{(0.3'') / (9.0)} - 1\right] = 1.1507$$

$\varepsilon_t = 1.1507 \quad \geq \quad 0.004$ ✓

Minimum Steel Check (ACI 318-08 10.5.1)

$\phi M_n = 12.08\ ft{\cdot}k / ft \quad \geq \quad (4 / 3) M_u = [4 / 3](1.68\ ft{\cdot}k / ft) = 2.24\ ft{\cdot}k / ft$

Check is waived per ACI 10.5.3 ✓

Shrinkage _Temperature Steel (ACI 318-08 7.12.2)

$$\rho_{ST_prov} = \frac{A_{ST}}{t\, s_{ST}} = \frac{(0.62\ in^2)}{(15'')(16'')} = 0.0026$$

$$\rho_{ST_min} = \frac{0.0018(60000)}{f_y} = \frac{0.0018(60000)}{(60000\ psi)} = 0.0018$$

$\rho_{ST_min} = 0.0018$

$\rho_{ST_prov} = 0.0026 \quad \geq \quad \rho_{ST_min} = 0.0018$ ✓

18 inch limit governs

$s_{ST_max} = 18''$

$s_{ST} = 16'' \quad \leq \quad s_{ST_max} = 18''$ ✓

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16'') / 2 = 8''$

cover + $d_b / 2 = (3'') + (0.6'') / 2 = 3.3''$

$c = 3.3''$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (12 inches or less cast below - 11.38 inches)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0''$ (no transverse reinforcement)

$c + K_{tr} / d_b = (3.3'') + (0'') / (0.6'') = 5.30$

$$l_d = \left[\frac{3.}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\frac{\psi_t \psi_e \psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\frac{(60000\ psi)}{(1.0)\sqrt{5000\ psi}}\frac{(1.0)(0.80)}{2.5}\right](0.6'') = 12.7''$$ (term 'c plus Ktr over db' limited to 2.5)

$M_u / \phi M_n = (1.68\ ft{\cdot}k / ft) / (12.08\ ft{\cdot}k / ft) = 0.1390$

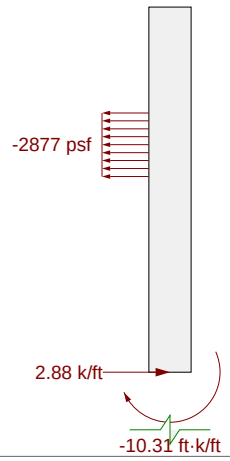
Excess reinforcement reduction of 12.3.3 (a) applies: $l_d = 1.8''$

12 inch minimum controls

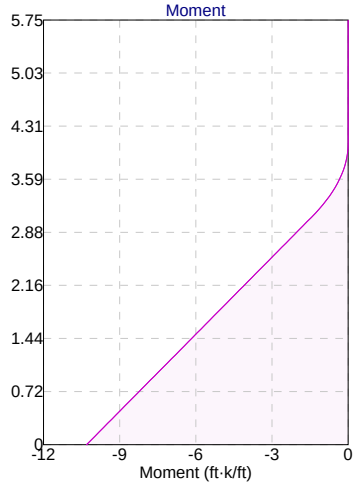
$l_{d_prov} = 35'' \quad \geq \quad l_d = 12''$ ✓

Stem Forces [combination Load Case 1: 1.4D + 1.4F]

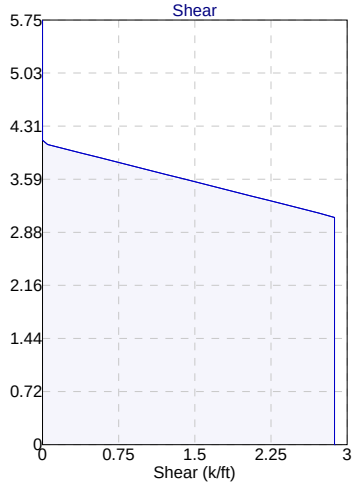
Stem Internal Forces



Stem Internal Forces



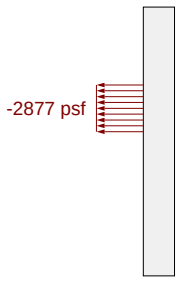
Stem Internal Forces



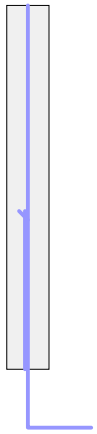
Stem Joint Force Transfer

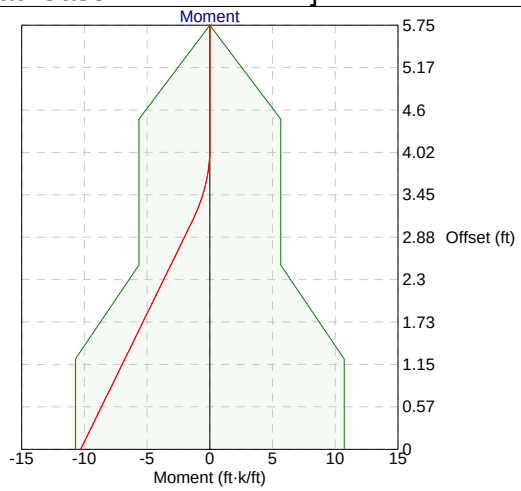
Location	Force
@ stem base	2.88 k/ft

Stem Internal Forces



Stem Moment Checks [combination Load Case 1: 1.4D + 1.4F]





Check (ACI 318-08 Ch 10) @ 0' 0" from base

ϕM_n = 10.73 ft·k / ft ≥ M_u = 10.31 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 1' 2.7" from base

ϕM_n = 10.73 ft·k / ft ≥ M_u = 6.8 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 1' 3.3" from base

ϕM_n = 10.53 ft·k / ft ≥ M_u = 6.63 ft·k / ft ✓

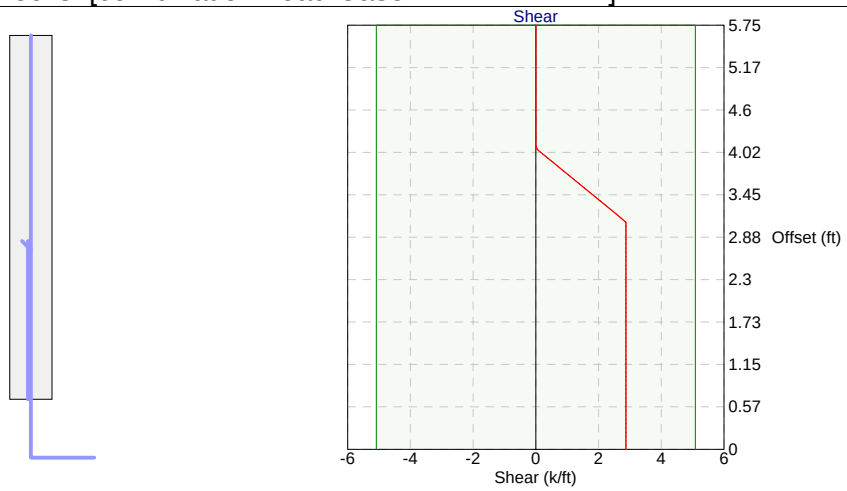
Check (ACI 318-08 Ch 10) @ 2' 6" from base

ϕM_n = 5.65 ft·k / ft ≥ M_u = 3.12 ft·k / ft ✓

Check (ACI 318-08 Ch 10) @ 2' 6.7" from base

ϕM_n = 5.65 ft·k / ft ≥ M_u = 2.96 ft·k / ft ✓

Stem Shear Checks [combination Load Case 1: 1.4D + 1.4F]



Shear Check (ACI 318-08 Ch 11.1.1) @ 0' 0" from base

ϕV_n = 5.09 k / ft ≥ V_u = 2.88 k / ft ✓

Stem Miscellaneous Checks [combination Load Case 1: 1.4D + 1.4F]

Minimum Steel Check (ACI 318-08 10.5.1) @ 0' 0" from base [Stem in negative flexure]

$\phi M_n = 10.73\ ft{\cdot}k / ft < (4/3) M_u = [4/3](10.31\ ft{\cdot}k / ft) = 13.75\ ft{\cdot}k / ft$

$A_{s_min} = \frac{3\sqrt{f'_c}}{f_y} d = \frac{3\sqrt{5000\ psi}}{(60000\ psi)}(4") = 0.01\ in^2 / in$

$200\ d / f_y = 200\ (4") / (60000\ psi) = 0.01\ in^2 / in$

$A_s = 0.06\ in^2 / in \geq A_{s_min} = 0.01\ in^2 / in$ ✓

Minimum Steel Check (ACI 318-08 10.5.1) @ 2' 6" from base [Stem in negative flexure]

$\phi M_n = 5.65\ ft{\cdot}k / ft \geq (4/3) M_u = [4/3](3.12\ ft{\cdot}k / ft) = 4.17\ ft{\cdot}k / ft$

Check is waived per ACI 10.5.3 ✓

Minimum Steel Check (ACI 318-08 10.5.1) @ 5' 9" from base [Stem in negative flexure]

$\phi M_n = 0\ ft{\cdot}k / ft \geq (4/3) M_u = [4/3](0\ ft{\cdot}k / ft) = 0\ ft{\cdot}k / ft$

Check is waived per ACI 10.5.3 ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 0' 0" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.06\ in^2 / in)(60000\ psi)}{0.85\ (5000\ psi)} = 0.8"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.8") / (9.0)} - 1\right] = 0.1361$

$\varepsilon_t = 0.1361 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 2' 6" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03\ in^2 / in)(60000\ psi)}{0.85\ (5000\ psi)} = 0.4"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.4") / (9.0)} - 1\right] = 0.2752$

$\varepsilon_t = 0.2752 \geq 0.004$ ✓

Maximum Steel Check (ACI 318-08 10.3.5) @ 5' 9" from base [Stem in negative flexure]

$\beta_1 = 0.85 - 0.05\left[\frac{f'_c - 4000}{1000}\right] = 0.85 - 0.05\left[\frac{(5000\ psi) - 4000}{1000}\right] = 0.80$

$a = \frac{A_s f_y}{0.85 f'_c} = \frac{(0.03\ in^2 / in)(60000\ psi)}{0.85\ (5000\ psi)} = 0.4"$

$\varepsilon_t = 0.003\left[\frac{d}{a / \beta_1} - 1\right] = 0.003\left[\frac{(4")}{(0.4") / (9.0)} - 1\right] = 0.2752$

$\varepsilon_t = 0.2752 \geq 0.004$ ✓

Wall Horizontal Steel (ACI 318-08 14.3.3, 14.3.5)

$\rho_t = \frac{A_{s_horz} / s_{horz}}{t} = \frac{(0.31\ in^2) / (16")}{(8")} = 0.0024$

$\rho_t = 0.0024 \geq \rho_{t_min} = 0.0020$ ✓

$3\ t = 3\ (8") = 24"$

18 inch limit governs

$s_{horz_max} = 18"$

$s_{horz} = 16" \leq s_{horz_max} = 18"$ ✓

Stem Miscellaneous Checks [combination Load Case 1: 1.4D + 1.4F] (continued)

Development Check (ACI 318-08 12.12, 12.2.3)

$\psi_e = 1.0$ (bar not epoxy - coated)

$\lambda = 1.0$ (normal weight concrete)

$$l_{dh} = \frac{0.02\,\psi_e\,f_y}{\lambda\sqrt{f'_c}}\,d_b = \frac{0.02\,(1.0)\,(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,(0.8") = 12.7"$$

0.7 multiplier of 12.5.3 (a) applies: $l_{dh} = 8.9"$

$$\frac{M_u}{\phi M_n} = \frac{(10.31\text{ ft·k / ft})}{(10.73\text{ ft·k / ft})} = 0.9611$$

Factor l_{dh} by this ratio (excess reinforcement) per 12.5.3 (d): $l_{dh} = 8.6"$

$8\,d_b = 8\,(0.8") = 6.0$

$l_{dh_prov} = 12" \geq l_{dh} = 8.6"$ ✓

Lap Splice Checks (ACI 318-05 12.14.2.3, 12.15.1, 12.15.2) - #6 lap with #6, from 0' 0" to 2' 6" (from stem base)

$1/5\,l_{lap} = 1/5\,(19.9") = 3.9711 \leq 6.0$

$s_{trans} = 0" \leq 1/5\,l_{lap} = 1/5\,(19.9") = 3.9711$ ✓

$\psi_e = 1.0$ (bar not epoxy - coated)

$\psi_s = 0.80$ (bars are #6 or smaller)

$s / 2 = (16") / 2 = 8"$

$\text{cover} + d_b / 2 = (2") + (0.8") / 2 = 2.4"$

$c = 2.4"$ (lesser of half spacing, ctr to surface)

$\psi_t = 1.0$ (bars are not horizontal)

$\lambda = 1.0$ (normal weight concrete)

$K_{tr} = 0"$ (no transverse reinforcement)

$c + K_{tr} / d_b = (2.4") + (0") / (0.8") = 3.1667$

$$l_d = \left[\frac{3.}{40}\,\frac{f_y}{\lambda\sqrt{f'_c}}\,\frac{\psi_t\,\psi_e\,\psi_s}{2.5}\right] d_b = \left[\frac{3.}{40}\,\frac{(60000\text{ psi})}{(1.0)\sqrt{5000\text{ psi}}}\,\frac{(1.0)\,(0.80)}{2.5}\right](0.8") = 15.3"$$ (term 'c plus Ktr over db' limited to 2.5)

$l_{lap} = 1.3\,l_d = 1.3\,(15.3") = 19.9"$ (class B splice assumed)

$l_{lap_prov} = 30" \geq l_{lap} = 19.9"$ ✓

Cutoff Checks (ACI 318-05 12.10.3, 12.10.5) - #6 cut off at 2' 6"

$d = 5.6" < 12\,d_b = 12\,(0.8") = 9.0$

$l_{ext} = 10.6" \geq 12\,d_b = 12\,(0.8") = 9.0$ ✓

$\frac{2}{3}\phi V_n = \frac{2}{3}(5.09\text{ k / ft}) = 3.39\text{ k / ft} \geq V_u = 2.88\text{ k / ft}$ ✓

General Structural Notes

GENERAL

All construction and materials shall be in accordance with the requirements of the 2010 California Building Code and the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318-95) hereinafter collectively termed the "Code." Where explicit details and/or specifications are not shown or described, the most stringent requirements of the Code shall apply. Where conflicts occur between these notes and the requirements set forth in the Code, the latter shall govern. If interpretation of the structural drawings is necessary, the structural design engineer shall be contacted in writing for clarification, prior to commencing said work.

The Contractor shall verify existing conditions and dimensions prior to starting construction. The Engineer shall be notified of any discrepancies or inconsistencies found.

The Contractor shall notify the Engineer 48 hours prior to starting work so that inspection may be provided.

The Contractor shall be responsible for restoration of any improvements that are disturbed or damaged during the construction at no cost to the Owner.

The Contractor shall verify existence and location of all utilities before commencing work. Location of all existing utilities are shown per available record drawings obtained during design. The Contractor shall contact appropriate agencies to obtain revised updated or record information available just prior to construction. The Contractor shall take precautionary measures to protect and maintain utility lines shown and any others not of record or shown on these drawings.

The Contractor shall be responsible for enforcement of safety measures and regulations. The Contractor shall design and maintain safety devises including shoring and shall be solely responsible for conforming to all local, state and federal safety and health standards and regulations.

Upon completion of each day's work, the Contractor shall be responsible for leaving the work area free of hazards and shall provide all necessary temporary signs, warning devices and barricades.

The Contractor shall keep accurate and legible records on a set of project blueline prints of all changes of work which occur during construction. Prior to field acceptance, the Contractor shall deliver this Record Drawing information to the Engineer.

The Contractor shall perform all surveying necessary to construct the work to the lines, elevations and grades shown on the Drawings and for the Engineer's use in checking such work. All survey work on dry land shall be performed by a Land Surveyor registered in the State of California. All survey work for submerged areas shall be performed by a hydrographic surveyor certified by the American Congress of Surveying and Mapping.

Representatives of the Owner shall be allowed access to all parts of the construction.

DESIGN LOADS

The structure and portions thereof were designed to sustain, within the stress and deflection limits specified in the Code, applicable combinations of dead loads with the loads noted below:

Condition	Loading
Live Load (sidewalk)	100 psf
Wind	UBC - 80 mph; Exposure "B"
Seismic	UBC - Zone 4

FOUNDATIONS

All footings shall be founded on approved compacted fill and/or undisturbed native ground suitable for support of the planned foundation loads. Construction of foundation and soil preparations shall be performed in accordance with the geotechnical recommendations provided for the project in the XXXXXXXXXXXXXXXXXX report dated XXXXXXXXXXX and in pertinent additional reports and/or Project Memoranda provided by XXXXXXXXXXXX subsequent to that report. Footing excavations are subject to review and approval by the Project Geotechnical Consultant (XXXXXXXXXXXXXXXX) prior to placement of steel and concrete.

CONCRETE

Concrete shall have a 28 day compressive strength of 5,000 psi

The water-cement ratio shall not exceed 0.40 in accordance with Section 4.5 of ACI 318 Concrete in Corrosive Environments.

Portland cement shall be ASTM C150, type V with maximum alkali content of 0.6%. Pozzolan shall be used to replace a maximum of 20% of the required portland cement in the concrete. Pozzolan shall conform to the requirements of ASTM C618, Class F, except that the loss on ignition for Class F pozzolan shall not exceed 4%. Aggregate shall be ASTM C33, size number 3/4-inch. Aggregate shall meet Los Angeles rattler values of 75 per ASTM C131 and C535. Calcium nitrate and plasticizing admixtures shall conform to ASTM C494. Air entrainment admixtures shall conform to ASTM C260. Minimum air entrainment shall be 5% by volume. Air entrainment agents shall not exceed 6% by volume of the concrete mix.

Calcium Nitrate Corrosion Inhibitor DCI or DCI-S, manufactured by W.R. Grace & Company, shall be added to all concrete walkway components at the rate of 4 gallons per cubic yard of concrete. The corrosion inhibitor shall contain 32% of calcium nitrate by weight.

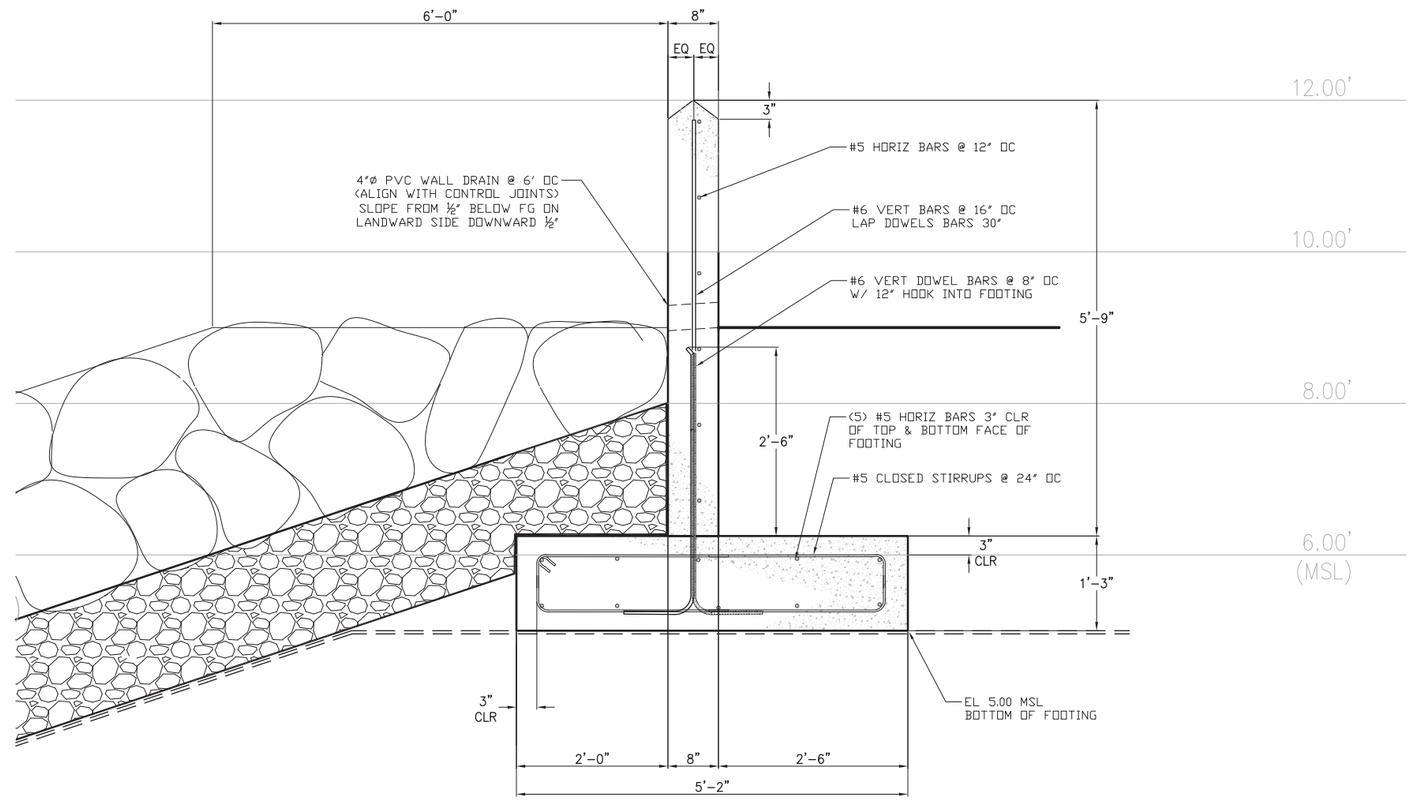
Rheocrete CNI, as manufactured by Master Builders, Inc., may be used as an alternate calcium nitrate corrosion inhibitor at the contractor's option.

Damp cure concrete work for a period of not less than 7 days after the work is completed to prevent rapid drying.

Walls shall be divided into separate panels with vertical control joints installed at nearly equal intervals not exceeding 24-feet. To the extent practicable, locate control joints near corners and intersecting walls, and at changes in wall heights. Wall panel ends shall be reinforced with (2) #5 vertical bars, minimum. To allow longitudinal movement, discontinue horizontal reinforcement, separate grout with a bond-breaker and eliminated end-mortar between masonry units at the control joint. Install backer rod and joint sealant, on both faces, between wall panels at all control joints.

REINFORCING STEEL

Reinforcing bars shall comply with ASTM A615, Grade 60, except that Number 4 and smaller bars shall be Grade 40. All bars shall be epoxy-coated per ASTM A 934. Reinforcing steel shall be prefabricated to the size and shape shown and securely tied in place with #16 double annealed PVC coated iron wire. Lap all reinforcing bars 30 bar diameters at splices. Unless noted otherwise on the drawings, concrete cover for reinforcing shall be 3" for concrete poured against earth and 3" for formed concrete exposed to earth.



X / S1 S1

SHORELINE REVETMENT WALL DETAIL
SCALE: 1" = 1'-0"

SPECIAL INSPECTION REQUIREMENTS
STRUCTURAL (REVETMENT WALKWAY)

Special Inspector shall perform inspection provisions required by Chapter 17 of the California Building Code, the construction documents and approved submittals. The following items are subject to special inspection:

1. CONCRETE
a. Verify use of required design mix (Fc = 5000 PSI)
b. Inspection of reinforcing steel (Fy = 60 KSI, Epoxy coated)
c. At the time fresh concrete is sampled to fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.
d. Inspection of concrete placement for proper application techniques.
e. Inspection for maintenance of specified curing temperature and techniques.

DRAFT
NOT FOR CONSTRUCTION

SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: NOBLE CONSULTANTS, INC. 2201 DUPONT DRIVE, SUITE 620, IRVINE, CA 92612, Tel. 949-752-5135, Fax. 949-752-5181

SIZE D
IF SHEET IS LESS THAN 22" X 34" IT IS A REDUCED PRINT
SCALE REDUCED ACCORDINGLY

DRAWN BY: TJF
DESIGN BY: RMN
CHIEF ENG:
PM/CM:

ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

SHORELINE REVETMENT WALL DETAIL
GENERAL STRUCTURAL NOTES

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO.
SHEET OF 40 SHEETS

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A16. Filter Stone Size

Project	HPNS, Parcel E-2	Component/System:	Filter Stone Size
Prepared by:	ALM	Checked by:	DB
Date	1-2013	Date	3-2013

PURPOSE

This purpose of this calculation is to determine the stone size of the filter layer that will be placed below the revetment armor layer.

DATA

- The recommended armor layer gradation is as follows

Percent Lighter Limits of Stone by Weight	Weight (Pounds)
95-100%	900
0-5-%	450
0-15%	180
0-5%	75

METHODOLOGY

The USACE (2006) recommends that the underlayer for riprap armor be sized in accordance with Equation VI-5-122 as follows:

$$D_{15}\text{ (cover)} \leq 5D_{85}\text{ (under)}$$

Where the nominal stone diameter, *D*, can be related to stone weight, *W*, through the layer thickness equation setting *n* equal to 1.0.

$$\left[D = \left(\frac{W}{\gamma_r} \right)^{1/3} \right]$$

Where:

W	=	weight of individual riprap stone. In this case D_{15} (cover) = 180 lbs
γ_r	=	specific weight of the armor unit = 165 lb/ft^3

This method produces a minimum criterion.

A more conservative underlayer than the minimum criterion may be constructed (USACE, 2006) by using:

$$W_{50}\ (under) = W_{50}\ (cover)/20$$

The USACE also recommends that the underlayer thickness be at least 3 thicknesses of W_{50} (under) stone, but never less than 0.23 m (9 inches)

The filter layer gradation has been developed using the USACE guidelines for armor layer gradation:

- Stones can range from 4.0 W_{50} to 0.125 W_{50} (USACE, 2006).
- The lower limit of the W_{100} stone (W_{100} min) should not be less than twice W_{50} min (USACE, 1995).
- The lower limit of the W_{15} stone (W_{15} min) should be about 0.4 times W_{50} min (USACE, 1995).

CALCULATIONS

$$\left[D_{15armor} = \left(\frac{W_{15armor}}{\gamma_r} \right)^{1/3} \right]$$

$D_{15armor}$ *[or D_{15} (cover)] = 1.03 ft = 12 inches*

and

$12 \leq 5D_{85}\ (under)$, $D_{85}\ (under) \geq 2.4$ *inches*

Or more conservatively:

$$W_{50}\ (under) = W_{50}\ (cover)/20 = 22.5\ lbs$$

This weight corresponds to a nominal diameter of 0.52 feet or 6.25 inches.

CONCLUSIONS

Using the more conservative W_{50} of 22.5 lbs or 6.25 inches, a 19-inch thick filter stone layer is recommended. The filter stone should have the following gradation:

Percent Lighter Limits of Stone by Weight	Weight (pounds)	Size (inches)
95-100%	45	8
0-50-%	22.5	6
0-5%	9	4.5

The dimensions listed in the table assume that the shape of the individual filter stones will be approximately cubical (quarry rock).

REFERENCES

U.S. Army Corps of Engineers. 1995. "Design of Coastal Revetments, Seawalls, and Bulkheads." June.

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

A17. Shoreline Revetment Material Quantities

Project	HPNS, Parcel E-2	Component/System:	Shoreline Revetment Material Quantities
Prepared by:	MJG	Checked by:	JS
Date	3-2013	Date	3-2013

PURPOSE

This purpose of these calculations is to determine the construction material quantities associated with the proposed revetment structure. Quantities calculated include:

1. Shoreline excavation volume
2. Armor layer material quantity
3. Filter layer material quantity
4. Filter fabric material quantity

DATA

- Toe length: 1,763 LF (CAD)
- Crest length: 1,819 LF (CAD)
- Approximate plan surface area: 48,780 ft^2 (CAD)
- Approximate excavation volume: 4,860 yd^3 (Grading Volume brief)
- Armor layer thickness: 2.8 ft (Armor Layer Thickness brief)
- Filter layer thickness: 1.6 ft (Filter Stone Size brief)
- Riprap specific weight: 1.3 tons/yd^3 (based on similar material used during the remedial actions in Parcel B)
- Filter stone specific weight: 1.4 tons/yd^3 (based on similar material used during the remedial actions in Parcel B)
- Assumed porosity for rock material: 30%

METHODOLOGY

The approximate shoreline excavation volume was calculated using the composite volume calculation tool in AutoCAD Civil 3D 2013 (CAD).

Surface Area Adjustment

The approximate plan area of the shoreline revetment was calculated using the surface properties module in CAD. This plan area was subsequently adjusted for slope consideration. The slope area was added to the area between the crest of the revetment and the sea wall to get the total adjusted area of the revetment. This adjusted area was used for the estimation of the stone material quantities.

Volume Calculation Methodology

The armor layer thickness was calculated in the Armor Layer Thickness brief. The total adjusted revetment area was then multiplied by the armor layer thickness to calculate the total volume of the layer. The porosity was removed from the total layer volume to find the material volume for the rip rap. The material volume was converted to the total material quantity by multiplying by the specific weight of the particular stone.

The same calculation was also used for the filter layer material quantity, where volume was calculated by multiplying the total revetment area in CAD and by the thickness of the filter layer, calculated in the Filter Stone Size brief. The porosity was removed from the total volume to calculate the material volume of the filter stone. The material volume was converted to total material quantity by multiplying by the specific weight.

Filter Fabric Calculation Methodology

The filter fabric area calculation was based on several assumptions regarding the size and overlap of the fabric sections that will be placed. The specified fabric is typically manufactured in 12 foot wide rolls, therefore, the width of a fabric section was assumed to be 12 feet. Fabric sections placed side by side are required to have a minimum 2 foot overlap and will be installed along the entire length of the revetment (USACE, 1995). Only the two end sections will have the full widths utilized. Every section in between, due to the overlap, will only utilize 10 feet of the full width. The length of the crest and toe of the revetment were calculated in CAD. The crest length was used for the calculation to ensure the fabric quantity calculated will adequately cover the entire revetment subgrade slope face.

CALCULATIONS

1. Shoreline Excavation Volume

The in-place shoreline excavation volume (V_{ex}) was calculated in CAD and is presented below.

$$V_{ex} = 4{,}860\ yd^3$$

2. Armor Layer Volume and Quantity

The armor layer volume was calculated, as follows:

$$V_{tot} = \frac{SA_{tot} \cdot d_l}{27\frac{ft^3}{yd^3}}$$

$$V_{tot} = 6{,}501\ yd^3$$

Where:

V_{tot} = *total volume of the armor layer (yd^3)*
SA_{tot} = *total adjusted surface area of the revetment (62,684 ft^2)*
d_l = *armor layer depth (2.8 ft)*

The material volume (V_{mat}) for the riprap is calculated, as follows:

$$V_{mat} = V_{tot} \cdot (1 - 0.30)$$

$$V_{mat} = 4{,}550\ yd^3$$

The armor layer material volume was then converted to a total material weight (in tons) was calculated, as follows:

$$W_{mat} = V_{mat} \cdot \gamma_{arm}$$

$$W_{mat} = 5{,}915\ tons$$

Where:

W_{mat} = *total weight of the riprap (tons)*
V_{mat} = *material volume of the riprap (4,550 yd^3)*
γ_{arm} = *specific weight of the riprap (assumed to be 1.3 tons/yd^3)*

3. Filter Layer Volume and Quantity

The filter layer volume was calculated, as follows:

$$V_{tot} = \frac{SA_{tot} \cdot d_l}{27\frac{ft^3}{yd^3}}$$

$$V_{tot} = 3{,}676\ yd^3$$

Where:

V_{tot} = *total volume of the filter layer (yd^3)*
SA_{tot} = *total adjusted surface area of the revetment (62,684 ft^2)*
d_l = *filter layer depth (1.6 ft)*

The material volume (V_{mat}) for the filter stone is calculated, as follows:

$$V_{mat} = V_{tot} \cdot (1 - 0.30)$$

$$V_{mat} = 2{,}573\ yd^3$$

The filter layer material volume was then converted to a total material weight (in tons) was calculated, as follows:

$$W_{mat} = V_{mat} \cdot \gamma_{arm}$$

$$W_{mat} = 3{,}602\ tons$$

Where:

W_{mat} = total weight of the filter stone (tons)
V_{mat} = material volume of the filter stone (2,573 yd^3)
γ_{arm} = specific weight of the filter stone (assumed to be 1.4 tons/yd^3)

4. Filter Fabric Area and Quantity

When calculating the quantity of filter fabric, the following assumptions were made:

- 12 foot wide sections;
- 2 foot overlap of each section according to USACE guidelines for filter fabric placement (1995);
- Revetment length is approximately 35 feet from crest to toe;
- An additional 30 feet (total) of fabric is required to secure the fabric at the crest and toe.

The filter fabric quantity was calculated, as follows:

$$N = \left(\frac{L_{crest} - 2L_{fab}}{\left(L_{fab} - 2\right)}\right) + 2$$

$$N = 182\ sections$$

Where:

N = the number of filter fabric sections
L_{crest} = length of the crest of the revetment (1,819 ft)
L_{fab} = width of the filter fabric sections (12 ft)

Where the total material quantity of the filter fabric (total area) was calculated, as follows:

$$SA_{fab} = \frac{L_{fab} \cdot L_{sec} \cdot N}{9\frac{ft^2}{yd^2}}$$

$$SA_{fab} = 15{,}730\ yd^2$$

Where:

SA_{fab} = *total material quantity of the filter fabric (yd^3)*

N = *the number of filter fabric sections (182 sections)*

L_{sec} = *length of each section of filter fabric (65 ft)*

L_{fab} = *width of the filter fabric sections (12 ft)*

CONCLUSIONS

The results of the calculations from the previous section are summarized in the following table. The table presents the estimated shoreline revetment material quantities.

Excavation Layer	Quantity	Unit
Excavation Volume	4,860	yd^3

Armor Layer	Quantity	Unit
Total Layer Volume	6,501	yd^3
Total Material Volume	4,550	yd^3
Material Quantity	5,915	tons

Filter Stone Layer	Quantity	Unit
Total Layer Volume	3,676	yd^3
Total Material Volume	2,573	yd^3
Material Quantity	3,602	tons

Filter Fabric Layer	Quantity	Unit
Filter Fabric Area	15,730	yd^2

REFERENCES

U.S. Army Corps of Engineers. 1995. "Design of Coastal Revetments, Seawalls, and Bulkheads." June.

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual." June.

A18. Excavation Volume Outside Slurry Wall

Project	HPNS, Parcel E-2	**Component/System:**	Excavation Volume Outside Slurry Wall
Prepared by:	PDL	**Checked by:**	MJG
Date	3-2013	**Date**	3-2013

PURPOSE

The purpose of this calculation is to estimate the projected quantities of the wedge of potential impacted soils above the Bay Mud between the proposed nearshore slurry wall and the revetment between Stations 2+00 and 12+37. The first 200 feet of the nearshore slurry wall is away from the shoreline, so was not included. This soil would be excavated and replaced with clean import soil to minimize direct contact between impacted landfill soils and the waters of San Francisco Bay.

DATA

The nearshore slurry wall alignment and final grades are based on design drawing C-5 "Groundwater Control System Plans". The Bay Mud depths are based upon preliminary geologic sections shown on attached drawings "Sections D-D',E-E',F-F', and G-G'" and "Plan Location Sections D-D',E-E',F-F', and G-G'' (Attachment 1).

METHODOLOGY

Volumes were calculated using the average end-area method. For the end area method, the new final grades and slurry wall location were added to the preliminary sections. Cross Sectional areas using the Adobe Acrobat area measuring tool were used to the determine the cross-sectional areas within each section for the existing soil above the Bay Mud on the shoreline side of the proposed nearshore slurry wall. The distances between sections, between section E-E' and Station 2+00 of the slurry wall and between section G-G' and Station 12+37 were scaled off the plan (Attachment 1). The cross-sectional area for Section E-E' was assumed to represent the shoreline north to Station 2+00 and the cross-sectional area of Section G-G' was assumed to represent the shoreline south to Station 12+37.

The cross sections shown have a 5 to 1 vertical exaggeration and so the areas measured by Adobe acrobat need to be first converted based on scale of drawing and then divided by 5 to account for the exaggeration.

CALCULATIONS

End-Area Method Calculation:

The average end-area method formula was used to calculate the volumes, as follows:

Volume of Cut/Fill:

$$\sum V = L\,(A_1 + A_2)/2$$

Where:

V = volume of cut or fill between the profiles

L = the perpendicular distance between the two area faces

A_1 = area of cut/fill for Profile 1

A_2 = area of cut/fill for Profile 2

Station	Section	Adobe Tool Area (in^2)	Cross-Sectional Area (ft^2)	Distance Between Section (feet)	Incremental Volume (ft^3)	Cumuluative Volume (ft^3)	Cumuluative Volume (yd^3)
2+00	start (E-E')	0.06	120	-	-	-	-
3+70	E-E'	0.06	120	170	20,400	20,400	756
5+70	F-F'	0.13	260	200	38,000	58,400	2,163
6+90	D-D'	0.11	220	120	28,800	87,200	3,230
8+40	G-G'	0.09	180	150	30,000	117,200	4,341
12+37	End (G-G')	0.09	180	500	90,000	207,200	7,674

CONCLUSIONS

Approximately 7,700 yd^3 of soil will need to be excavated and replaced between the proposed nearshore slurry wall alignment and the shoreline to minimize direct contact between impacted soils and the waters of San Francisco Bay.

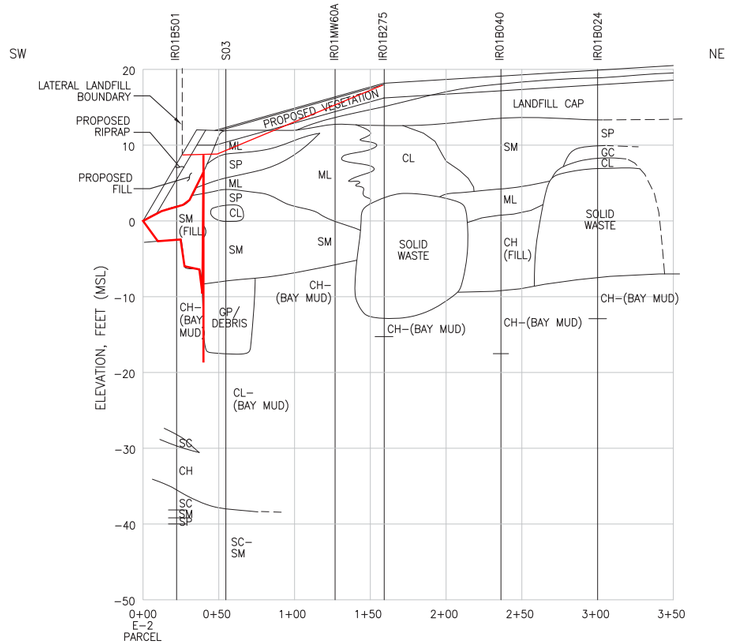
REFERENCES

Engineering/Remediation Resources Group (ERRG), 2011. "Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

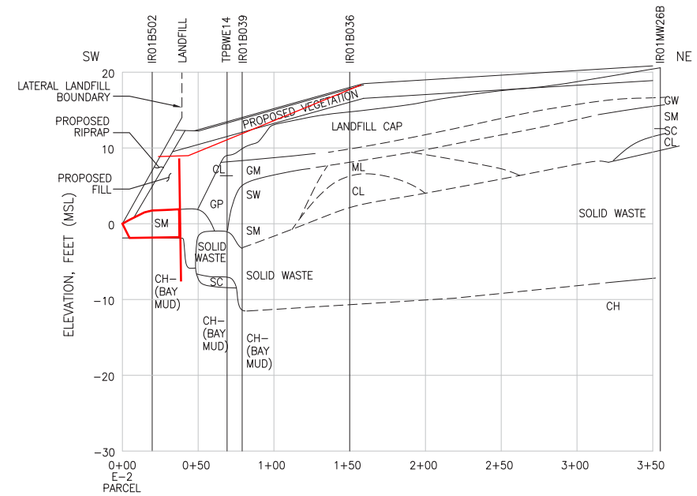
ATTACHMENTS

Attachment 1. Cross Sections and Locations

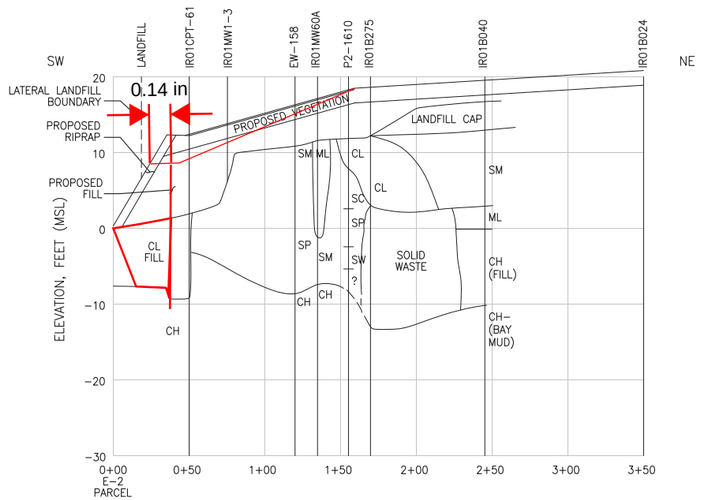
Attachment 1. Cross-Sections and Locations



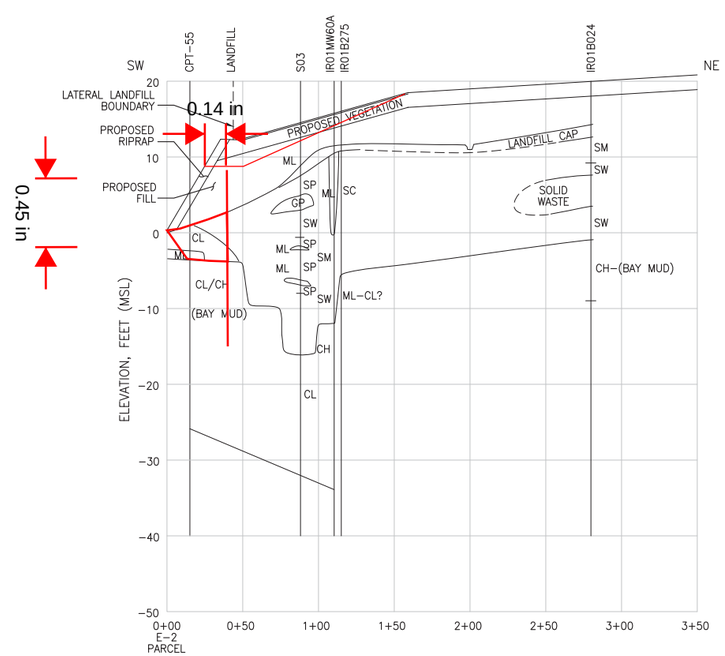
SECTION D–D'



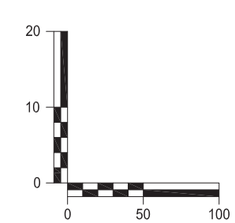
SECTION E–E'



SECTION F–F'



SECTION G–G'



APPROXIMATE SCALE IN FEET
VERTICAL EXAGGERATION = 5X

STM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy Naval Facilities Engineering Command Base Realignment and Closure Program Management Office West San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-0974 ERRG

SIZE D
IF SHEET IS LESS THAN 22" X 34" IT IS A REDUCED PRINT
SCALE REDUCED ACCORDINGLY

DESIGN BY: PDL
REVIEWED BY: PDL
PM/CM:
CHIEF ENG:

ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

SECTIONS D-D', E-E', F-F', AND G-G'

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22X34
SCALE: AS NOTED
PROJ. NO.
CONSTR. CONTR. NO.
DRAWING NO.
SHEET OF SHEETS

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A19. Slurry Wall, Groundwater Inceptor, and Leachate Monitoring Trench Material Quantities

Project	HNPS, Parcel E-2	**Component/System:**	Slurry Wall, Groundwater Inceptor, and Leachate Monitoring Trench Material Quantities
Prepared by:	DTB	**Checked by:**	JS
Date	2-2013	**Date**	3-2013

PURPOSE

This calculation brief was used to estimate the excavated materials and materials to build the near shore slurry wall alignment and its' corresponding leachate monitoring well network for the upland slurry wall and its' corresponding groundwater diversion trench (French drain).

DATA

The following design data is being used for this calculation. See design drawings C5, C6, and C7 for more details and specifications:

- Total length of the western boundary slurry wall alignment: approximately 571 feet (ft).
- Total length of the western boundary groundwater diversion trench (French drain): approximately 571 (ft), with an additional 139 ft outlet pipe running from the end of the trench to the outfall in the freshwater wetland.
- Total length of the near shore slurry wall alignment: approximately 1,237 ft
- Depth of the western boundary slurry wall alignment: approximately -10 mean sea level (msl) as shown on cross section A-A in design drawing C6
- Depth of the groundwater water diversion (French drain) along the western boundary slurry wall alignment is above 5.5 msl
- Depth of the near shore slurry wall alignment varies between -20 and -8 msl, as shown on cross section B-B in design drawing C6.
- Width of upland and near shore slurry walls: 2.0 ft minimum
- Width of French drain: 2.0 ft minimum
- French drain pipe: 571 ft of 4" diameter perforated Sch80 PVC collection pipe.
- French drain outlet pipe: 139 ft of 4" diameter Sch80 PVC.
- Non-perforated clean-out risers for the French drain: 77 ft of 4" diameter Sch 80 PVC pipe.
- Depth of 26 leachate monitoring/extraction wells up gradient of the near shore slurry wall alignment vary from 16-27 ft: 526 ft of Sch80 PVC well casing (including screen interval).
- Depth of 13 piezometers along near shore slurry wall alignment vary from 15-26 ft: 122.5 ft of Sch80 PVC well casing (including screen interval)

- Depth of 4 piezometers along western boundary slurry wall alignment vary from 23-27 ft: 139 ft of Sch80 PVC well casing (including screen interval)
- Non-woven geotextile fabric assumes 12" min. overlap for trench lining, and 1" min. overlap for 4" diameter Sch 80 PVC perforated pipe: approximately 11,098 square feet.

METHODOLOGY

It is assumed the walls and trenches will be constructed from the finish grade along the alignments (design drawing C5 Slurry Walls Plan View). The cut volumes were determined by estimating cross sectional areas every 100 feet along the slurry wall and trench alignments, according to the stationing established for each of the alignments (design drawings C5, C6, and C7, slurry wall plan view, cross sections, and details). The calculation estimates the depth from finish grade. The finish grade is not the same grade as the top of the near shore slurry wall alignment. The bottom of the near shore slurry wall (varies), approximately every 100 feet. In order to build the near shore slurry wall to the slurry wall finish grade (7 feet above msl), it is assumed the near shore slurry wall alignment will need to be constructed a minimum of 4 feet above the existing groundwater level (at approximately 9 msl). The near shore slurry wall will then be cut down to accommodate the slurry wall surface completions.

The depth of the two slurry wall alignments is estimated for each 100 foot station. Each of the stations are considered as 1 of the 2 bases of a trapezoid, and the 100 foot spacing between stations is assumed perpendicular to the two bases when calculating the cross sectional areas as trapezoids (C6 Cross Sections A-A and B-B). There was less than a 1% relative percent difference between the hand calculations and the AutoCAD slurry wall cut estimates. The volumes of the slurry walls, leachate monitoring and groundwater diversion trenches assumed a trench width of 2 ft. A similar method calculating cross sectional areas as trapezoids was used to estimate cut volumes for the groundwater diversion and the leachate monitoring trenches. All other slurry wall materials are tabulated in the Estimate of Quantities table, below.

ESTIMATE OF QUANTITIES

CUT MATERIALS	LENGTH (FEET)	AREA (SQUARE FEET)	WIDTH (FEET)	VOLUME (CUBIC YARDS)[1]
WESTERN BOUNDARY SLURRY WALL	571	14,015	2	1,350
WESTERN BOUNDARY GROUNDWATER DIVERSION (FRENCH DRAIN)	571	8,422	2	811
CONVEYANCE LINE FROM FRENCH DRAIN TO WETLAND	139			
NEAR SHORE SLURRY WALL ALIGNMENT	1,237	28,223	2	2,718

BUILD MATERIALS[2]	LENGTH/ITEM (FEET/UNITS)	AREA (SQUARE FEET)	WIDTH (FEET)	VOLUME (CUBIC YARDS)
SLURRY WALL SURFACE COMPLETIONS[3]	571 + 1237	--	--	1,073
IMPORT CLEAN FILL (VEGETATIVE LAYER[4])	1,797	2,198	2	179
CLEAN DRAIN ROCK	680	1,360	2	347
BEDDING SAND	1,117	1,452	2	108
NON-WOVEN GEOTEXTILE	1,171	11,098		
6" ϕ SCH 80 PVC WELL CASING	525.5			
4" ϕ SCH 80 PVC WELL CASING	368			
4" ϕ SCH 80 PERFORATED PVC	571			
6" ϕ SCH 80 PVC	1,213			
4" ϕ SCH 80 PVC	77			
2" ϕ ELECTRCIAL CONDUIT	2,426			
6" ϕ SCH 80 PVC SLIP COUPLINGS	60			
4" ϕ SCH 80 PVC SLIP COUPLINGS	35			
4" ϕ SCH 80 PVC WYES	3			
6" ϕ SCH 80 PVC, 45 DEGREE SWEEP ELBOWS	4			
6" ϕ SCH 80 PVC, 90 DEGREE SWEEP ELBOWS	1			
2' ϕ TRAFFIC RATE MONITORING WELL	26			
VAULT OR, 2'X3'X2' DEEP CONCRETE VAULT AND LID[5]	26			
1' ϕ TRAFFIC RATED MONITORING WELL VAULTS	21			
6" ϕ LOCKING WELL CAPS	26			
4" ϕ LOCKING WELL CAPS	21			

NOTES:

1. Assumed additonal volume for excavated native material is 30%.
2. Slurry, soil, and cement quantities used in construction of the slurry walls to be determined during completion of backfill mix design, and compatability testing.
3. Surface completions for slurry wall alignments can use backfill design determined for the near shore slurry wall alignment (assuming a strength min. of 30 psi).
4. Assumed compaction volume for clean import soil is 10%.
5. Frequency of concrete vaults vs. monitoring well head completions not yet determined.

REFERENCES

U.S Army Corps of Engineers (COE). 1986 "Engineering Manual 1110-2-1901 Seepage Analysis and Controls for Dams." September 30

A20. Landfill Gas System - Extraction Well Radius of Influence (*to be completed at a later date*)

Project	HPNS, Parcel E-2	Component/System:	Landfill Gas System – Extraction Well Radius of Influence
Prepared by:	(Golder)	Checked by:	(Golder)
Date	TBD	Date	TBD

Golder Project Information:

Proj. No. 123-97584
Client/Site: ERRG-USN Hunters Point Naval Shipyard
Calc.: LFG Extraction Well Radius of Influence
Purpose: Internal Coordination
Approved By:

PURPOSE

To be included after completion of ITSI report.

DATA ASSUMPTIONS

METHODOLOGY

CALCULATIONS

RESULTS

REFERENCES

A21. Landfill Gas System - Header Pipe Flow Headloss and Sizing (*to be completed at a later date*)

Project	HPNS, Parcel E-2	Component/System:	Landfill Gas System – Header Pipe Flow Headloss and Sizing
Prepared by:	(Golder)	Checked by:	(Golder)
Date	TBD	Date	TBD

Golder Project Information:

Proj. No. 123-97584
Client/Site: ERRG-USN Hunters Point Naval Shipyard
Calc.: LFG Header Pipe Flow Headloss and Sizing
Purpose: Internal Coordination
Approved By:

PURPOSE

To be included after completion of ITSI report.

DATA ASSUMPTIONS

METHODOLOGY

CALCULATIONS

RESULTS

REFERENCES

A22. Landfill Gas System - Condensate Generation

Project	HPNS, Parcel E-2	**Component/System:**	Landfill Gas System – Condensate Generation
Prepared by:	SN (Golder)	**Checked by:**	AW (Golder)
Date	3-2013	**Date**	3-2013

Golder Project Information:

Proj. No. 123-97584
Client/Site: ERRG-USN Hunters Point Naval Shipyard
Calc.: LFG Condensate Generation
Purpose: Internal Coordination
Approved By: RH

PURPOSE

This calculation is used for estimating the maximum LFG condensate generation for Parcel E-2 Landfill for sizing condensate collection system components.

DATA ASSUMPTIONS

The following design data assumptions are used for this calculation:

LFG Flow Volume (SCFM)= 60

Initial vapor conditions:

Gage Pressure (in. w.c.g.)= -30.0

Temperature (°F)= 80

Final vapor conditions:

Gage Pressure (in. w.c.g.)= 80.0

Avg. Max. Monthly Temperature (°F)= 57

Avg. Min. Monthly Temperature (°F)= 43

Hours @T_{max}= 10

Hours @ T_{min}= 14

METHODOLOGY

LFG condensate is generated primarily due to cooling of LFG in the collection system. The LFG is assumed to be at its maximum temperature as it exits the well. The LFG typically cools to ambient temperature as it travels through the LFG collection piping. The magnitude of temperature drop and the vapor pressure of water determine the volume of condensate generated over the section(s) of collection piping under consideration. The increase in pressure also induces additional condensation, but to a lesser degree than the typical temperature change.

CALCULATIONS

Antoine's Equation is used to estimate the vapor pressure of water at various temperatures:

$$Ln(P_{vp}/P_c) = (1-x)^{-1}[(A)x + (B)x^{1.5} + (C)x^3 + (D)x^6]$$

Where:

$x = 1 - (T/T_c)$
P_{vp} = Vapor pressure of water, [bars]
P_c = Critical pressure, [bars]
T_c = Critical temperature, [°Kelvin]
T = Vapor temperature [°Kelvin]
A, B, C, D are matched Antoine coefficients derived from regression analysis of experimental data (A = -7.76451; B = 1.45383; C = -2.77580; D = -1.23303)

Antoine's Equation is applied to the initial and final states of the site LFG quantity (e.g., maximum and minimum vapor temperatures and pressures) for the worst case daily ambient temperature conditions. The extraction rate estimates below were evaluated with respect to the Remedial Investigation – Feasibility Study (ERRG and Shaw Environmental, Inc., 2011) LFG generation modeling result of approximately 30 standard cubic feet per minute (SCFM), and LFG at 50% methane concentration. The condensate generation estimations below assumes a very dilute LFG flow. As conservative measure for estimating the condensate generation rate, the LFG extraction rate was doubled and the methane concentration halved. The assumed LFG system extraction rate for these condensate generation calculations is 60 SCFM. The differential in vapor content (in moles) is converted to a generation rate of LFG condensate volume in gallons per minute (GPM). The maximum daily condensate generation rate is calculated from the time-weighted average of the estimated maximum (9 gallons per day [GPD]) and minimum (5 GPD) LFG extraction rates (see Attachment 1). For ease of use, Antoine's Equation in Attachment 1 was reduced to a spreadsheet "look-up" Vapor Pressure Table for the commonly encountered range of landfill and ambient temperatures.

RESULTS

Condensate generation results for the data assumptions above are summarized below:

			GPM	Hrs.	GPD
Condensate generation rate @T_{max} =			0.0085	10	5
Condensate generation rate @T_{min} =			0.0103	14	9
Maximum condensate generation rate =					14

Where:

GPD = Estimate of the average daily LFG condensate generation rates
Hrs. = Estimated hours per day of LFG system operations at Tmax and Tmin (The assumed number of hours per day at the average maximum or minimum ambient temperature is estimated based on engineering judgment, in lieu of a more accurate calculation using 30-year average hourly temperatures [which are not available for many locations]. The number of hours estimated at the ambient minimum temperature is conservatively high and generally biases the resultant condensate generation rate estimate upwards. For the purposes of this application, the impact of the cumulative calculation error on the treatment process selection and/or discharge costs is minimal relative to the true variability in the actual site conditions.)
GPM = Estimate of condensate generation rate in GPM

REFERENCES

ERRG and Shaw Environmental, Inc., 2011. "Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

Green, Donald W., and Perry, Robert H., *Perry's Chemical Engineering Handbook*, Sixth Ed., McGraw-Hill Book Co., Inc. New York. 1984.

Reid, Robert C., Prausnitz, John M., and Poling, Bruce E. *The Properties of Gases and Liquids*, Fourth Ed., McGraw-Hill Book Co., Inc. New York. 1987.

National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC) 1981-2010 Climate Data Normals (July 1, 2011)

ATTACHMENTS

Attachment 1. Daily Generation – Summary Table

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Attachment 1. Daily Generation – Summary Table

Project Name: Hunters Point E-2 Landfill
Project No.: 123-97583 ph. 003

Date: 2/1/2013
By: sn

LFG CONDENSATE ESTIMATE
LFG CONTROL SYSTEM
DAILY GENERATION - SUMMARY TABLE

PERIOD:	WINTER			SPRING			SUMMER			FALL		
	HRS.	@ TEMP (F)	FLOW (gpd)	HRS.	@ TEMP (F)	FLOW (gpd)	HRS.	@ TEMP (F)	FLOW (gpd)	HRS.	@ TEMP (F)	FLOW (gpd)
AVG. HIGH	10	57.0	5	12	63.7	6	14	71.4	5	12	68.7	5
AVG. LOW	14	43.2	9	12	47.6	7	10	53.8	6	12	51.4	7
DAILY TOTAL			14			13			10			11

PERIOD:	3 DAY WORST CASE			3 DAY BEST CASE		
	HRS.	@ TEMP (F)	FLOW (gpd)	HRS.	@ TEMP (F)	FLOW (gpd)
AVG. HIGH	10	55.6	5	14	70.3	5
AVG. LOW	14	41.8	9	10	52.6	6
DAILY TOTAL			14			10

LFG FLOW DATA		
MAX. SYSTEM VACUUM	-30	in. w.c.
MAX. SYSTEM PRESSURE	80	in. w.c.
AVG. LFG WELL TEMP.	80	°F
MAX. LFG FLOW	60	scfm

Note: denotes user input value

Project Name: Hunters Point E-2 Landfill
Project No.: 123-97583 ph. 003

Date: 2/1/2013
By: sn

LFG CONDENSATE GENERATION	WINTER AVERAGE	
INPUT		
Flow Volume (SCFM)=	60	
Inlet		
Gage Pressure (in W.C. (g))=	-30.0	
Temperature (F)=	80	
Outlet		
Gage Pressure (in W.C. (g))=	80.0	
High Avg. Temperature (F)=	57.0333	
Low Avg. Temperature (F)=	43.1667	
Hours @Tmax=	10	
Hours @ Tmin=	14	
RESULTS	GPM	GPD
Tmax Condensate (GPM)=	0.0085	5
Tmin Condensate (GPM)=	0.0103	9
Avg. daily condensate (GPM)=	0.0095	14

P (abs)	VP (psia)	Y (moles)
13.62	0.507	0.037
P (abs)	VP (psia)	Y (moles)
17.59	0.217	0.012
P (abs)	VP (psia)	Y (moles)
17.59	0.122	0.007

VAPOR PRESSURE TABLE

Temp (F)	VP (psia)
35	0.100
40	0.122
45	0.147
50	0.178
55	0.217
60	0.256
65	0.310
70	0.363
75	0.435
80	0.507
85	0.603
90	0.699
95	0.825
100	0.950
105	1.115
110	1.280
115	1.485
120	1.690

A23. Headwall Sizing

PURPOSE AND SITE CONDITIONS

The purpose of these calculations is to evaluate the design for the headwall for the inlets and outlets to the underground storm water discharge pipes and culverts for the Remedial Design for the Parcel E-2 Landfill at Hunters Point Naval Shipyard. This includes the discharge pipes for the proposed freshwater wetlands and for the perimeter surface water runoff channel along the east perimeter of the parcel. Both of these discharge structures will outfall into San Francisco Bay and will require a tidal valve at the end of the outfall pipes.

Discharge from the freshwater wetlands into San Francisco Bay will be through an SDR 17 solid-wall HDPE pipe. A headwall will be constructed at the upstream end of this pipe where storm water enters it from the freshwater wetlands. This headwall will be identified on the Drawings as the Freshwater Wetlands Outlet Headwall. The headwall is required so that adequate cover can be placed over the pipe near the inlet without steepening the surrounding slopes.

A second headwall will be constructed at the downstream end of this pipe where storm water discharges into the San Francisco Bay. This headwall will be identified on the Drawings as the Freshwater Wetlands Outfall Headwall. The headwall is required so that adequate cover can be placed over the pipe near the outfall without steepening the surrounding slopes, and to connect into a cutoff wall that will prevent undercutting below the downstream face of the headwall footing due to scour.

Surface water runoff along the east perimeter channel must flow through a culvert under the proposed site maintenance road coming from Spear Ave. The culvert pipe will be a double-wall corrugated HDPE pipe with flared ends. Therefore, no headwalls will be installed at this culvert

Discharge of the east perimeter drainage channel will be directed through an SDR 17 solid-wall HDPE pipe into a manhole structure containing a tidal valve assembly. A headwall will be constructed at the upstream end of this pipe where storm water enters it from the perimeter drainage channel. This headwall will be identified on the Drawings as the Perimeter Surface Drainage Channel Outlet Headwall. The headwall is required so that adequate cover can be placed over the pipe near the inlet without steepening the surrounding slopes.

The downstream of the manhole and the tidal vale assembly surface water runoff will be directed through an open-ended pipe that will project through the revetment armor along the shoreline of the site, and

discharge directly into the bay. Flow at the outfall will be over the revetment armor. A headwall will not be necessary for this configuration.

DATA

Pipe sizes were evaluated in the Culverts calculation. Both pipes will be 20-inch outside diameter (OD), solid-wall, SDR 17 HDPE. Clearance between the top of the headwall footing and the outside bottom of the pipe should be 1 inch to allow insertion of grout sealant around the pipe. The headwall will extend approximately 18 inches above the top of the pipe for adequate soil cover. Therefore, the top of the headwall should be approximately 39 inches (3.25 feet) above the top of the footing.

The following design drawings show the design details explained in this calculation brief:

- C22: Freshwater Wetland Outlet Headwall Details
- C23: Freshwater Wetland Outfall Details

METHODOLGY

Headwall design is based on State of California Department of Transportation (Caltrans) Standard Plans (Attachment 1 [Caltrans, 1992 and 2010]). The Standard Plans used herein are as follows: Standard Plan B3-3, Retaining Wall Type 1A; Standard Plan D86B, Pipe Culvert Headwalls, Endwalls, and Warped Wingwalls; and Standard Plan D89, Pipe Headwalls. Copies of these Standard Plans are attached.

For the Freshwater Wetlands Outlet Headwall, the top of the headwall, as shown on the Remedial Design Drawings, slopes up from 8 inches to 3.2 feet above the top of the footing. The 3.2-foot-high end of the wall is at a corner that intersects with a similar section of wall, thus creating a partial box, or buttress. A Design H of 4 feet from Standard Plan B3-3 was used for determining footing dimensions. Reinforcement steel in the Freshwater Wetlands Outlet Headwall will be No. 5 at 12-inches on center (OC). This exceeds what is shown on Standard Plan B3-3. Due to the sloping top of the wall, and the buttress effect from the adjacent wall, the use of Standard Plan B3-3 provides a conservative design.

For the Freshwater Wetlands Outfall Headwall, the top of the headwall, as shown on the Remedial Design Drawings, is 3.5 feet above the top of the footing. Therefore, Design H of 4 feet from Standard Plan B3-3 was used for determining footing dimensions. Reinforcement steel in the Freshwater Wetlands Outfall Headwall will be No. 5 at 12-inches OC. This exceeds what is shown on Standard Plan B3-3. A cutoff wall will be constructed below the footing. The dimensions of the cutoff wall are in accordance with those shown on Standard Plan D86B. Reinforcement steel in the cutoff wall will be No. 4 at 12-inches OC. This exceeds what is shown on Standard Plan D86B. Attachment of the cutoff wall reinforcement steel into the footing follows what is shown on Standard Plan D86B.

The Perimeter Surface Drainage Channel Outlet Headwall will be constructed in accordance with Standard Plan D89. A structure meeting the requirements of Standard Plan D89 is available in precast concrete.

CONCLUSIONS

Based on the evaluation of site and flow conditions, the structures shown on the Caltrans Standard Plans are suitable for use at the site.

Design Drawings based on the Caltrans Standard Plans are attached.

REFERENCES

State of California Department of Transportation. 2006. "Standard Plans." May.

State of California Department of Transportation. 2010. "Standard Plans."

ATTACHMENTS

Attachment 1. Caltrans Standard Plans

Attachment 1. Caltrans Standard Plans

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS

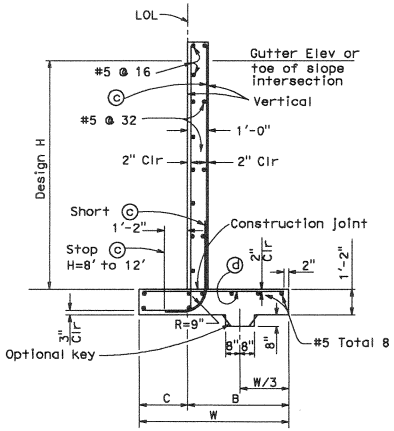
REGISTERED CIVIL ENGINEER

May 1, 2006
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER Dwarcomar Y. Hor No. C45803 Exp. 12-31-06 CIVIL STATE OF CALIFORNIA

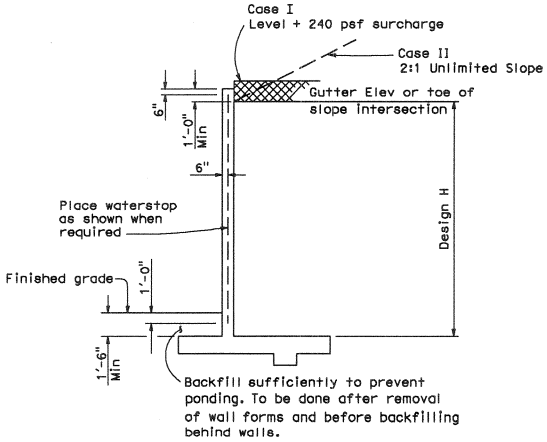
The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

To get to the Caltrans web site, go to: http://www.dot.ca.gov

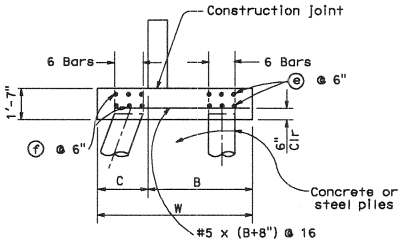


SPREAD FOOTING SECTION

Place concrete in toe, against undisturbed material, except as permitted by the Engineer.



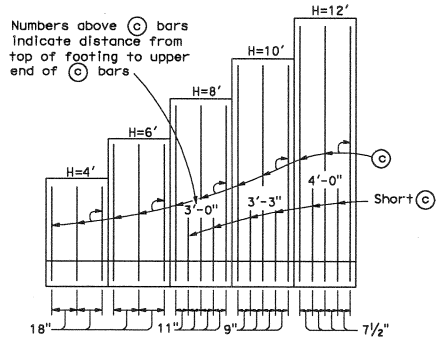
DESIGN



90 KIP PILE FOOTING SECTION

Reinforcement detailed is to be placed in addition to that shown for spread footing. All piles not shown, see Pile Layout on other sheets. For pile footing for Design H=4' use same footing dimensions as for Design H=6'.

TABLE OF REINFORCING STEEL, DIMENSIONS AND DATA					
Design H	4'	6'	8'	10'	12'
W	3'-2"	4'-2"	5'-2"	6'-2"	7'-2"
C	1'-0"	1'-4"	1'-8"	2'-0"	2'-4"
B	2'-2"	2'-10"	3'-6"	4'-2"	4'-10"
c bars	#5 @ 16	#5 @ 16	#5 @ 8	#6 @ 8	#8 @ 8
d bars	#5 @ 16	#5 @ 16	#5 @ 16	#5 @ 8	#6 @ 8
Total e bars	6-#6	6-#6	6-#6	6-#8	6-#8
Total f bars	—	—	—	6-#6	6-#6
Case I-Toe Press. ksf	1.6	2.0	2.3	2.6	2.8
Case II-Toe Press. ksf	1.0	1.5	1.9	2.3	2.7



ELEVATION

NOTES:

1. Retaining Wall Type 1A designed for Design Loading Cases I and II only.
2. For design notes, drainage notes and other details, see B3-8.
3. For wall stem joint details, see B0-3/3-3 and B0-3/3-4.
4. At c and Short c bars:
   H ≤ 6', no splices are allowed within 1'-8" above the top of footing.
   H > 6', no splices are allowed within H/4 above the top of footing.

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

RETAINING WALL TYPE 1A

NO SCALE

B3-3

2006 STANDARD PLAN B3-3

248

8-1-05

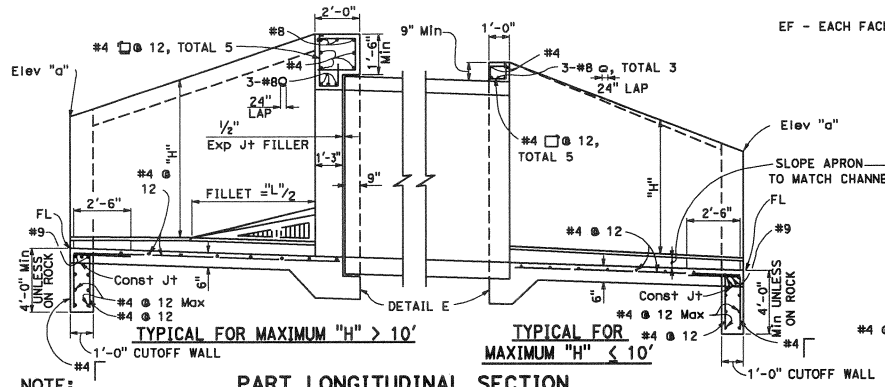
Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

REGISTERED CIVIL ENGINEER

May 20, 2011
PLANS APPROVAL DATE

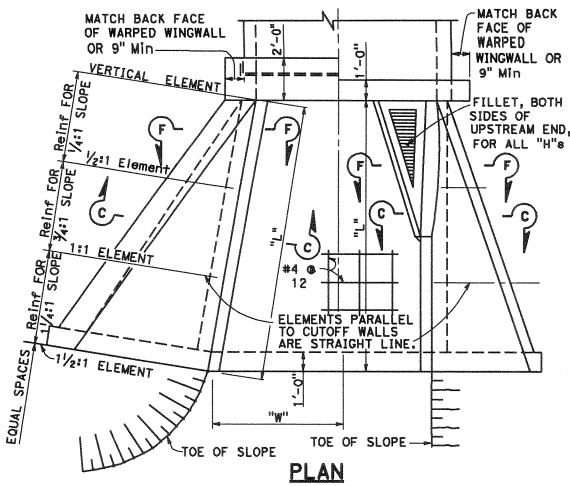
REGISTERED PROFESSIONAL ENGINEER Dalton Forrester No. C37765 Exp. 12-31-12 CIVIL STATE OF CALIFORNIA

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

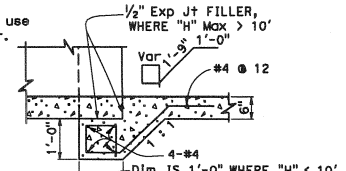


NOTE: RCP shown. Metal pipe similar except eliminate the expansion joint and use hook bolts @ 1'-7" ± spacing. Size and length provided by manufacturer.

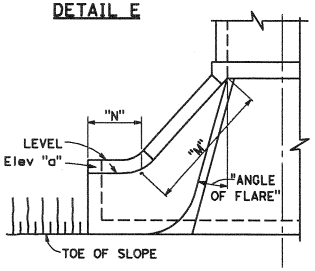
PART LONGITUDINAL SECTION



PLAN

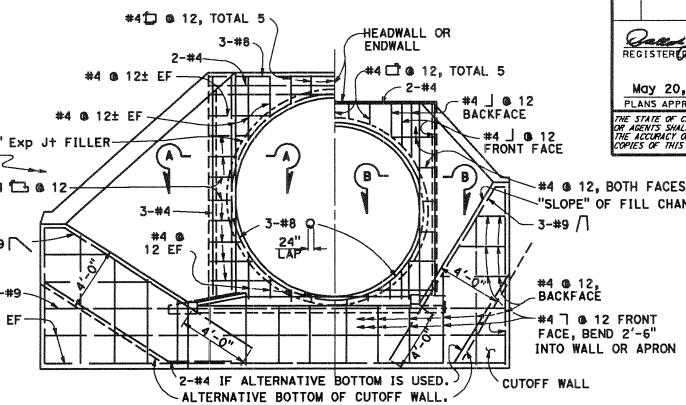


DETAIL E



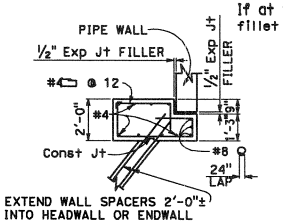
ALTERNATIVE WARPED WINGWALL

Use where additional protection to toe of embankment is required. If at upstream end, fillet is not shown.

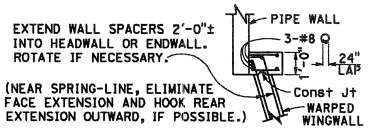


END ELEVATION

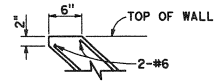
If at upstream end, fillet is not shown.



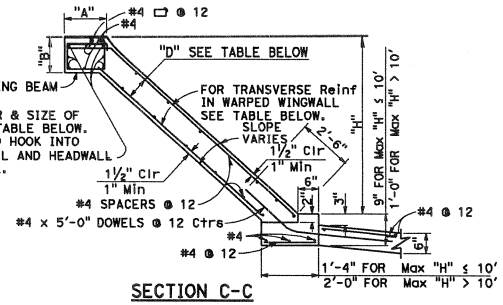
SECTION A-A



SECTION B-B

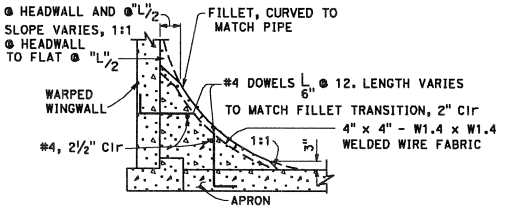


TYPICAL FOR MAXIMUM "H" ≤ 10' WITHOUT STIFFENING BEAM



SECTION C-C

Where abrasion is anticipated, increase apron thickness to 7" minimum to provide 2" minimum reinforcement coverage.



SECTION F-F

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PIPE CULVERT HEADWALLS, ENDWALLS AND WARPED WINGWALLS

NO SCALE

WARPED WINGWALLS

WALL DIMENSIONS AND REINFORCING								
ELEMENT SLOPE	"H"	8' OR LESS	10'	12'	14'	16'	18'	20'
1/4:1	FRONT FACE Reinf	#4 @ 12	#4 @ 7	#5 @ 7	#5 @ 5	#6 @ 6	#7 @ 7	#7 @ 6
	REAR FACE Reinf	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12
3/4:1	FRONT FACE Reinf	#4 @ 12	#4 @ 12	#4 @ 8	#4 @ 8	#4 @ 8	#4 @ 6	#4 @ 6
	REAR FACE Reinf	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 10	#4 @ 7	#4 @ 6	#5 @ 8
1 1/4:1	FRONT FACE Reinf	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12	#4 @ 12
	REAR FACE Reinf	#4 @ 8	#4 @ 8	#4 @ 5	#5 @ 6	#6 @ 7	#6 @ 6	#7 @ 6
"D" AT CUTOFF WALL		6"	6"	6"	7 1/2"	8"	9 1/2"	11"
"D" AT CULVERT		6"	6"	6"	8"	9 1/2"	11"	1'-1"

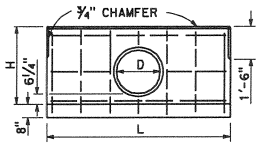
STIFFENING BEAM DIMENSIONS AND REINFORCING									
"H" Max \ "L"	12'	14'	16'	18'	20'	25'	30'	35'	40'
6'	NO BEAM. PLACE 2-#6 IN EACH FACE ALONG TOP OF WALL.								
8'			"A"= 1'-0"						
10'						"A"= 1'-6"			
12'		"B"= 9"						"A"= 1'-10"	
14'	TOTAL 6-#6		"B"= 1'-0"				"B"= 1'-3"		
16'									"A"= 2'-2"
18'			TOTAL 6-#7			TOTAL 8-#8			"B"= 1'-6"
20'								TOTAL 8-#9	

NOTES: Walls designed for 2'-0" surcharge; earth density = 120 pcf; equivalent fluid pressure = 36 pcf.
Vary "D" of warped wall uniformly from that at cutoff wall to that at headwall or endwall, for maximum "H" > 12'-0".
Dimensions "L", "W", "H", "M", "N", Elevation "a", "Angle of flare", and end "Slope" (as apply) are shown on the plans.

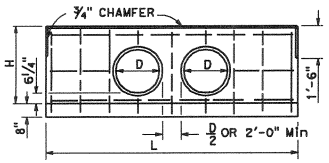
D86B

2010 STANDARD PLAN D86B

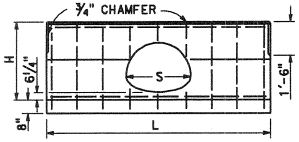
9-21-10



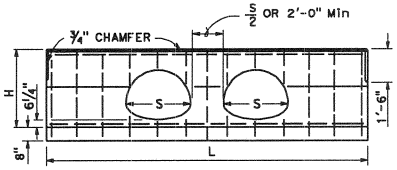
FRONT ELEVATION
SINGLE HEADWALL



FRONT ELEVATION
DOUBLE HEADWALL



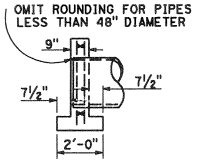
FRONT ELEVATION
SINGLE HEADWALL



FRONT ELEVATION
DOUBLE HEADWALL

D	H	SINGLE			DOUBLE		
		L	STEEL LB	Conc CY	L	STEEL LB	Conc CY
12"	2'-8"	5'-0"	35	0.60	8'-0"	50	0.94
15"	2'-11"	6'-0"	40	0.75	9'-6"	60	1.17
18"	3'-2"	7'-0"	50	0.91	10'-6"	75	1.35
21"	3'-5"	7'-6"	60	1.02	11'-6"	90	1.52
24"	3'-8"	8'-6"	75	1.20	12'-6"	100	1.72
27"	3'-11"	9'-6"	85	1.39	14'-0"	115	2.00
30"	4'-2"	10'-0"	90	1.52	15'-0"	126	2.21
33"	4'-5"	11'-0"	100	1.73	16'-0"	130	2.42
36"	4'-8"	12'-0"	105	1.95	17'-0"	145	2.65
39"	4'-11"	12'-6"	130	2.09	18'-0"	170	2.88
42"	5'-2"	13'-6"	140	2.34	19'-0"	185	3.13
45"	5'-5"	14'-6"	150	2.60	20'-0"	195	3.38
48"	5'-8"	15'-0"	160	2.75	21'-0"	200	3.64
51"	5'-11"	16'-0"	180	3.03	22'-6"	225	4.02
54"	6'-2"	17'-0"	190	3.31	23'-6"	240	4.30

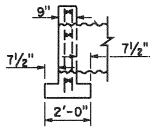
STRAIGHT HEADWALLS



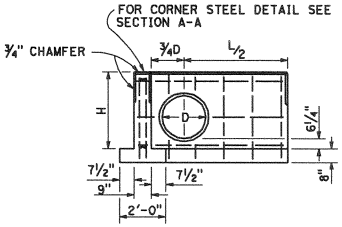
SECTION, SINGLE
AND DOUBLE HEADWALLS

CMP ARCH SIZE	SINGLE				DOUBLE		
	H	L	STEEL LB	Conc CY	L	STEEL LB	Conc CY
21" x 15"	2'-11"	6'-6"	45	0.80	10'-0"	60	1.22
24" x 18"	3'-2"	7'-6"	50	0.96	11'-6"	70	1.45
28" x 20"	3'-4"	8'-6"	60	1.12	13'-6"	90	1.76
35" x 24"	3'-8"	10'-6"	85	1.47	15'-6"	120	2.16
42" x 29"	4'-1"	12'-6"	110	1.76	18'-0"	145	2.57
49" x 33"	4'-5"	14'-6"	130	2.26	21'-0"	170	3.13
57" x 38"	4'-10"	17'-0"	155	2.81	24'-6"	210	3.86
64" x 43"	5'-3"	19'-0"	175	3.31	27'-0"	230	4.42
71" x 47"	5'-7"	21'-0"	195	3.81	30'-0"	255	5.09

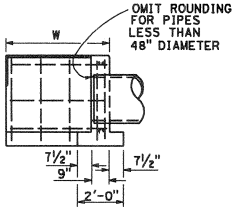
STRAIGHT HEADWALLS



SECTION, SINGLE
AND DOUBLE HEADWALLS



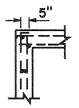
FRONT ELEVATION "L" HEADWALL



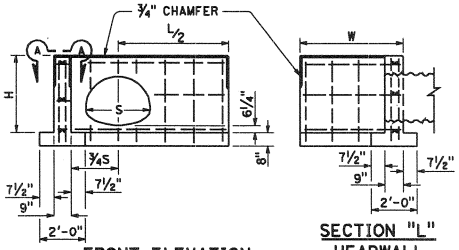
SECTION "L" HEADWALL

D	H	L/2	LENGTH OF W									
			3'-4"		4'-10"		6'-4"		7'-10"		9'-4"	
			STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY
12"	2'-8"	2'-6"	50	0.79	60	0.98	—	—	—	—	—	—
15"	2'-11"	3'-0"	55	0.91	65	1.11	—	—	—	—	—	—
18"	3'-2"	3'-6"	65	1.04	75	1.25	—	—	—	—	—	—
21"	3'-5"	3'-9"	75	1.15	90	1.36	—	—	—	—	—	—
24"	3'-8"	4'-3"	85	1.29	100	1.51	110	1.74	—	—	—	—
27"	3'-11"	4'-9"	90	1.44	105	1.67	115	1.91	—	—	—	—
30"	4'-2"	5'-0"	95	1.55	110	1.80	120	2.05	135	2.29	—	—
33"	4'-5"	5'-6"	105	1.71	120	1.97	135	2.23	150	2.48	—	—
36"	4'-8"	6'-0"	110	1.88	125	2.15	140	2.41	155	2.68	170	2.95
39"	4'-11"	6'-3"	—	—	150	2.28	170	2.56	185	2.84	200	3.12
42"	5'-2"	6'-9"	—	—	155	2.42	175	2.76	190	3.05	210	3.34
45"	5'-5"	7'-3"	—	—	—	—	180	2.97	200	3.27	215	3.57
48"	5'-8"	7'-6"	—	—	—	—	190	3.13	215	3.44	230	3.75
51"	5'-11"	8'-0"	—	—	—	—	—	—	220	3.67	235	3.99
54"	6'-2"	8'-6"	—	—	—	—	—	—	235	3.91	250	4.24

"L" HEADWALLS
CIRCULAR PIPE CULVERT HEADWALLS



SECTION A-A



FRONT ELEVATION
"L" HEADWALL

SECTION "L"
HEADWALL

CMP ARCH SIZE	H	L/2	LENGTH OF W									
			3'-4"		4'-10"		6'-4"		7'-10"		9'-4"	
			STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY	STEEL LB	Conc CY
21" x 15"	2'-11"	3'-3"	60	1.00	65	1.18	75	1.38	90	1.58	100	1.77
24" x 18"	3'-2"	3'-9"	60	1.07	70	1.32	80	1.53	95	1.74	110	1.94
28" x 20"	3'-4"	4'-3"	70	1.26	80	1.47	90	1.68	100	1.90	115	2.11
35" x 24"	3'-8"	5'-3"	100	1.51	110	1.74	120	1.97	140	2.20	155	2.42
42" x 29"	4'-1"	6'-3"	115	1.82	130	2.06	140	2.31	155	2.55	170	2.83
49" x 33"	4'-5"	7'-3"	130	2.12	145	2.37	155	2.64	170	2.90	185	3.15
57" x 38"	4'-10"	8'-6"	145	2.52	160	2.79	175	3.07	190	3.35	205	3.61
64" x 43"	5'-3"	9'-6"	185	2.89	200	3.11	215	3.48	235	3.77	250	4.06
71" x 47"	5'-7"	10'-6"	200	3.25	215	3.56	235	3.86	250	4.17	270	4.48

"L" HEADWALLS
CORRUGATED METAL PIPE ARCH CULVERT HEADWALLS

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS

REGISTERED CIVIL ENGINEER

May 20, 2011
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER Glenn DeCou No. C34547 Exp. 9-30-11 CIVIL STATE OF CALIFORNIA

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

NOTES:

1. No deduction made in quantities for thickness of pipe walls.
2. All reinforcing steel #4 bars. All vertical and horizontal tie bars 1'-6" maximum spacing.
3. Length of wall "W" may be varied to suit conditions encountered in the field, and straight line interpolation may be used to calculate quantities.
4. Quantities are for design purposes only.
5. Cable railing to be installed on top of headwall when shown on Project Plans. See Standard Plan B11-47 for cable railing details.

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PIPE CULVERT HEADWALLS STRAIGHT AND "L"

NO SCALE

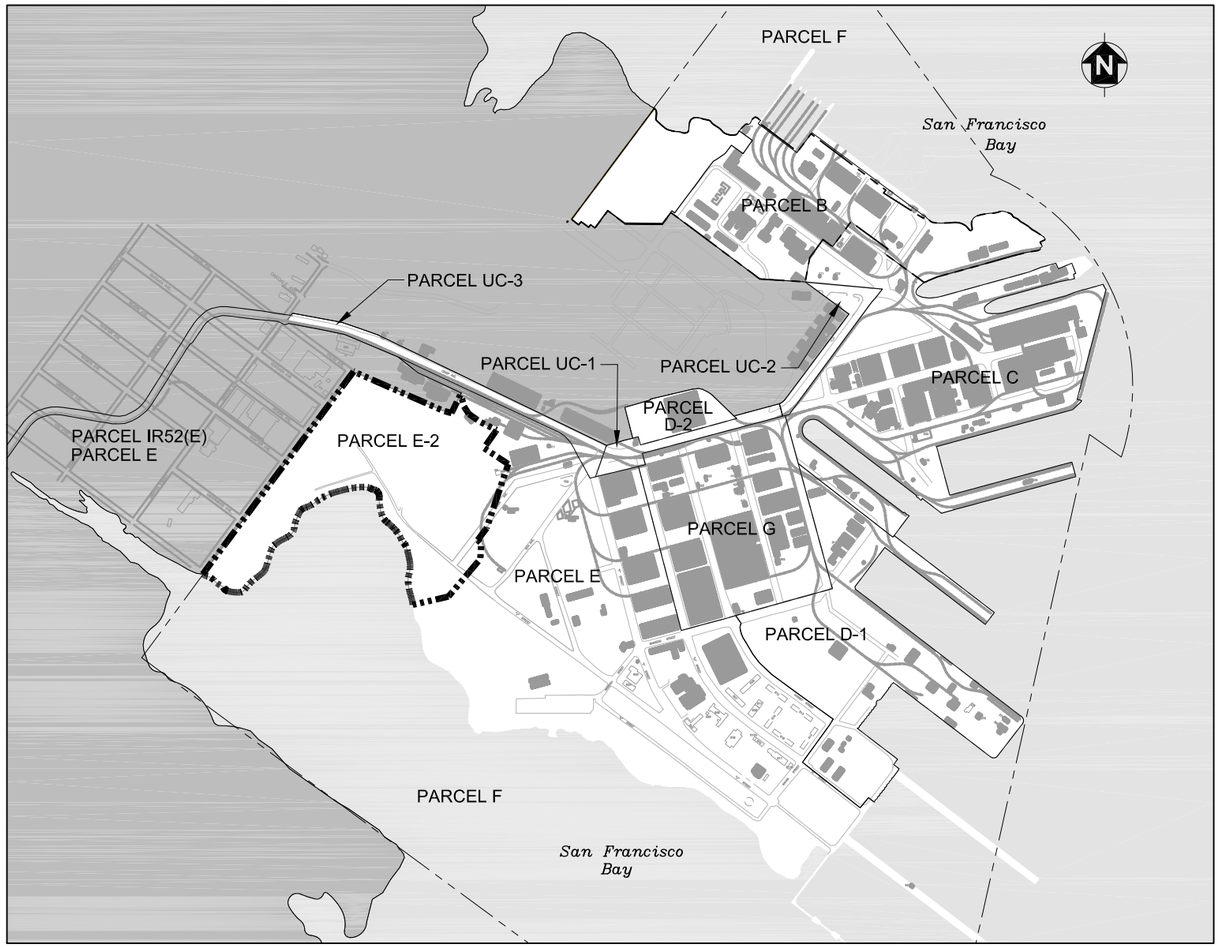
D89

2010 STANDARD PLAN D89

6-9-09

Appendix B. Design Drawings

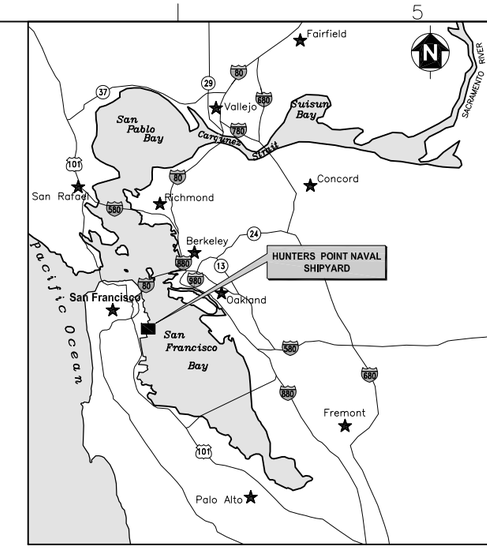
REMEDIAL DESIGN DRAWINGS
FOR PARCEL E-2
HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA



600' 0 600' 1200'

SCALE: 1" = 600'

SITE LOCATION MAP



SITE VICINITY MAP
NOT TO SCALE

INDEX OF DRAWINGS:

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	G1	SITE VICINITY MAP, SITE LOCATION MAP, AND INDEX OF DRAWINGS
2	G2	LEGEND, ABBREVIATIONS, AND GENERAL NOTES
3	C1	EXISTING CONDITIONS
4	C2	WORK AREA LIMITS, ENVIRONMENTAL PROTECTION, AND SITE SECURITY PLAN
5	C3	CLEARING, GRUBBING, DEMOLITION, AND SURFACE DEBRIS REMOVAL PLAN
6	C4	SOIL HOT SPOT REMOVAL PLAN
7	C5	GROUNDWATER CONTROL SYSTEM PLANS
8	C6	GROUNDWATER CONTROL SYSTEM PROFILES, CROSS SECTIONS, AND DETAILS
9	C7	GROUNDWATER CONTROL SYSTEM DETAILS 2
10	C8	SHORELINE REVETMENT FINISH GRADING PLAN
11	C9	SHORELINE REVETMENT CROSS SECTIONS
12	C10	SHORELINE REVETMENT DETAIL
13	C11	SUBGRADE EXCAVATION PLAN
14	C12	FOUNDATION GRADING PLAN
15	C13	FINISH GRADING PLAN
16	C14	LANDFILL COVER CROSS SECTIONS
17	C15	TIDAL AND FRESHWATER WETLANDS CROSS SECTIONS
18	C16	COVER TRANSITION DETAILS
19	C17	COVER TERMINATION DETAILS
20	C18	FINAL COVER DETAILS
21	C19	SURFACE WATER CONTROL PLAN
22	C20	SURFACE WATER CONTROL SECTIONS AND DETAIL
23	C21	FRENCH DRAIN OUTLET SECTIONS AND DETAIL
24	C22	FRESHWATER WETLAND OUTLET HEADWALL SECTIONS AND DETAIL
25	C23	FRESHWATER WETLAND OUTFALL SECTIONS AND DETAIL
26	C24	WETLANDS PLANTING PLAN AND DETAILS
27	C25	GROUNDWATER MONITORING WELL PLAN
28	C26	GROUNDWATER MONITORING WELL DETAILS
29	C27	PERIMETER FENCE, SIGN, AND SETTLEMENT MONUMENT DETAILS
30	C28	LFG COLLECTION SYSTEM PLAN
31	C29	LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 1
32	C30	LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 2
33	C31	LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 3
34	M1	LFG LEGEND AND TABLES
35	M2	LFG BLOWER FLARE FACILITY
36	M3	LFG BLOWER FLARE PFD
37	M4	LFG FLARE VIEWS
38	M5	LFG BLFL FLARE SKID DETAILS
39	M6	LFG BLFL FLARE FOUNDATION DETAILS
40	S1	SHORELINE REVETMENT WALL DETAIL AND NOTES
41	V1	SURVEY CONTROL POINTS AND COORDINATES 1

BASIS OF BEARINGS:

HORIZONTAL: NAD 1927 ZONE–III (HUNTERS POINT WEST 1 PID HT0613) USFT.

VERTICAL : NGVD 29.

SURVEY INFORMATION:

EXISTING CONDITIONS SURVEY PERFORMED BY ESP SURVEYING, INC. ON 10/29/2012–10/30/2012, 11/12/2012, 11/20/2012, 12/03/2012, 12/10/2012, 12/12/2012.

OFFSITE TOPOGRAPHY AS SHOWN, NOT TIED TO ONSITE TOPOGRAPHY.

DRAFT
NOT FOR CONSTRUCTION

SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, 1220 Pacifica Avenue, Suite 200, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974

SIZE D
IF SHEET IS LESS THAN 22" X 34" IT IS A REDUCED PRINT
SCALE REDUCED ACCORDINGLY

DRAWN BY:	SC
DESIGN BY:	DB
CHIEF ENG:	DB
PM/CM:	DB

ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

SITE VICINITY MAP, SITE LOCATION MAP, AND INDEX OF DRAWINGS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25–049
CONSTR. CONTR. NO.	N68711–05–C–6011
DRAWING NO.	G1
SHEET	1 OF 41 SHEETS

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\G1.dwg 6-07-13 02:39:38 PM

LEGEND (NEW):

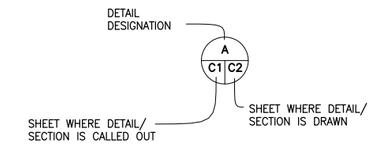
- PARCE E-2 LANDFILL AREA
- APPROXIMATE LIMIT OF PROPOSED GEOSYNTHETIC CAP
- SLURRY WALL
- LEACHATE EXTRACTION CONDUIT TRENCH
- GROUNDWATER DIVERSION DRAIN
- GUNDWALL
- PERIMETER DRAINAGE CHANNEL
- CATCHMENT SUB-AREA
- UNDERGROUND PIPE WITH OUTLET
- FENCE
- FRESHWATER WETLAND (NO GEOSYNTHETIC CAP)
- TIDAL WETLANDS
- GRADE IN AREA WHERE CUT
- HOTSPOT REMOVAL AREA
- RIPRAP SLOPE PROTECTION
- SERVICE ROAD
- FRESHWATER WETLANDS
- TIDAL WETLANDS
- 5, 4 — FINISH GRADE TOPOGRAPHIC CONTOUR LINE
- 1, 0 — SUBGRADE AND FOUNDATION TOPOGRAPHIC CONTOUR LINE
- CO — FRENCH DRAIN CLEAN OUT
- GROUNDWATER MONITORING WELL
- DRAIN INLET
- BUTTERFLY VALVE
- HP — HIGH POINT
- BURIED LFG HEADER, 6" HDPE
- BURRIED LFG LATERAL PIPE, 4" HDPE
- LFG EXTRACTION WELL
- LFG MONITORING PROBE
- CONDENSATE SUMP
- LEACHATE MONITORING/ EXTRACTION WELL
- PIEZOMETER
- SOIL BORING
- TO BE DEMOLISHED
- TO BE DEMOLISHED
- SURVEY MONUMENT

LEGEND (EXISTING):

- PARCEL E2 BOUNDARY
- PARCEL BOUNDARY OTHER
- APPROXIMATE LIMIT OF EXISITNG GEOSYNTHETIC CAP
- E — ELECTRICAL LINE
- SD — STORM DRAIN LINE
- W — WATER LINE
- 0 — PRE-CONSTRUCTION TOPOGRAPHIC CONTOUR LINE
- X — FENCE
- RAILROAD
- DI — DRAIN INLET
- GROUND WATER MONITORING WELL (TO REMAIN)
- SURVEY CONTROL POINT
- PP — POWER POLE AND ANCHOR
- LFG MONITORING PROBE
- LFG EXTRACTION WELL
- LFG TRENCH VENT

LIST OF ABBREVIATIONS

AB	AGGREGATE BASE	MIL	1 MIL = 1/1000 INCHES
ADS	ADVANCED DRAINAGE SYSTEM	MIN	MINIMUM
APPROX	APPROXIMATE	MAX	MAXIMUM
BFG	BELOW FINISH GRADE	MPT, MIPT	MALE PIPE THREAD
CL	CLASS	MSL	MEAN SEA LEVEL
℄	CENTER LINE	MW	MONITORING WELL
CLR	CLEAR	NL	NOT LISTED
CONC	CONCRETE	NO., #	NUMBER
DBL	DOUBLE	NTS	NOT TO SCALE
DI	DRAIN INLET	OD	OUTSIDE DIAMETER
ø	DIAMETER	OC	OF CENTER
EA	EACH	OU	OPERABLE UNIT
EL	ELEVATION	OZ/SQ. FT.	OUNCE PER SQUARE FOOT
EW	EACH WAY	PCF	POUNDS PER CUBIC FOOT
FAC	FACULTATIVE	PSI	POUNDS PER SQUARE INCH
FACU	FACULTATIVE UPLPAND	PVC	POLYVINYL CHLORIDE
FACW	FACULTATIVE WETLAND	r, R	RADIUS
FL	FLOW LINE	REQ	REQUIRED
FPT, FIPT	FEMALE PIPE THREAD	SF	SQUARE FEET
FT, '	FEET, FOOT	SCH	SCHEDULE
GALV	GALVANIZED	SDR	STANDARD DIMENSION RATIO
GCL	GEOSYNTHETIC CLAY LINER	SM	SETTLEMENT MONUMENT
GMP	GAS MONITORING PROBE	SS	STAINLESS STEEL
HDPE	HIGH-DENSITY POLYETHYLENE	STL	STEEL
ID	INNER DIAMETER	SQ. YD	SQUARE YARD
IN, "	INCH	T.O.C.	TOP OF CASING
INV	INVERT ELEVATION	TYP	TYPICAL
LFG	LANDFILL GAS	W/	WITH
L	LONG	@	AT
LF	LINEAR FEET	DR17	PRESSURE CLASS FOR STANDARD DIMENSION RATION'S (DR) FOR HDPE PIPES



NOTE: SECTION DETAILS ARE DESIGNATED BY A LETTER AND PLAN DETAILS ARE DESIGNATED BY A NUMBER.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

LEGEND, ABBREVIATIONS, AND GENERAL NOTES

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	G2
SHEET 2 OF 41 SHEETS	

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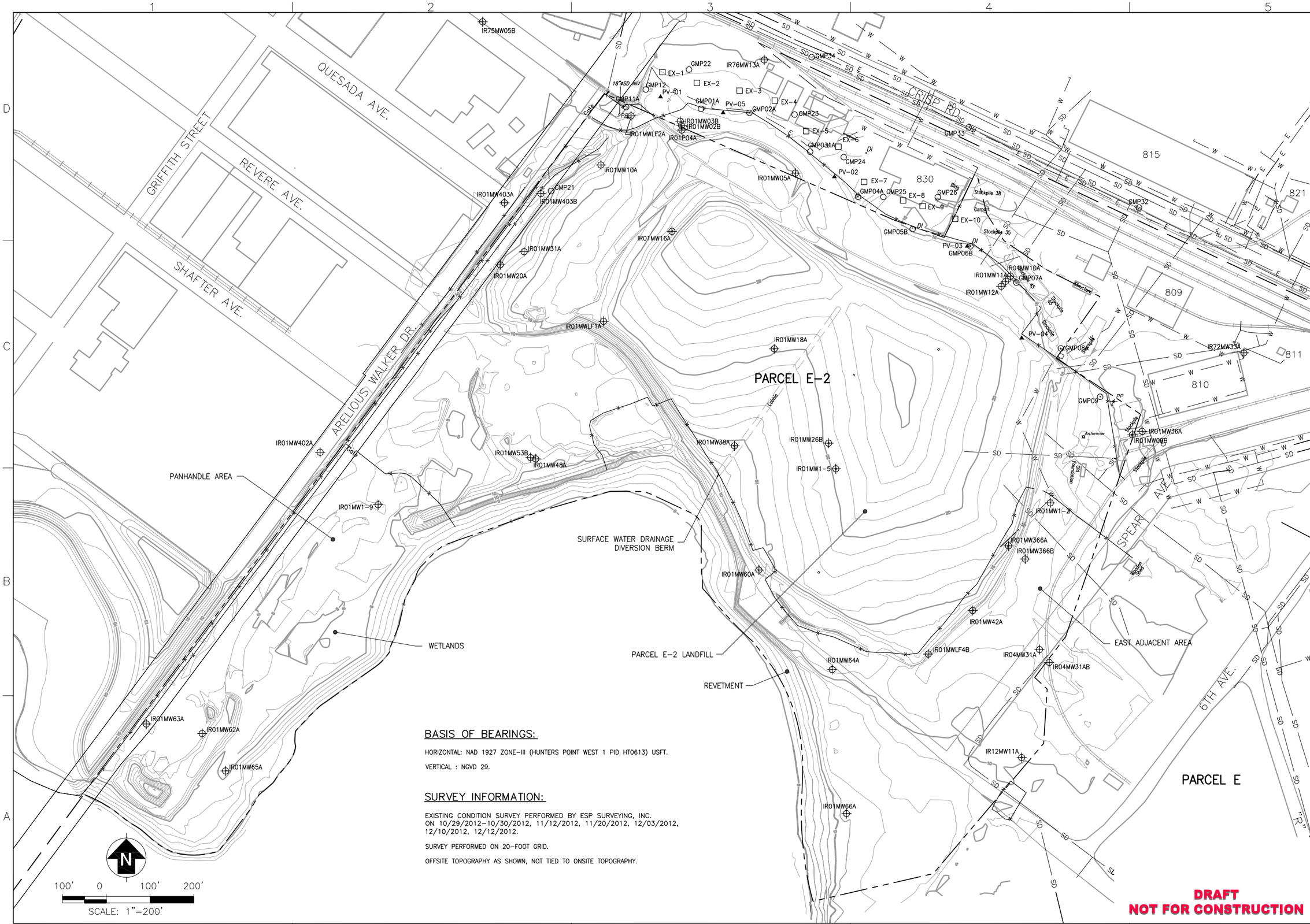

BASIS OF BEARINGS:

HORIZONTAL: NAD 1927 ZONE-III (HUNTERS POINT WEST 1 PID HT0613) USFT.

VERTICAL : NGVD 29.

SURVEY INFORMATION:

EXISTING CONDITION SURVEY PERFORMED BY ESP SURVEYING, INC. ON 10/29/2012-10/30/2012, 11/12/2012, 11/20/2012, 12/03/2012, 12/10/2012, 12/12/2012.

SURVEY PERFORMED ON 20-FOOT GRID.

OFFSITE TOPOGRAPHY AS SHOWN, NOT TIED TO ONSITE TOPOGRAPHY.

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SYM	DESCRIPTION	DATE	APPR.

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

EXISTING CONDITIONS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C1
SHEET 3 OF 41 SHEETS	

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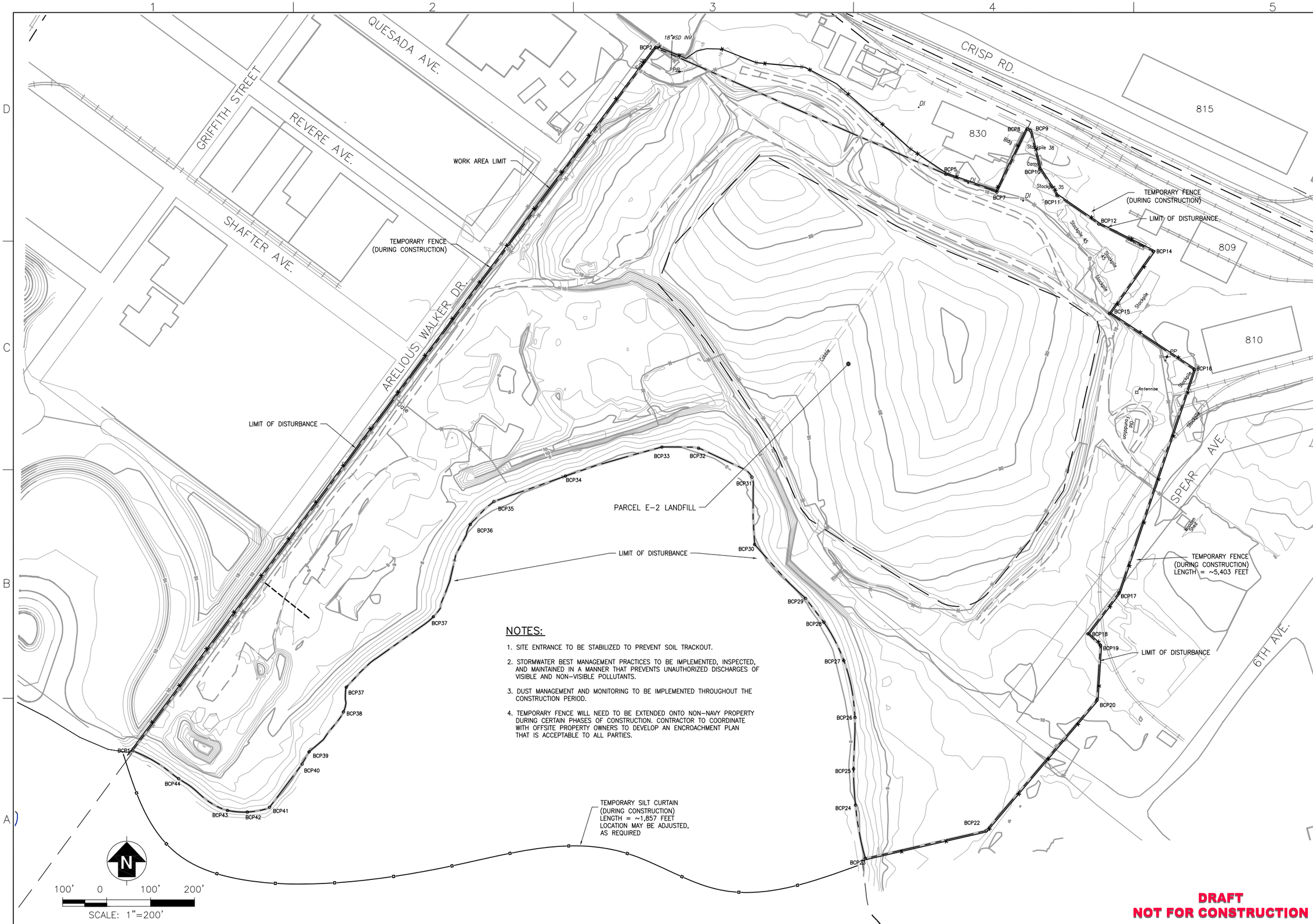

NOTES:

1. SITE ENTRANCE TO BE STABILIZED TO PREVENT SOIL TRACKOUT.
2. STORMWATER BEST MANAGEMENT PRACTICES TO BE IMPLEMENTED, INSPECTED, AND MAINTAINED IN A MANNER THAT PREVENTS UNAUTHORIZED DISCHARGES OF VISIBLE AND NON-VISIBLE POLLUTANTS.
3. DUST MANAGEMENT AND MONITORING TO BE IMPLEMENTED THROUGHOUT THE CONSTRUCTION PERIOD.
4. TEMPORARY FENCE WILL NEED TO BE EXTENDED ONTO NON-NAVY PROPERTY DURING CERTAIN PHASES OF CONSTRUCTION. CONTRACTOR TO COORDINATE WITH OFFSITE PROPERTY OWNERS TO DEVELOP AN ENCROACHMENT PLAN THAT IS ACCEPTABLE TO ALL PARTIES.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

WORK AREA LIMITS, ENVIRONMENTAL PROTECTION, AND SITE SECURITY PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C2
SHEET 4 OF 41 SHEETS	

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NOTES:

1. OBTAIN CONTRACTING OFFICER'S APPROVAL IF PERMANENT SURFACE FEATURES MUST BE REMOVED FROM SITE FOR CONSTRUCTABILITY.

2. REMOVE ALL EXISTING UTILITY FEATURES FROM WITHIN SITE BOUNDARY AS NECESSARY. PROTECT EXISTING FEATURES OUTSIDE THE SITE BOUNDARY. ACTIVE POWER POLES, STORM DRAINS, AND SANITARY SEWERS UTILITIES WILL BE PROTECTED OR REROUTED IN ACCORDANCE WITH THE APPLICABLE UTILITY COMMISSION.

3. REMOVE EXISTING PERIMETER FENCE WHERE FENCE IS OBSTRUCTIVE TO THE WORK AREA. REPLACE REMOVED FENCE WITH TEMPORARY FENCE; OFFSET, AS NEEDED, TO ALLOW WORK ALONG THE BOUNDARY.

4. USE EXISTING FENCE MATERIALS, AS APPROPRIATE, IN CONSTRUCTION OF THE TEMPORARY FENCE.

5. REMOVE ALL FENCING, DEBRIS, KEEL BLOCKS, ASPHALT, RAILROAD TRACKS, FOUNDATIONS, AND OTHER OBJECTS FROM WITHIN THE WORK AREA. REMOVE SIGNS AND OTHER MATERIALS FROM THE SHORELINE WHERE THEY OBSTRUCT THE WORK AREA. CLEAR AND GRUB EXISTING VEGETATION.

6. BOULDERS REMOVED FROM THE SHORELINE DURING DEBRIS CLEARING WILL BE SCREENED FOR RADIOLOGICAL CONTAMINATION. CLEARED BOULDERS WILL BE STOCKPILED FOR USE AS ADDITIONAL ARMORING.

7. EXISTING STOCKPILED SOIL WILL BE RADIOLOGICALY SCANNED AND CLEARED, WITH CONCURRENCE FROM RASO. ALL RADIOLOGICALY CLEARED DEBRIS MAY BE CONSOLIDATED WITHIN THE LANDFILL. ANY DEBRIS THAT IS NOT CLEARED MUST BE DISPOSED OF IN LOW LEVEL RADIOLOGICAL WASTE (LLRW) BINS AND TAKEN OFF SITE AND DISPOSED OF AT AN APPROVED FACILITY.

8. GROUNDWATER MONITORING AND LFG WELLS DESIGNATED FOR REMOVAL SHALL BE DECOMMISSIONED USING APPROVED WELL ABANDONMENT PROCEDURES.

9. GROUNDWATER MONITORING WELLS AND LFG WELLS TO BE PRESERVED WILL BE EXTENDED, AS NEEDED, OR REPLACED TO MEET THE FINAL SURFACE GRADE WITH EQUIVALENT MATERIALS. CONCRETE SURFACE COMPLETIONS CAN REMAIN IN PLACE IF NOT OBSTRUCTIVE TO THE EXTENSION. WELLHEAD VAULTS AND SURFACE COMPLETIONS WILL BE REPLACED IN ACCORDANCE WITH DESIGN DRAWING C26.

10. THE UCSF SOIL VAPOR EXTRACTION WELLS (EX1 THROUGH EX10) SHALL BE DECOMMISSIONED USING APPROVED WELL ABANDONMENT PROCEDURES.

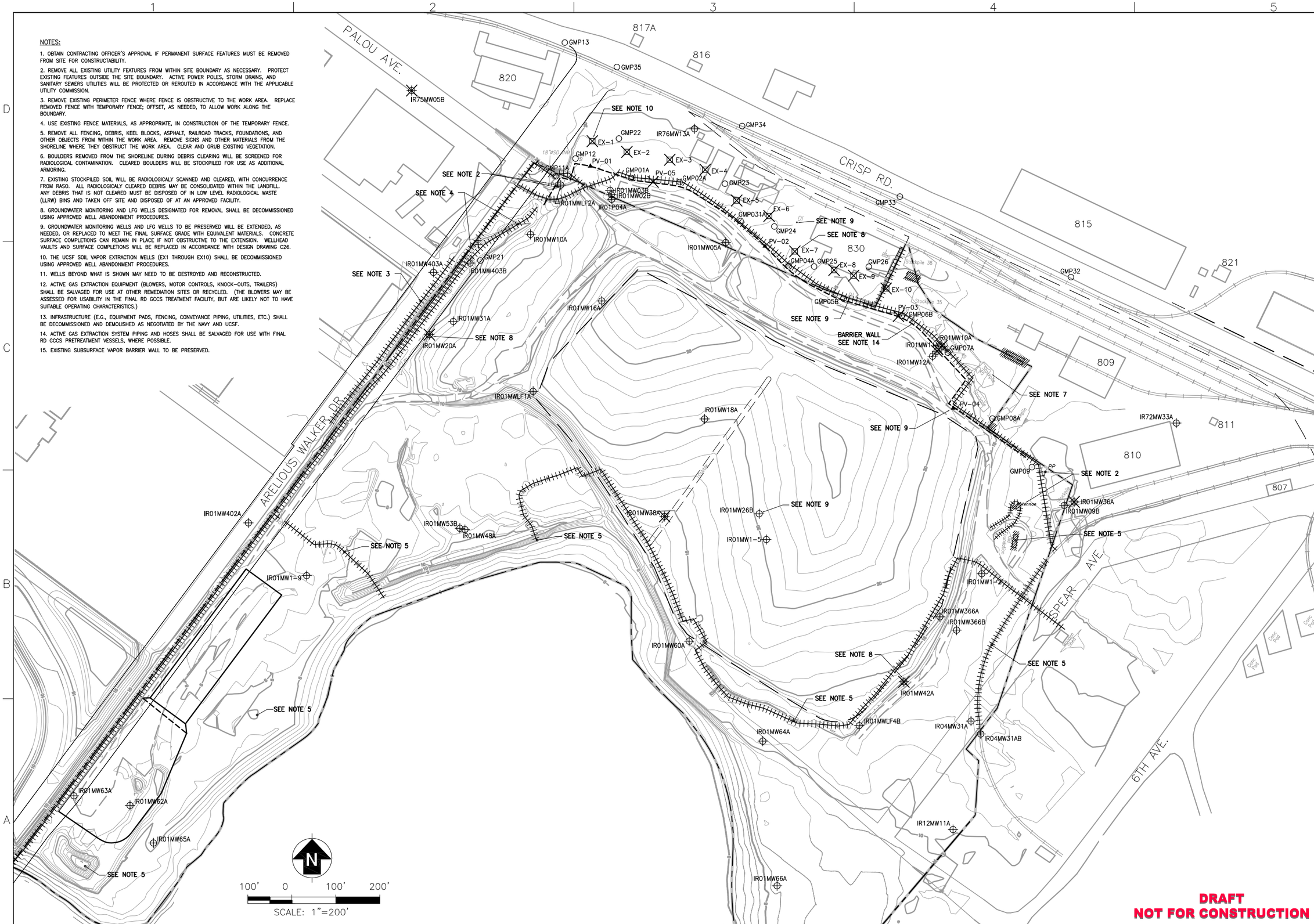
11. WELLS BEYOND WHAT IS SHOWN MAY NEED TO BE DESTROYED AND RECONSTRUCTED.

12. ACTIVE GAS EXTRACTION EQUIPMENT (BLOWERS, MOTOR CONTROLS, KNOCK-OUTS, TRAILERS) SHALL BE SALVAGED FOR USE AT OTHER REMEDIATION SITES OR RECYCLED. (THE BLOWERS MAY BE ASSESSED FOR USABILITY IN THE FINAL RD GCCS TREATMENT FACILITY, BUT ARE LIKELY NOT TO HAVE SUITABLE OPERATING CHARACTERISTICS.)

13. INFRASTRUCTURE (E.G., EQUIPMENT PADS, FENCING, CONVEYANCE PIPING, UTILITIES, ETC.) SHALL BE DECOMMISSIONED AND DEMOLISHED AS NEGOTIATED BY THE NAVY AND UCSF.

14. ACTIVE GAS EXTRACTION SYSTEM PIPING AND HOSES SHALL BE SALVAGED FOR USE WITH FINAL RD GCCS PRETREATMENT VESSELS, WHERE POSSIBLE.

15. EXISTING SUBSURFACE VAPOR BARRIER WALL TO BE PRESERVED.



SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, 33000 Nixie Way, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

CLEARING, GRUBBING, DEMOLITION, AND SURFACE DEBRIS REMOVAL PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C3
SHEET 5 OF 41 SHEETS	

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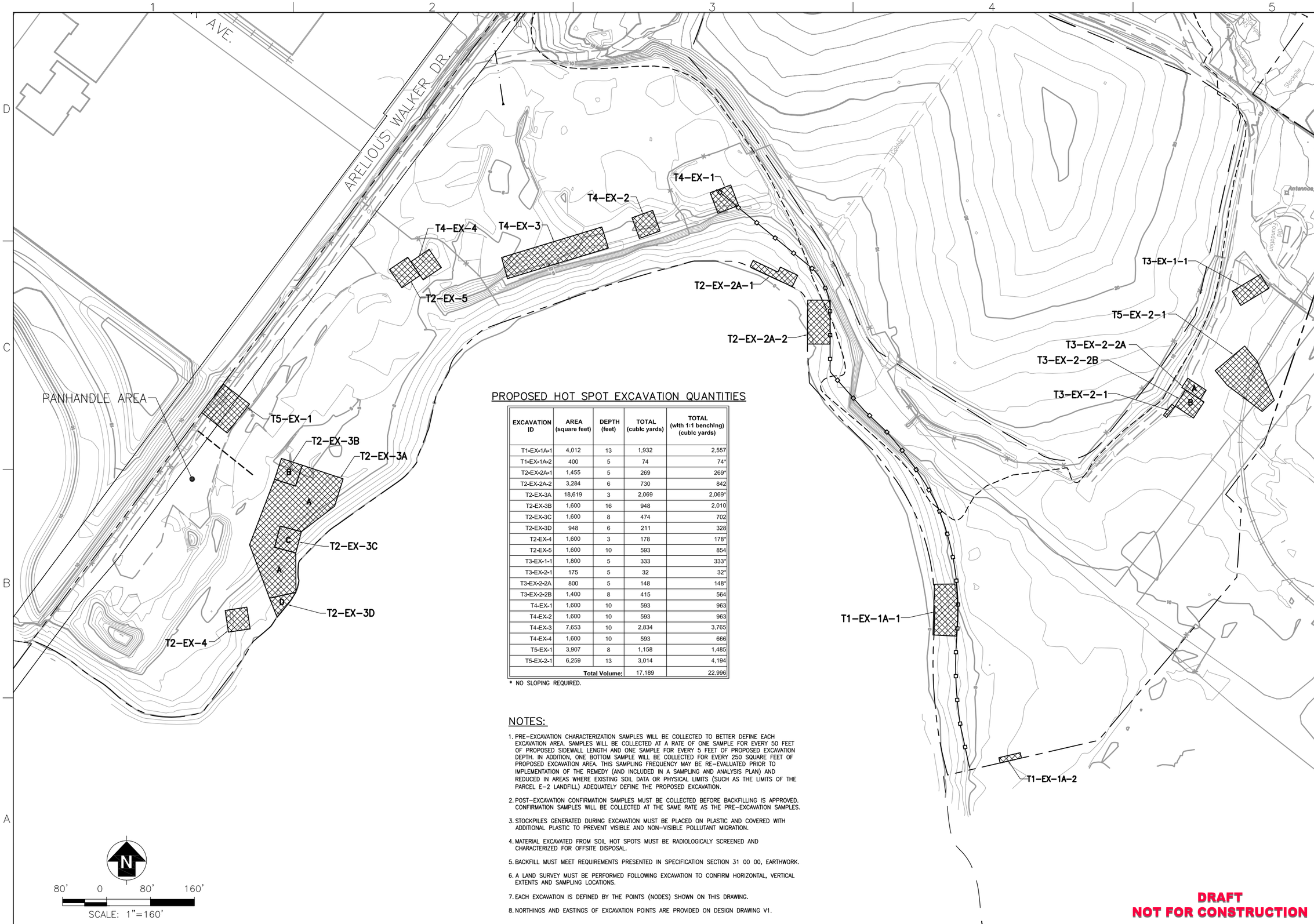

PROPOSED HOT SPOT EXCAVATION QUANTITIES

EXCAVATION ID	AREA (square feet)	DEPTH (feet)	TOTAL (cubic yards)	TOTAL (with 1:1 benching) (cubic yards)
T1-EX-1A-1	4,012	13	1,932	2,557
T1-EX-1A-2	400	5	74	74*
T2-EX-2A-1	1,455	5	269	269*
T2-EX-2A-2	3,284	6	730	842
T2-EX-3A	18,619	3	2,069	2,069*
T2-EX-3B	1,600	16	948	2,010
T2-EX-3C	1,600	8	474	702
T2-EX-3D	948	6	211	328
T2-EX-4	1,600	3	178	178*
T2-EX-5	1,600	10	593	854
T3-EX-1-1	1,800	5	333	333*
T3-EX-2-1	175	5	32	32*
T3-EX-2-2A	800	5	148	148*
T3-EX-2-2B	1,400	8	415	564
T4-EX-1	1,600	10	593	963
T4-EX-2	1,600	10	593	963
T4-EX-3	7,653	10	2,834	3,765
T4-EX-4	1,600	10	593	666
T5-EX-1	3,907	8	1,158	1,485
T5-EX-2-1	6,259	13	3,014	4,194
		Total Volume:	17,189	22,996

* NO SLOPING REQUIRED.

NOTES:

1. PRE-EXCAVATION CHARACTERIZATION SAMPLES WILL BE COLLECTED TO BETTER DEFINE EACH EXCAVATION AREA. SAMPLES WILL BE COLLECTED AT A RATE OF ONE SAMPLE FOR EVERY 50 FEET OF PROPOSED SIDEWALL LENGTH AND ONE SAMPLE FOR EVERY 5 FEET OF PROPOSED EXCAVATION DEPTH. IN ADDITION, ONE BOTTOM SAMPLE WILL BE COLLECTED FOR EVERY 250 SQUARE FEET OF PROPOSED EXCAVATION AREA. THIS SAMPLING FREQUENCY MAY BE RE-EVALUATED PRIOR TO IMPLEMENTATION OF THE REMEDY (AND INCLUDED IN A SAMPLING AND ANALYSIS PLAN) AND REDUCED IN AREAS WHERE EXISTING SOIL DATA OR PHYSICAL LIMITS (SUCH AS THE LIMITS OF THE PARCEL E-2 LANDFILL) ADEQUATELY DEFINE THE PROPOSED EXCAVATION.
2. POST-EXCAVATION CONFIRMATION SAMPLES MUST BE COLLECTED BEFORE BACKFILLING IS APPROVED. CONFIRMATION SAMPLES WILL BE COLLECTED AT THE SAME RATE AS THE PRE-EXCAVATION SAMPLES.
3. STOCKPILES GENERATED DURING EXCAVATION MUST BE PLACED ON PLASTIC AND COVERED WITH ADDITIONAL PLASTIC TO PREVENT VISIBLE AND NON-VISIBLE POLLUTANT MIGRATION.
4. MATERIAL EXCAVATED FROM SOIL HOT SPOTS MUST BE RADIOLOGICALY SCREENED AND CHARACTERIZED FOR OFFSITE DISPOSAL.
5. BACKFILL MUST MEET REQUIREMENTS PRESENTED IN SPECIFICATION SECTION 31 00 00, EARTHWORK.
6. A LAND SURVEY MUST BE PERFORMED FOLLOWING EXCAVATION TO CONFIRM HORIZONTAL, VERTICAL EXTENTS AND SAMPLING LOCATIONS.
7. EACH EXCAVATION IS DEFINED BY THE POINTS (NODES) SHOWN ON THIS DRAWING.
8. NORTHINGS AND EASTINGS OF EXCAVATION POINTS ARE PROVIDED ON DESIGN DRAWING V1.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, 1220 Pacific Highway, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

SIZE D
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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

SOIL HOT SPOT REMOVAL PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C4
SHEET 6 OF 41 SHEETS	

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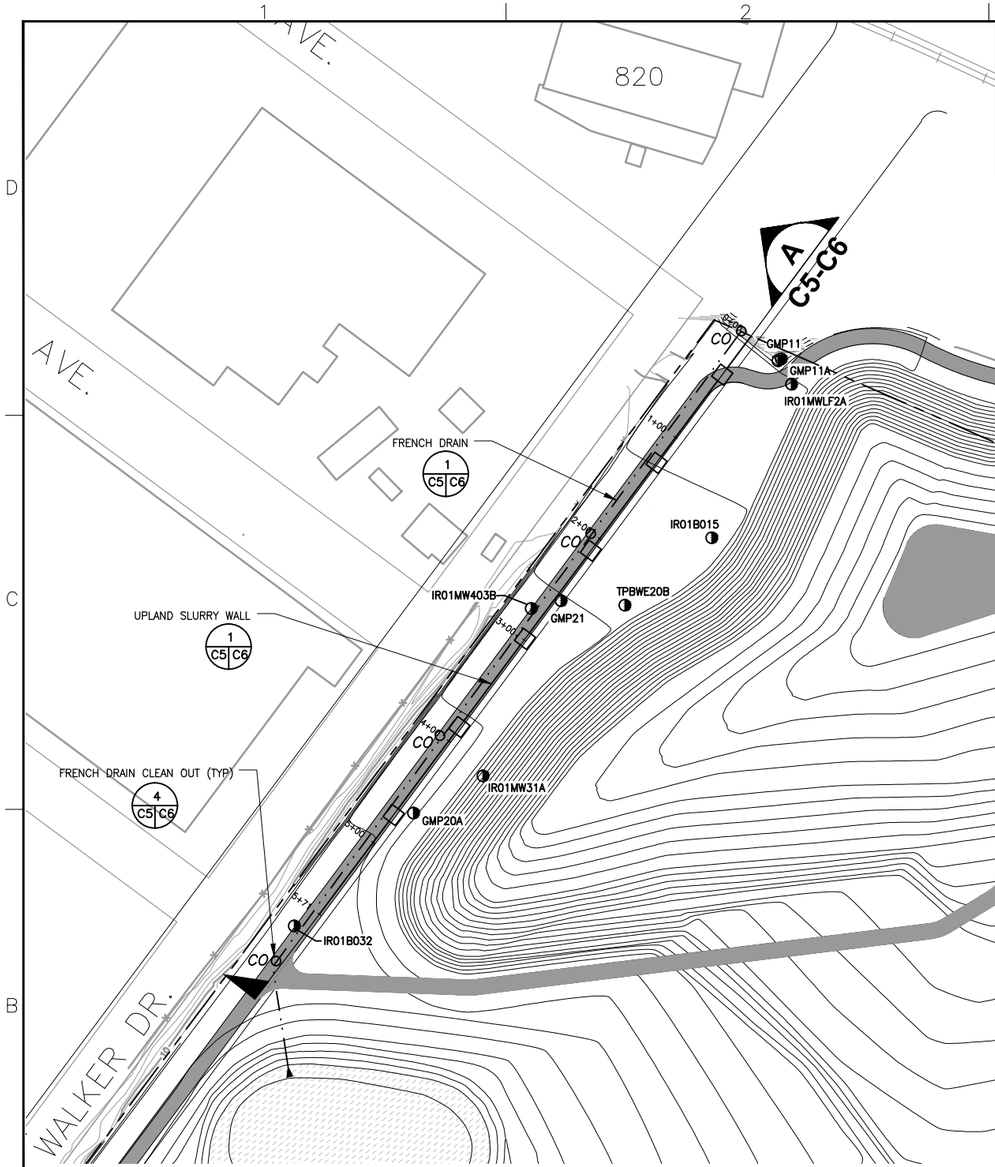

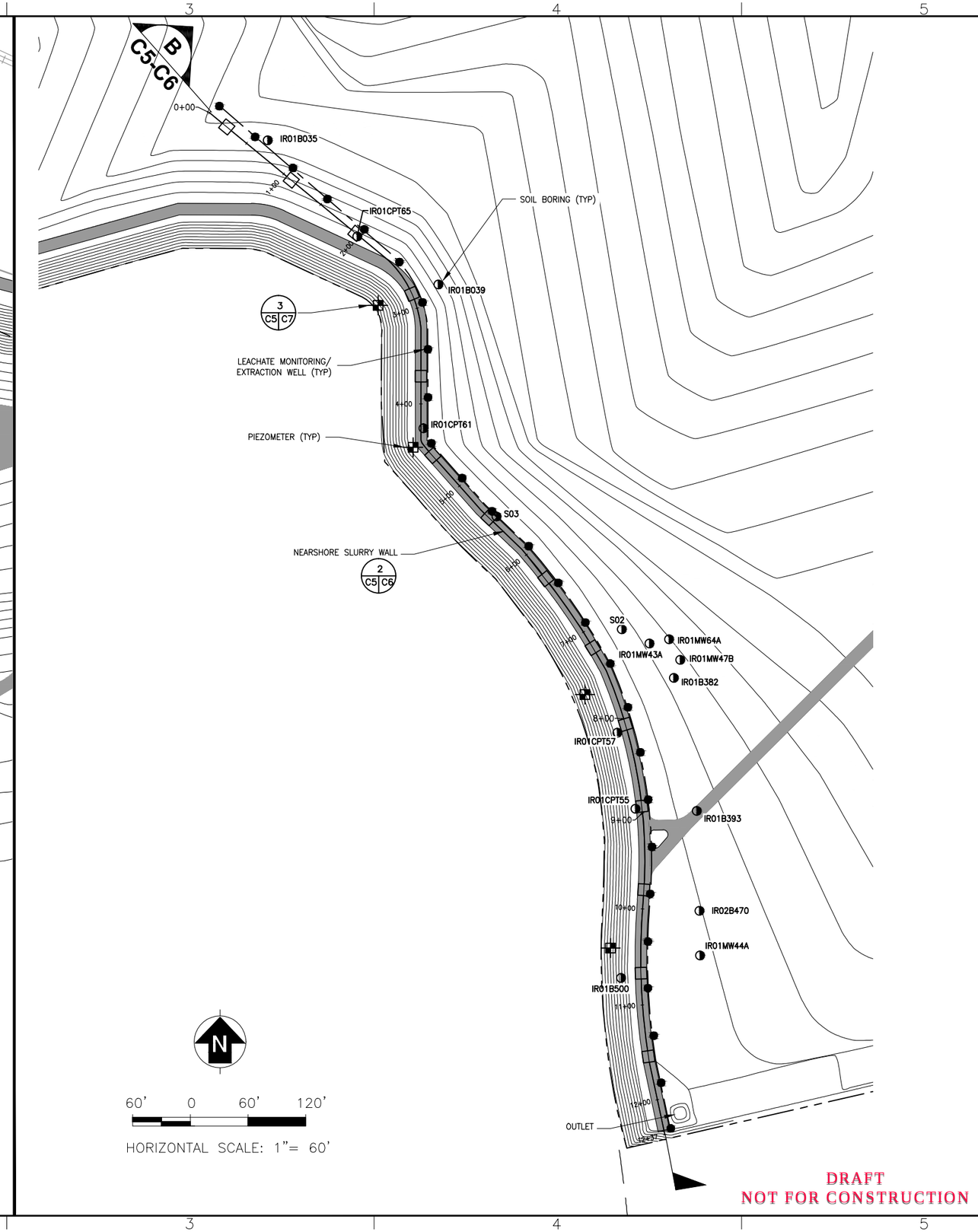

N

60' 0 60' 120'

HORIZONTAL SCALE: 1"= 60'

N

60' 0 60' 120'

HORIZONTAL SCALE: 1"= 60'

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Management Office West, Program Management Office West, San Diego, CA

PREPARED BY: EngineeringRemediation Resources Group, Inc., 115 Sansome Street, Suite 300, San Francisco, California 94104, (415) 399-9974, ERRG

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

GROUNDWATER CONTROL SYSTEM PLANS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C5

SHEET 7 OF 41 SHEETS

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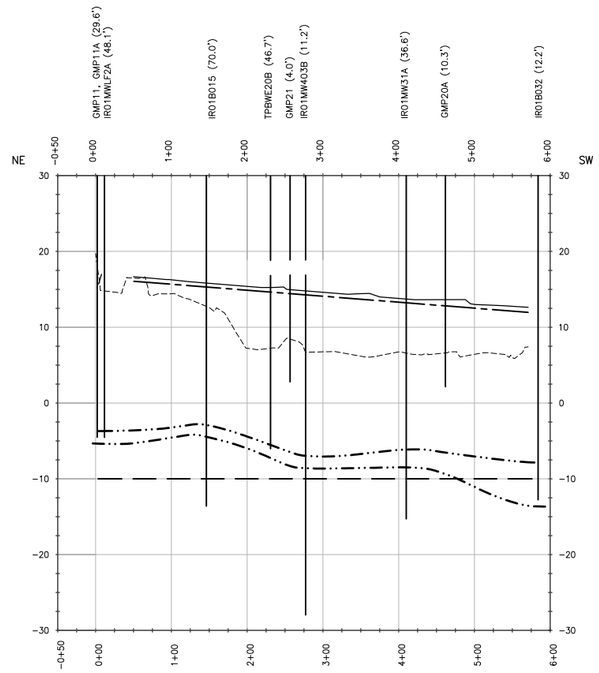
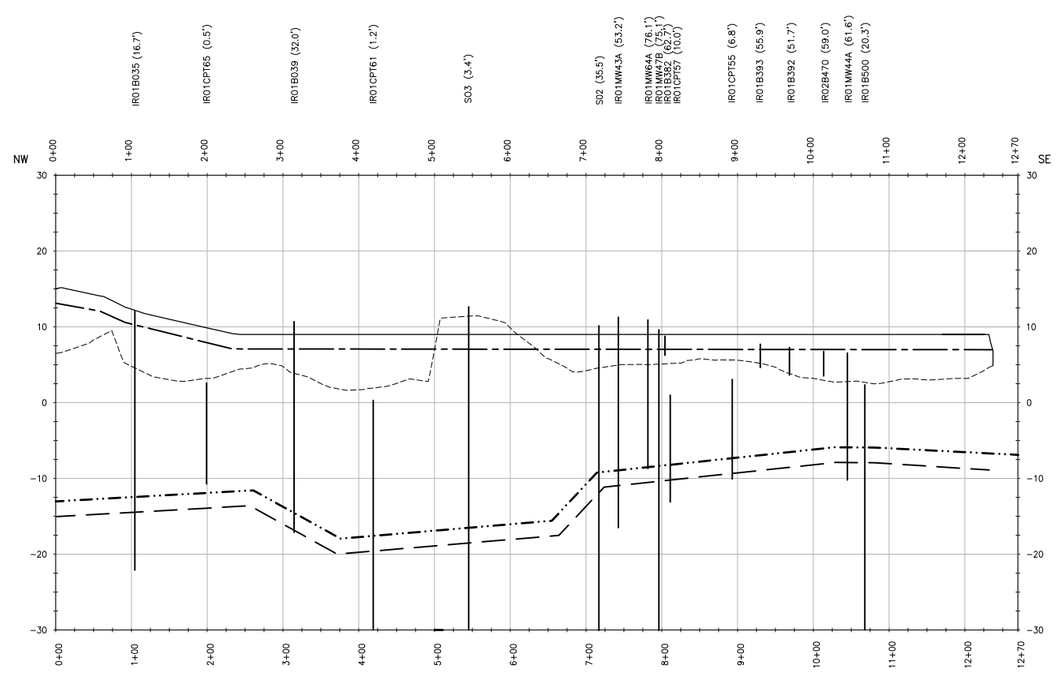


A | C5 C6 SECTION A–A



B | C5 C6 SECTION B–B

LEGEND:

- FINISH GRADE
- EXISTING GRADE
- APPROXIMATE TOP OF SLURRY WALL
- APPROXIMATE BOTTOM OF SLURRY WALL
- APPROXIMATE DEPTH TO BAY MUD

NOTES:

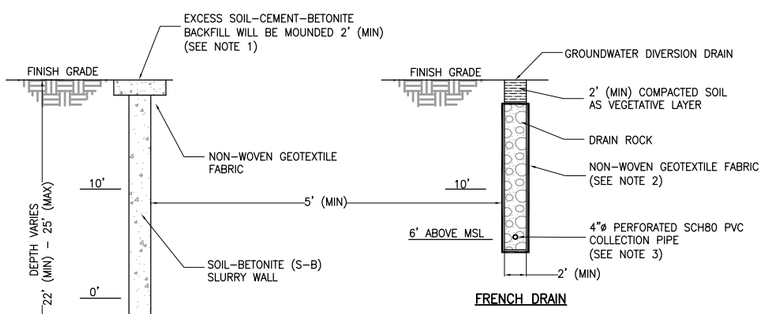
1. BORING PROJECTION DISTANCES (IN PARENTHESIS) ARE PERPENDICULAR TO CROSS SECTION ALIGNMENTS (SEE DESIGN DRAWING C–5).
2. BAY MUD FOR SECTION A–A IS NOT CONTINUOUS AND NOT CONSIDERED AN AQUATARD.
3. BORING LOG OFFSETS FROM SECTION ALIGNMENTS ARE SHOWN IN PARENTHESES NEXT TO THE BORING LOG NAME.
4. TRANSITION IN THE SLURRY WALL GRADE IS APPROXIMATE. ACTUAL CHANGE IN SLURRY WALL GRADE WILL BE DETERMINED IN THE CONTRACTOR'S SLURRY WALL IMPLEMENTATION PLAN. (SEE PROJECT SPECIFICATION 02 35 27)

100' 0 100' 200'

HORIZONTAL SCALE: 1"=200'

10' 0 10' 20'

VERTICAL SCALE: 1"=20'



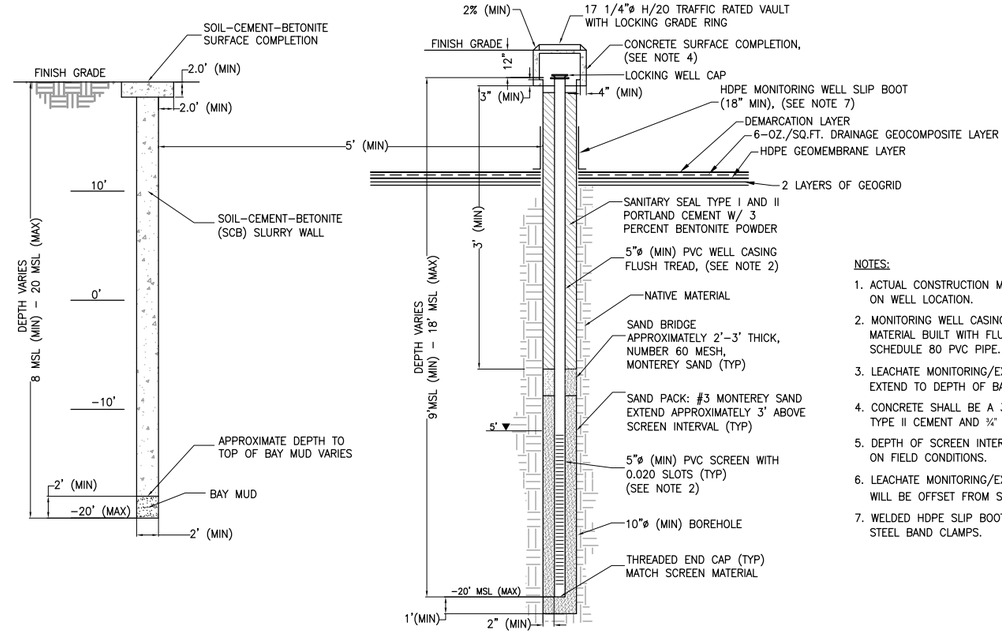
FRENCH DRAIN

NOTES:

1. MOUND CLEAN SOIL OVER SLURRY WALL FOR A MINIMUM 2 WEEKS BEFORE CONSTRUCTION SURFACE COMPLETION. SLURRY WALL COMPLETION SHALL BE A MINIMUM 30 PSI MIX. SEE PROJECT SPECIFICATIONS 02 35 27 – TREATMENT OF TOP OF SLURRY TRENCH.
2. LINE ALL SIDES, TOP, AND BOTTOM OF DRAIN ROCK IN THE FRENCH DRAIN TRENCH WITH NON–WOVEN GEOTEXTILE FABRIC. GEOTEXTILE FABRIC WILL OVERLAP AROUND DRAIN ROCK A MINIMUM OF 12" (MIN).
3. WRAP 4"ϕ PERFORATED SCH 80 PVC PIPE WITH NON–WOVEN SECURE GEOTEXTILE FABRIC. GEOTEXTILE FABRIC AROUND PIPE EVERY 12" (MIN).

1 | – – UPLAND SLURRY WALL DETAIL A–A

NOT TO SCALE



LEACHATE MONITORING / EXTRACTION WELL DETAIL

NOTES:

1. ACTUAL CONSTRUCTION MAY VARY DEPENDING ON WELL LOCATION.
2. MONITORING WELL CASING AND SCREEN MATERIAL BUILT WITH FLUSH THREADED SCHEDULE 80 PVC PIPE.
3. LEACHATE MONITORING/EXTRACTION WELL WILL EXTEND TO DEPTH OF BAY MUD.
4. CONCRETE SHALL BE A 3,000 PSI MIX USING TYPE II CEMENT AND ¾" MAX AGGREGATE.
5. DEPTH OF SCREEN INTERVAL WILL BE BASED ON FIELD CONDITIONS.
6. LEACHATE MONITORING/EXTRACTION WELLS WILL BE OFFSET FROM SLURRY WALL 5' MIN
7. WELDED HDPE SLIP BOOT WITH 2 STAINLESS STEEL BAND CLAMPS.

2 | – – NEARSHORE SLURRY WALL DETAIL B–B

NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, 1220 Pacifica Drive, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974

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DESIGN BY:	DTB
CHIEF ENG:	DB
PM/CM:	DB

ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

GROUNDWATER CONTROL SYSTEM PROFILES, CROSS SECTIONS, AND DETAILS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25–049
CONSTR. CONTR. NO.	N68711–05–C–6011
DRAWING NO.	C6
SHEET 8 OF 41 SHEETS	

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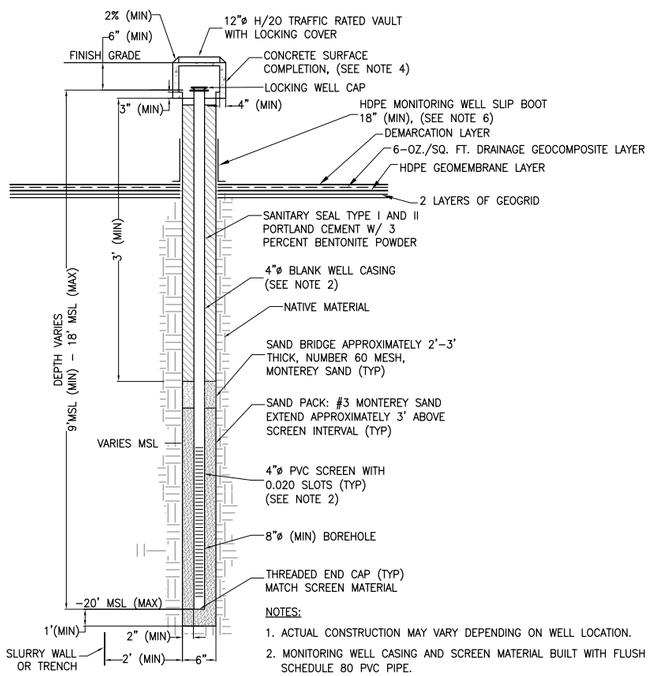
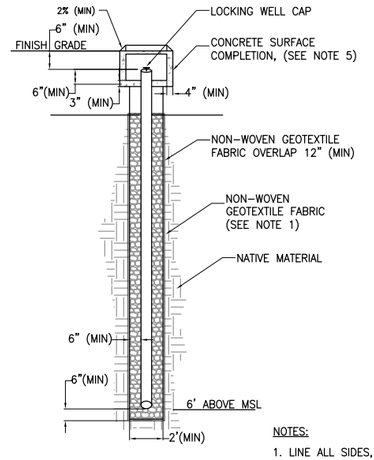


NOTES:

1. ACTUAL CONSTRUCTION MAY VARY DEPENDING ON WELL LOCATION.
2. MONITORING WELL CASING AND SCREEN MATERIAL BUILT WITH FLUSH THREADED SCHEDULE 80 PVC PIPE.
3. PIEZOMETERS WILL EXTEND TO DEPTH OF BAY MUD.
4. CONCRETE SHALL BE A 3,000 PSI MIX USING TYPE II CEMENT AND ¾" (MAX) AGGREGATE.
5. DEPTH OF SCREEN INTERVAL WILL BE BASED ON FIELD CONDITIONS.
6. WELDED HDPE SLIP BOOT WITH 2 STAINLESS STEEL BAND CLAMPS.

3 C5 C7 PIEZOMETER DETAIL

NOT TO SCALE

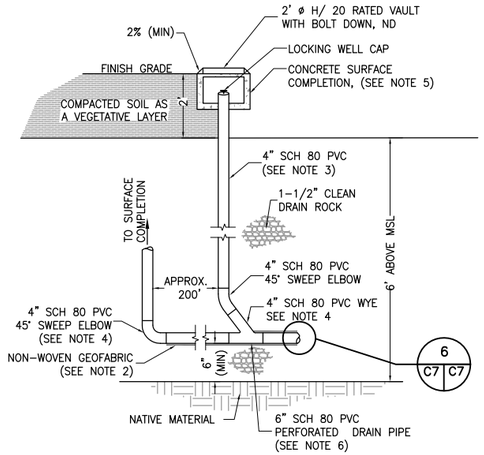


NOTES:

1. LINE ALL SIDES, TOPS, AND BOTTOM OF DRAIN ROCK IN FRENCH DRAIN TRENCH WITH NON-WOVEN GEOTEXTILE FABRIC. GEOTEXTILE FABRIC WILL OVERLAP AROUND THE DRAIN ROCK A MINIMUM OF 12".
2. WRAP 4"ϕ PERFORATED SCH 80 PVC DRAIN PIPE WITH NON-WOVEN GEOTEXTILE FABRIC. GEOTEXTILE FABRIC WILL OVERLAP AROUND THE PIPES 12" (MIN).
3. ALL PIPES AND FITTING WILL BE SCH80 PVC, UNLESS OTHERWISE SPECIFIED
4. FRENCH DRAIN CLEAN-OUTS WILL BE INSTALLED APPROXIMATE EVERY 200' FOR THE 4"ϕ SCH 80 PVC SWEEP ELBOWS, AND 4"ϕ SCH 80 PVC WYES.
5. CONCRETE SHALL BE A 3,000 PSI MIX USING TYPE II CEMENT AND ¾" (MAX) AGGREGATE.
6. PERFORATED DRAIN PIPE WILL BE PLACED HORIZONTALLY AT THE BOTTOM OF APPROXIMATELY 571 FEET OF THE WESTERN BOUNDARY SLURRY WALL. PERFORATED DRAIN PIPE WILL BE MANUFACTURED ACCORDING TO THE PERFORATED PIPE DETAIL (SEE PERFORATED PIPE DETAIL).

4 C5 C7 FRENCH DRAIN AND CLEANOUT DETAIL

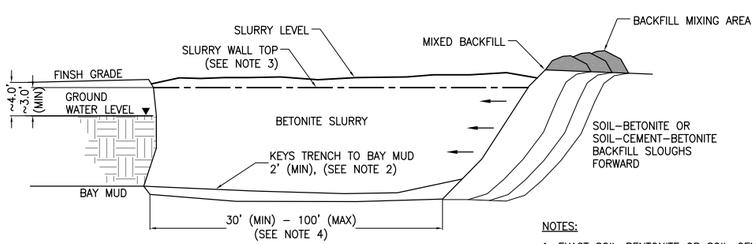
NOT TO SCALE



ESTIMATE OF CUT QUANTITIES	LENGTH (feet)	AREA (square feet)	WIDTH (feet)	VOLUME (cubic yards)
WESTERN BOUNDARY SLURRY WALL	571	14,015	2	1,350
WESTERN BOUNDARY GROUNDWATER DIVERSION (FRENCH DRAIN)	571	8,422	2	811
NEAR SHORE SLURRY WALL ALIGNMENT	1,237	28,223	2	2,718
ESTIMATE OF BUILD QUANTITIES	**LENGTH/ ITEM (feet units)**	**AREA (square feet)**	**WIDTH (feet)**	**VOLUME (cubic yards)**
SLURRY WALL SURFACE COMPLETIONS	571 + 1237	--	--	1,071
IMPORT CLEAN FILL (VEGETATIVE LAYER)	1,797	2,198	2	179
CLEAN DRAIN ROCK	680	1,360	2	347
BEDDING SAND	1,117	1,452	2	108
NON-WOVEN GEOTEXTILE	1,171	11,098		
6" Ø SCH 80 PVC WELL CASING	242			
4" Ø SCH 80 PVC WELL CASING	222.5			
4" Ø SCH 80 PERFORATED PVC	571			
6" Ø SCH 80 PVC	1,213			
4" Ø SCH 80 PVC	139			
2" Ø ELECTRCIAL CONDUIT	2,426			
6" Ø SCH 80 PVC SLIP COUPLINGS	60			
4" Ø SCH 80 PVC SLIP COUPLINGS	35			
4" Ø SCH 80 PVC WYES	3			
4" Ø SCH 80 PVC, 45 DEGREE SWEEP ELBOWS	4			
4" Ø SCH 80 PVC, 90 DEGREE SWEEP ELBOWS	1			
2' Ø TRAFFIC RATE MONITORING WELL VAULT OR, 2'X3'X2' DEEP CONCRETE VAULT AND LID5	24			
	24			
1' Ø TRAFFIC RATED MONITORING WELL VAULTS	20			
6" Ø LOCKING WELL CAPS	24			
4" Ø LOCKING WELL CAPS	20			

NOTES:

1. ASSUMED ADDITIONAL VOLUME FOR EXCAVATED NATIVE MATERIAL IS 30%.
2. SLURRY, SOIL, AND CEMENT QUANTITIES USED IN CONSTRUCTION OF THE SLURRY WALLS TO BE DETERMINED DURING COMPLETION OF BACKFILL MIX DESIGN, AND COMPATIBILITY TESTING.
3. SURFACE COMPLETIONS FOR SLURRY WALL ALIGNMENTS SHALL BE THE SAME AS THE BACKFILL DESIGN SELECTED FOR THE NEARSHORE SLURRY WALL ALIGNMENT (ASSUMING A STRENGTH MIN OF 30 PSI).
4. ASSUMED COMPACTION VOLUME FOR CLEAN IMPORT SOIL IS 10%.

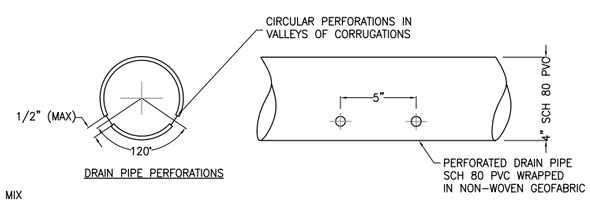


NOTES:

1. EXACT SOIL-BENTONITE OR SOIL-CEMENT-BENTONITE MIX DESIGN AND COMPATIBILITY TEST WILL BE PRESENTED BY THE CONTRACTOR ALONG WITH THE SLURRY WALL PRE-CONSTRUCTION TESTING PLAN (SEE CONSTRUCTION SPECIFICATIONS 02 35 27).
2. METHOD TO CONFIRM SLURRY WALL DESIGN DEPTHS, BAY MUD 'KEY-IN' DEPTHS (2' MIN), AND METHOD FOR INSTALLATION OF THE APPROVED BACKFILL WILL BE PRESENTED BY THE CONTRACTOR IN THE SLURRY WALL IMPLEMENTATION PLAN (SEE CONSTRUCTION SPECIFICATIONS 02 35 27).
3. NEAR SHORE SLURRY WALL CONSTRUCTION MAY REQUIRE THE WORKING SURFACE TO BE BUILT UP BEYOND THE SLURRY WALL FINISH GRADE IN ORDER TO MITIGATE SHALLOW GROUNDWATER LEVELS ALONG THE BAY.
4. BACKFILL AND EXCAVATION SEPARATION LIMITS ONLY NECESSARY DURING CONSTRUCTION. BACKFILL CAN BE USED TO PROTECT THE TRENCH AS NEEDED AT THE END OF THE WORK DAY.

5 C7 C7 SLURRY WALL CONSTRUCTION PROCEDURE (TYP)

NOT TO SCALE



6 C7 C7 PERFORATED PIPE DETAIL

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GROUNDWATER CONTROL SYSTEM DETAILS 2

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C7
SHEET 9 OF 41 SHEETS

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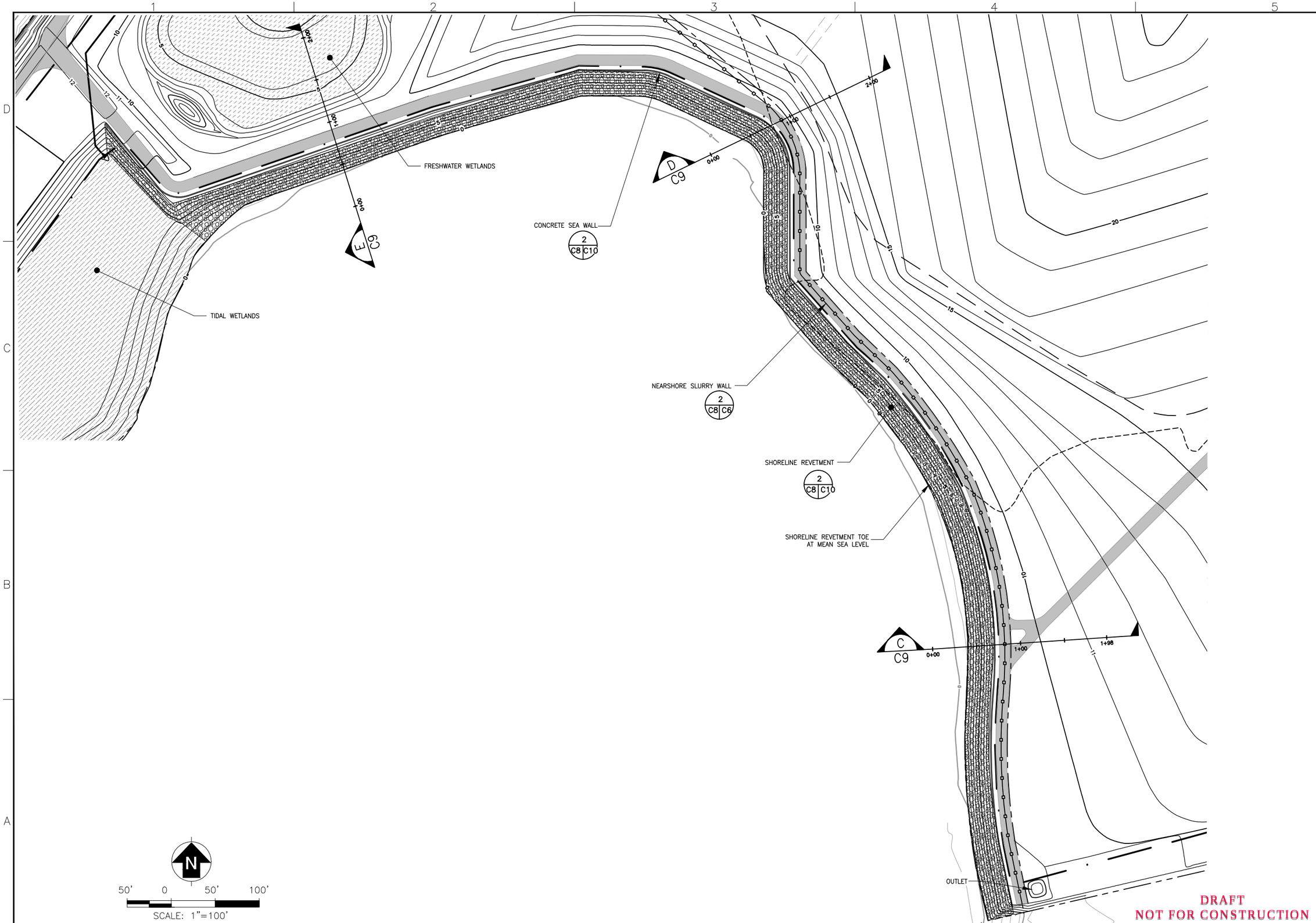

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SYM	DESCRIPTION	DATE	APPR.

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Department of the Navy
Naval Facilities Engineering Command
Base Management Division
Program Management Office West
San Diego, CA

PREPARED BY:
EngineeringRemediation Resources Group, Inc.
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SHORELINE REVETMENT FINISH GRADING PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C8
SHEET 10 OF 41 SHEETS	

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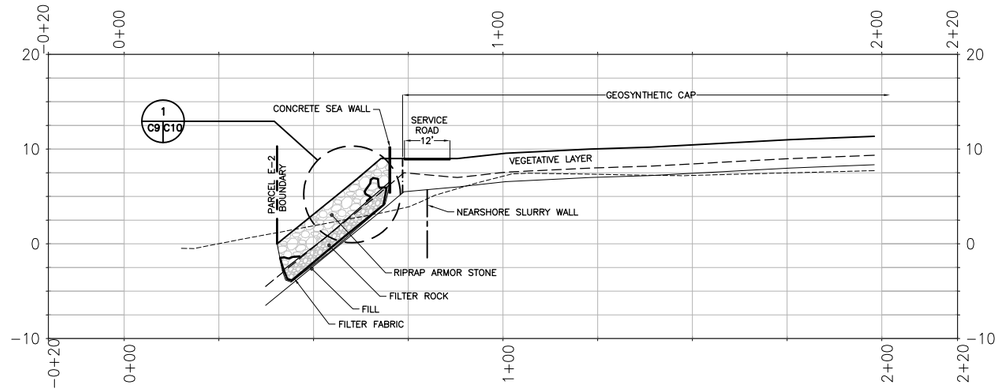
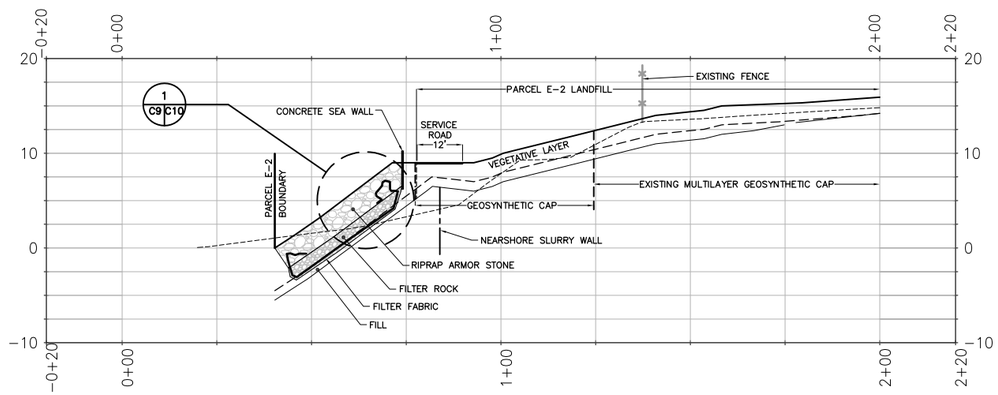


C
C13 C9
EAST REVETMENT SECTION



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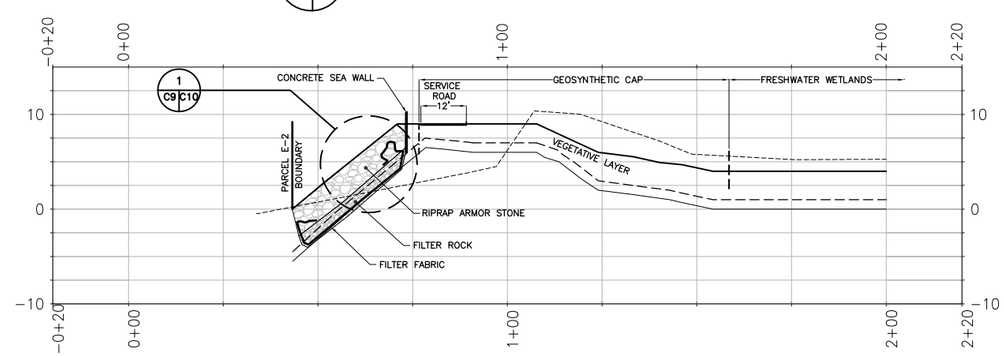
LANDFILL REVETMENT SECTION



E
C13 C9
FRESHWATER WETLANDS REVETMENT SECTION

LEGEND:

- FINISH GRADE
- FOUNDATION GRADE
- SUBGRADE
- EXISTING GRADE

20' 0 20' 40'

HORIZONTAL SCALE: 1"=40'

8' 0 8' 16'

VERTICAL SCALE: 1"=16'

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR:
Department of the Navy
Naval Facilities Engineering Command
Base Realignment and Closure
Program Management Office West
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SAN FRANCISCO, CA

SHORELINE REVETMENT CROSS SECTIONS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C9
SHEET 11 OF 41 SHEETS

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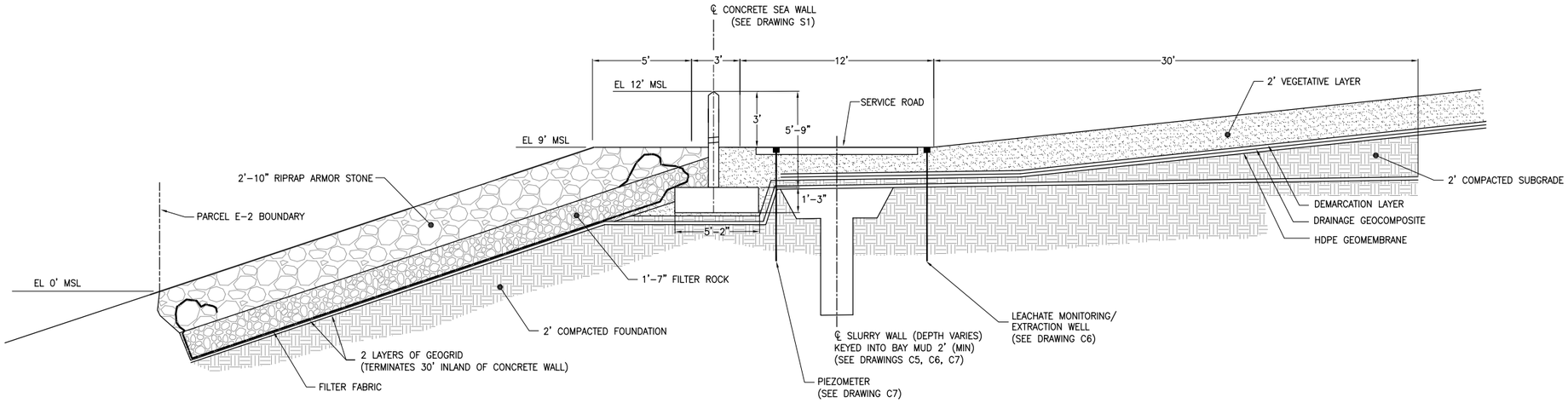

1
C8 C10

SHORELINE REVETMENT DETAIL

SCALE: 1" = 4'

2' 0 2' 4'
SCALE: 1" = 2'

8' 0 8' 16'
SCALE: 1" = 8'

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Program Management Office West
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SAN FRANCISCO, CA

SHORELINE REVETMENT DETAIL

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C10

SHEET 12 OF 41 SHEETS

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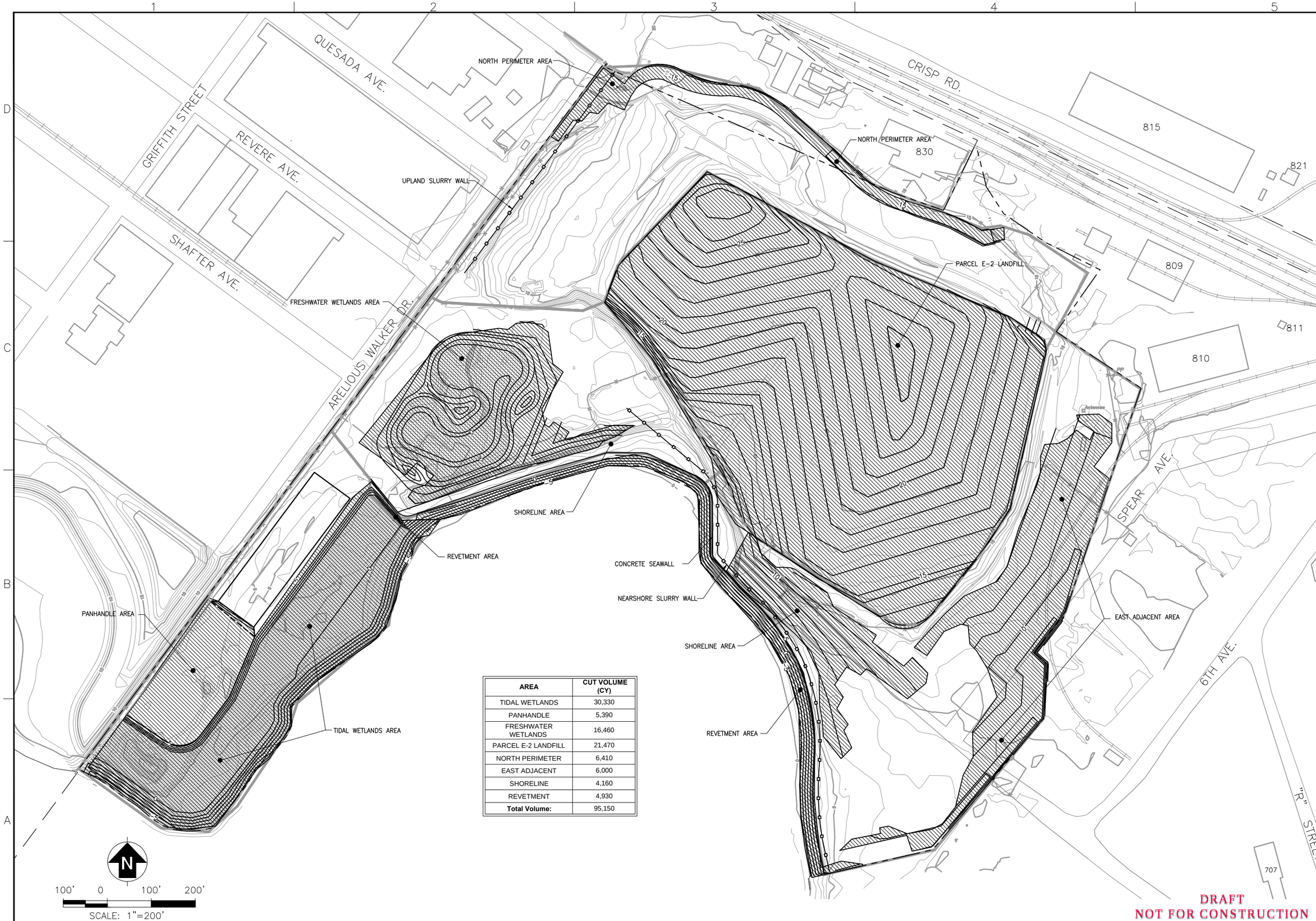

AREA	CUT VOLUME (CY)
TIDAL WETLANDS	30,330
PANHANDLE	5,390
FRESHWATER WETLANDS	16,460
PARCEL E-2 LANDFILL	21,470
NORTH PERIMETER	6,410
EAST ADJACENT	6,000
SHORELINE	4,160
REVETMENT	4,930
Total Volume:	95,150

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SUBGRADE EXCAVATION PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
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SHEET 13 OF 41 SHEETS

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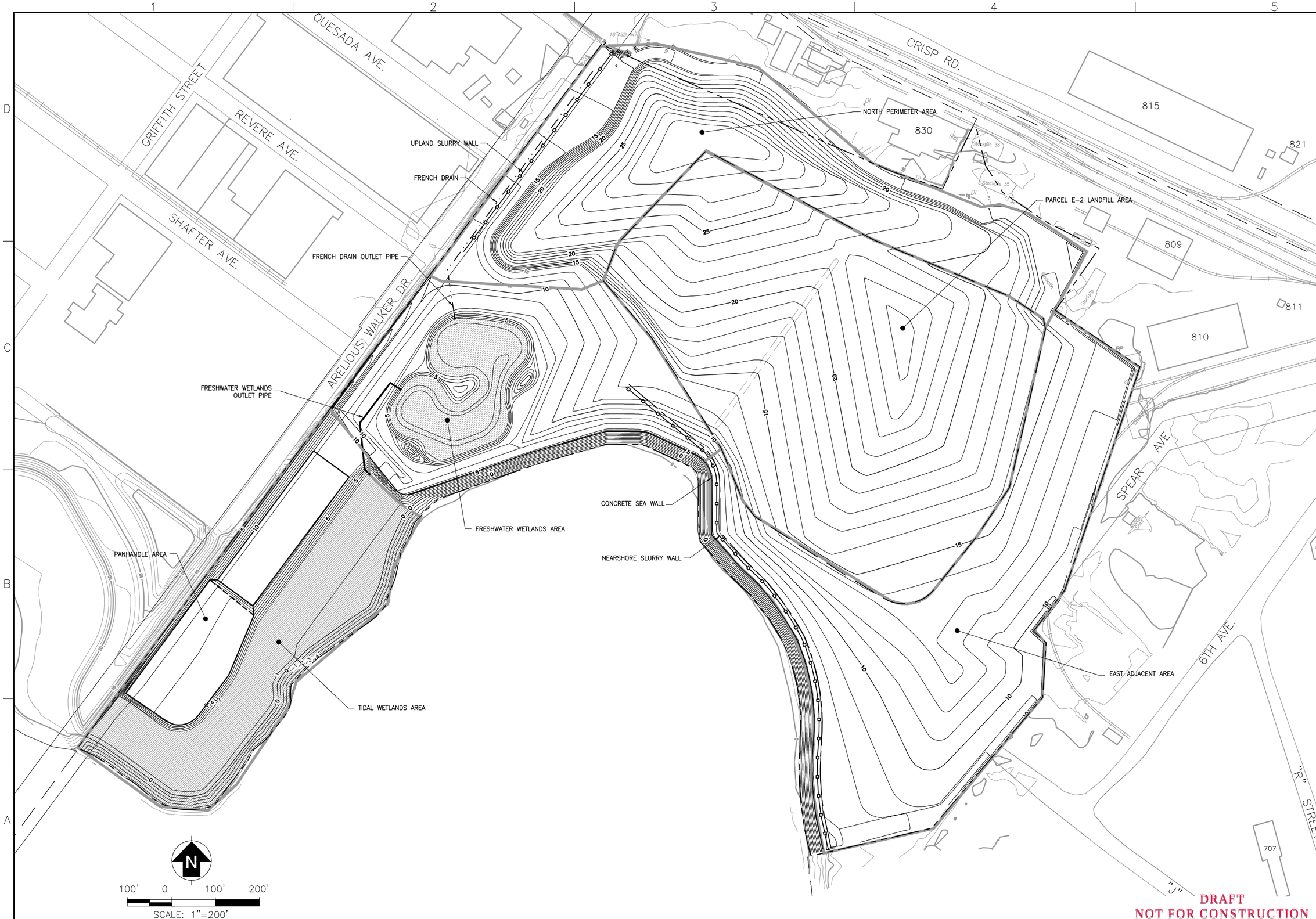

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
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FOUNDATION GRADING PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C12
SHEET 14 OF 41 SHEETS

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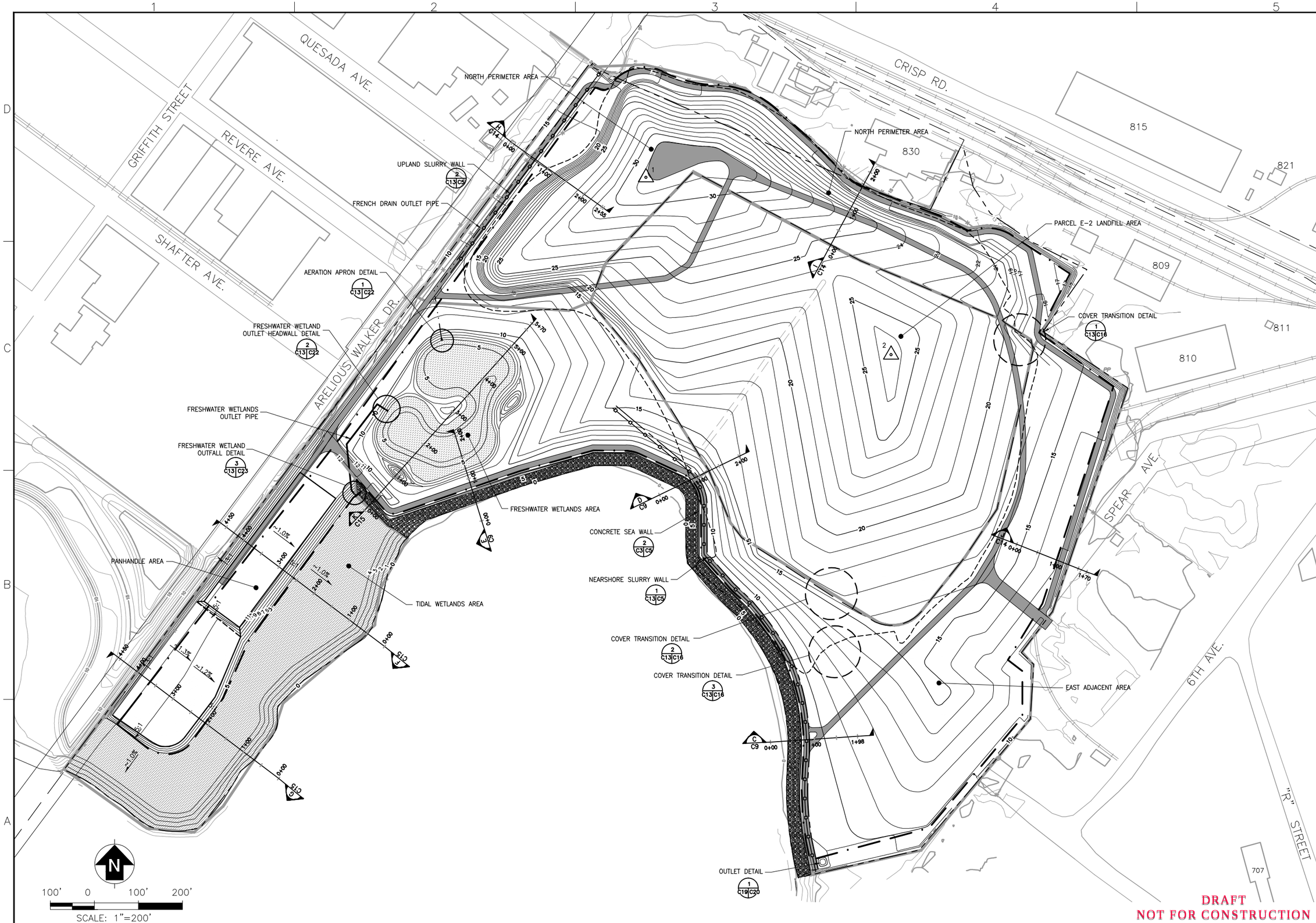

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

FINISH GRADING PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
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CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C13
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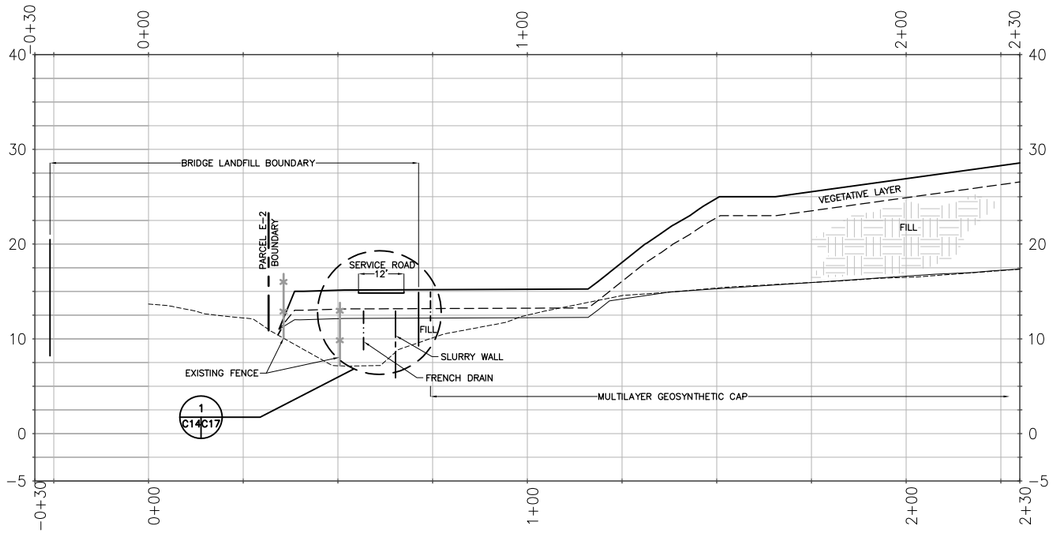
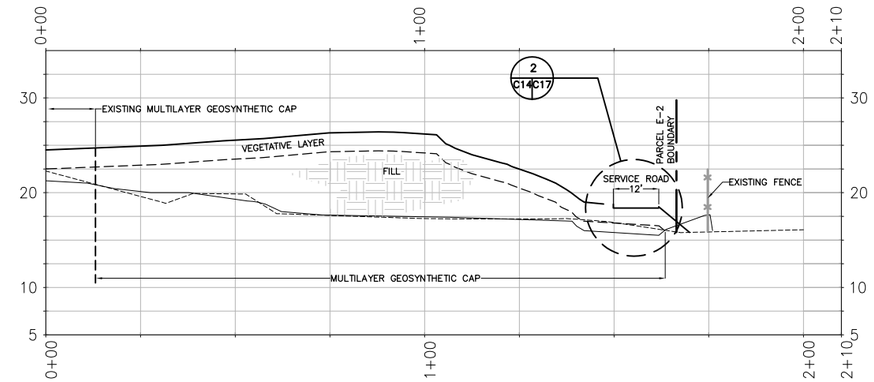


H C13C14 WEST LANDFILL SECTION



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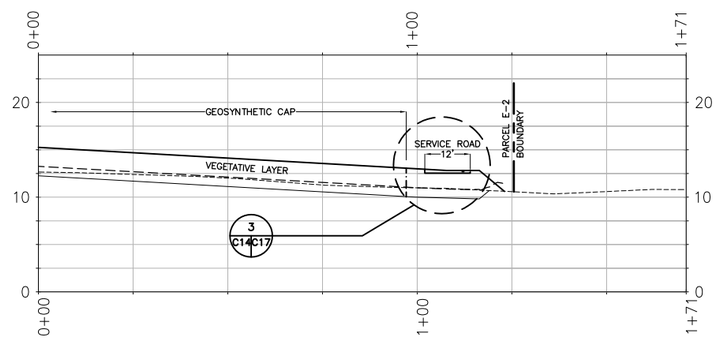

J C13C14 EAST ADJACAENT AREA SECTION

LEGEND:

- FINISH GRADE
- FOUNDATION GRADE
- SUBGRADE
- EXISTING GRADE

20' 0 20' 40'

HORIZONTAL SCALE: 1"=40'

8' 0 8' 16'

VERTICAL SCALE: 1"=16'

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LANDFILL COVER CROSS SECTIONS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C14
SHEET 16 OF 41 SHEETS

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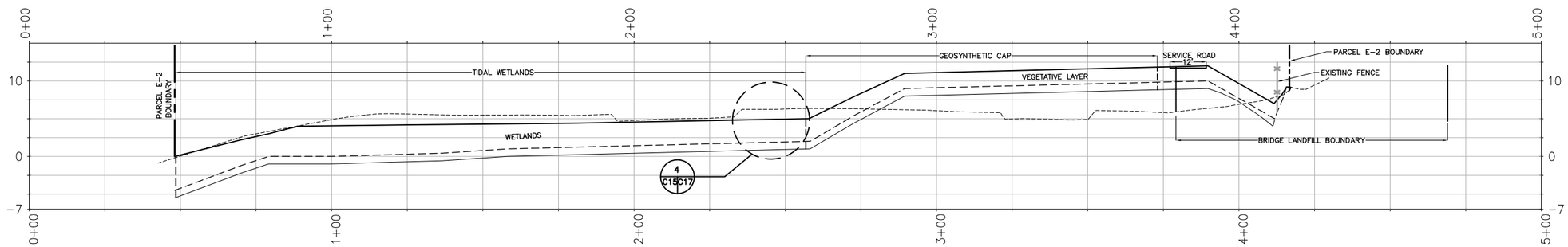
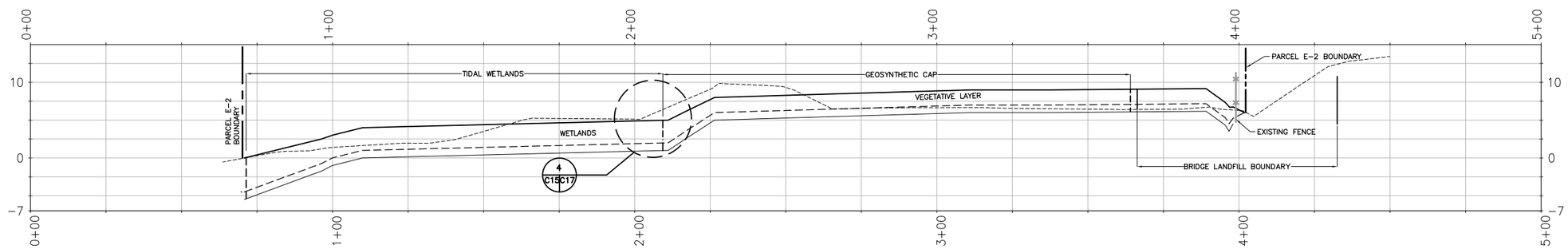
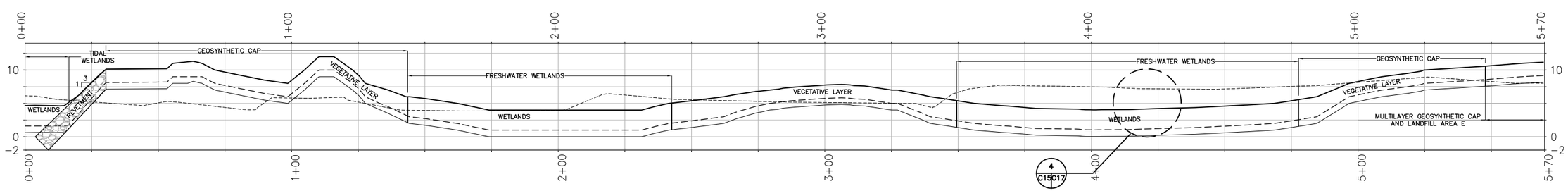


F C13C15 NORTH PANHANDLE/ TIDAL WETLANDS SECTION



G C13C15 SOUTH PANHANDLE/ TIDAL WETLANDS SECTION



K C13C15 FRESHWATER WETLANDS SECTION

20' 0 20' 40'

HORIZONTAL SCALE: 1"=40'

8' 0 8' 16'

VERTICAL SCALE: 1"=16'

LEGEND:

- FINISH GRADE
- FOUNDATION GRADE
- SUBGRADE
- EXISTING GRADE

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TIDAL AND FRESHWATER WETLANDS CROSS SECTIONS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C15
SHEET 17 OF 41 SHEETS

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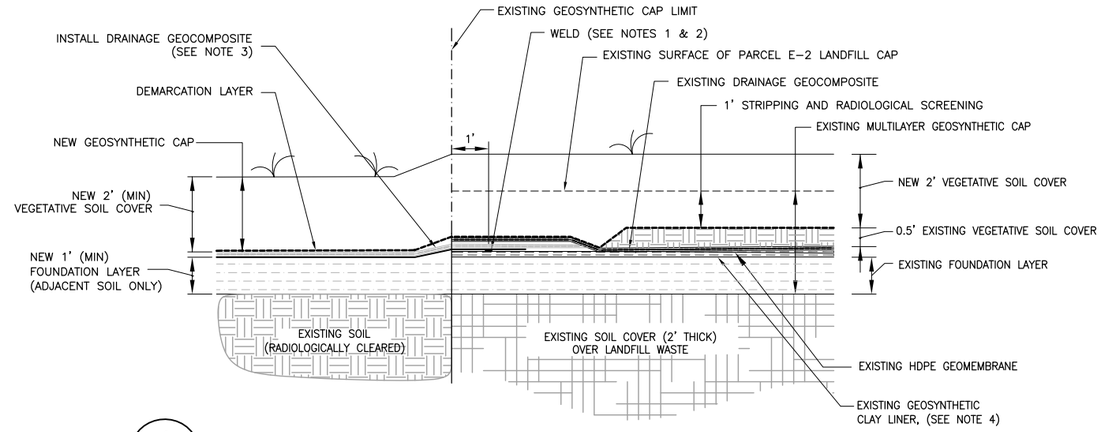
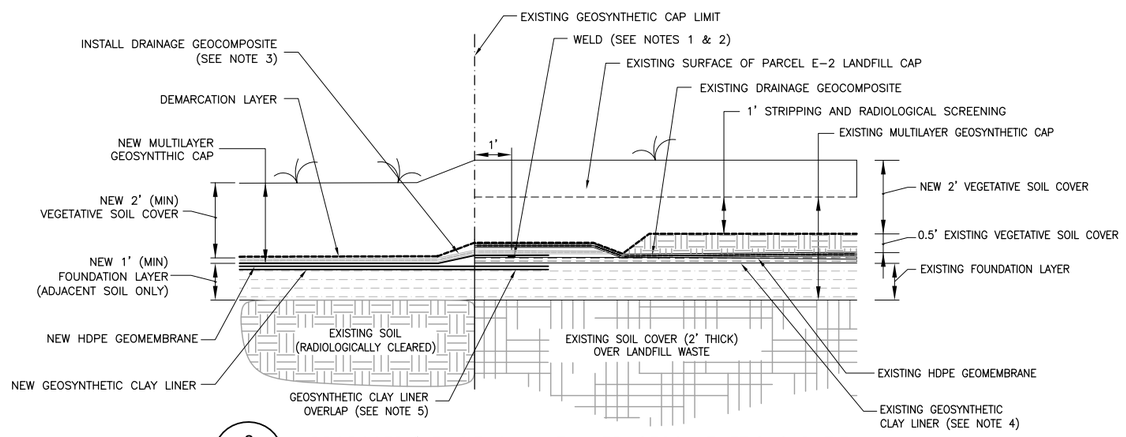


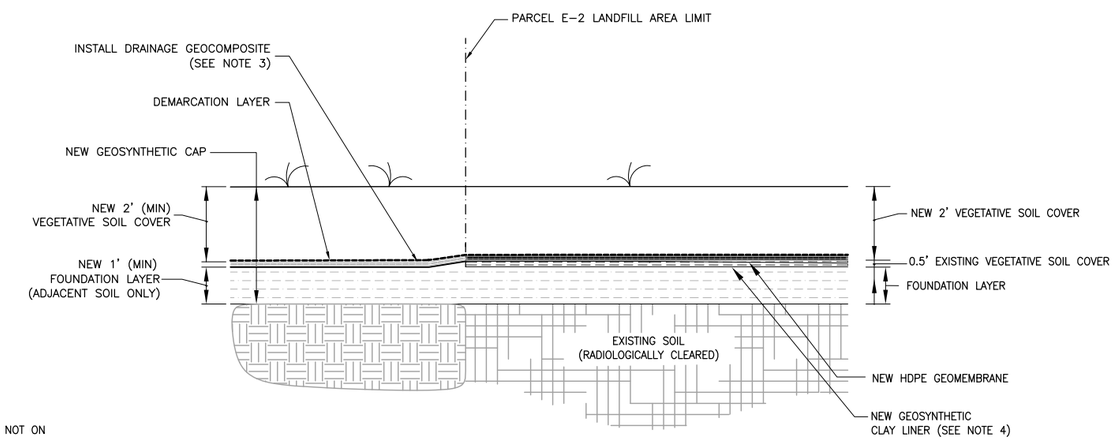
1 C13 C16 PROPOSED GEOSYNTHETIC/ EXISITNG MULTILAYER GEOSYNTHETIC CAP TIE-IN

THE TRANSISTION/ TIE-IN IS BETWEEN COVER TYPES C & E
NOT TO SCALE



2 C13 C16 PROPOSED/ EXISITNG MULTILAYER GEOSYNTHETIC CAP TIE-IN

THE TRANSISTION/ TIE-IN IS BETWEEN COVER TYPES C & E
NOT TO SCALE



3 C13 C16 PROPOSED GEOSYNTHETIC/ PROPOSED MULTILAYER GEOSYNTHETIC CAP TIE-IN

THE TRANSISTION/ TIE-IN IS BETWEEN COVER TYPES C&E
NOT TO SCALE

NOTES:

1. REMOVE EXISTING SOIL COVER AND LAY BACK EXISTING GEOSYNTHETICS FOR NEW GEOMEMBRANE CONNECTION.
2. EXPOSE AND CLEAN 1' MINIMUM WIDTH OF GEOMEMBRANE FOR OVERLAP CONNECTION WITH NEW GEOMEMBRANE. WELD AND SEAM.
3. PROVIDE 4' (MIN) OVERLAP FOR NEW DRAINAGE GEOCOMPOSITE INSTALLATION.
4. EXISTING GEOSYNTHETIC CLAY LINER WAS INSTALLED ON TOP DECK AREA ONLY AND NOT ON SIDESLOPE OF THE LANDFILL.
5. PROVIDE 2' (MIN) OVERLAP FOR NEW GEOSYNTHETIC CLAY LINER INSTALLATION.

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SYM	DESCRIPTION	DATE	APPR.

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SAN FRANCISCO, CA

COVER TRANSITION DETAILS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C16
SHEET 18 OF 41 SHEETS	

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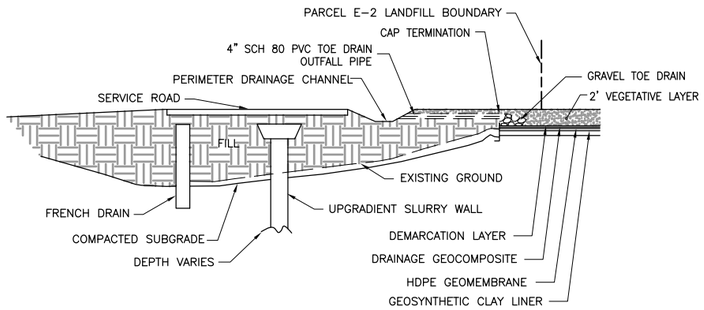
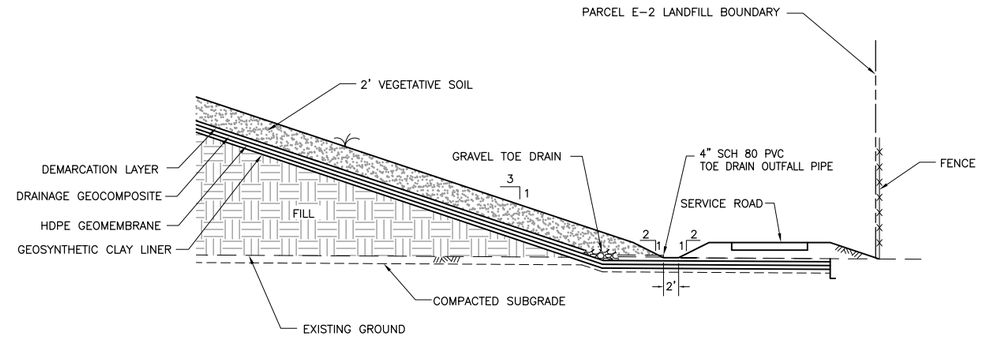


1 C14 C17 CAP TERMINATION (WEST BOUNDARY)
NOT TO SCALE



2 C14 C17 CAP TERMINATION (NORTH PERIMETER)
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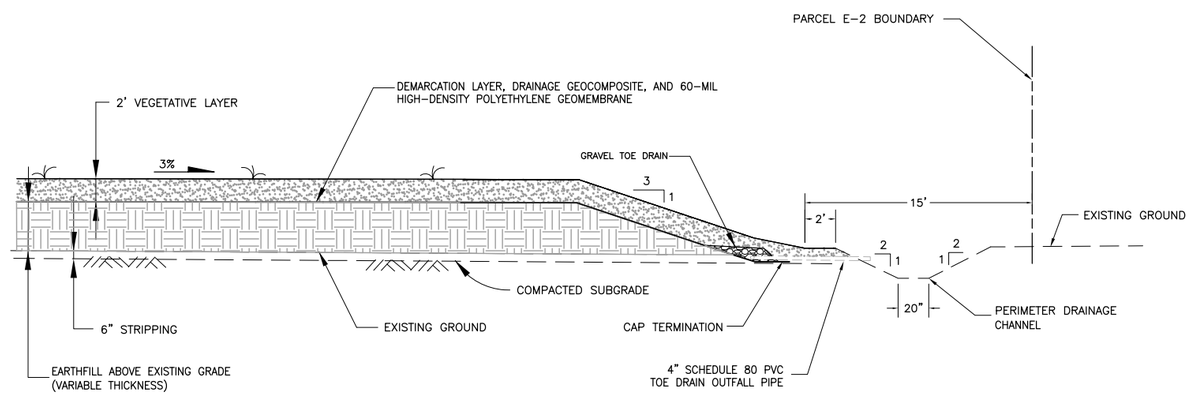

3 C14 C17 CAP TERMINATION (EAST BOUNDARY)
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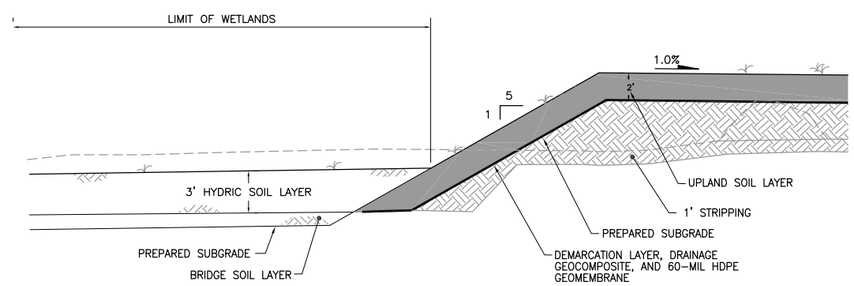

4 C15 C17 CAP TERMINATION (SOUTH PANHANDLAE/ TIDAL WETANDS)
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure, Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

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PM/CM:	DB

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SAN FRANCISCO, CA

COVER TERMINATION DETAILS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C17
SHEET 19 OF 41 SHEETS	

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COVER TYPE (TIDAL AND FRESHWATER WETLANDS)
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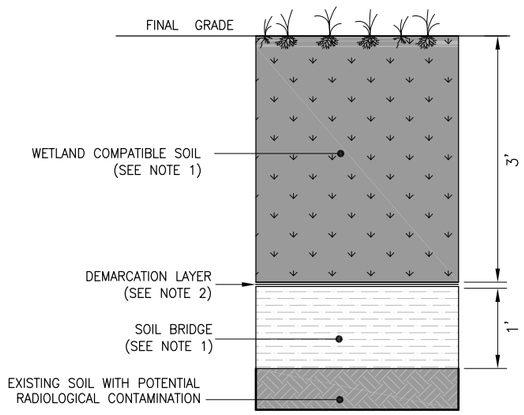

COVER TYPE C (FINAL GRADE–FILL AREAS)
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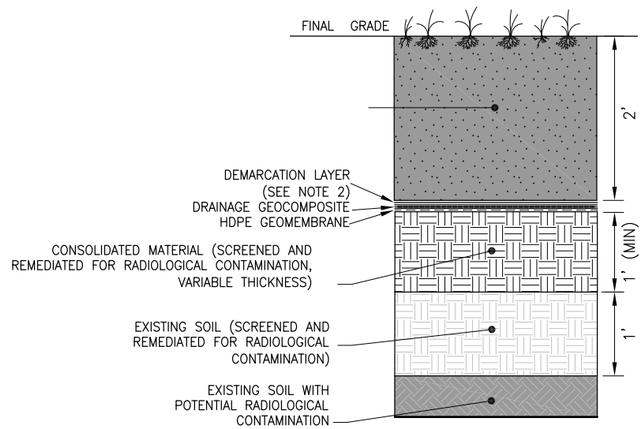
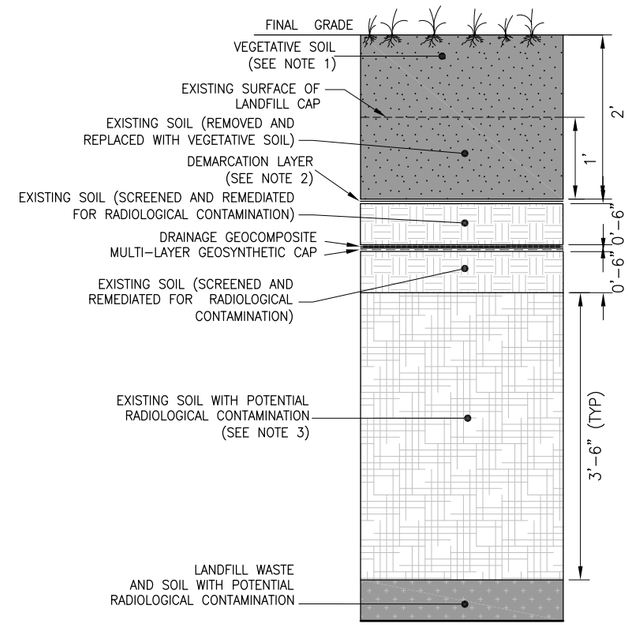


COVER TYPE E (FINAL GRADE–EXISITNG LANDFILL)
NOT TO SCALE



COVER TYPE B (SHORELINE REVETMENT)
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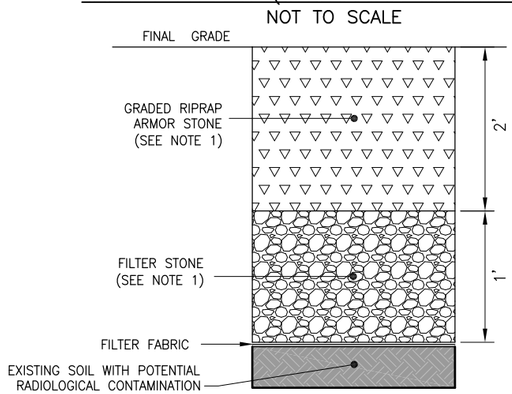

COVER TYPE D (FINAL GRADE–CUT AREAS)
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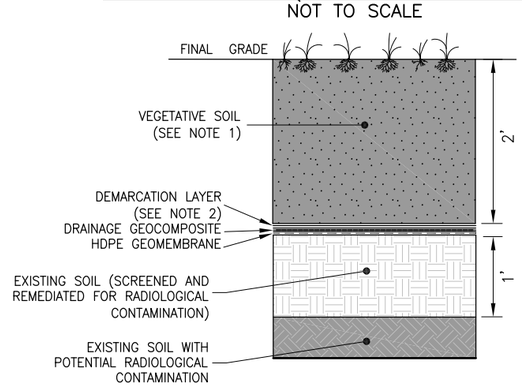

NOTES:

1. IMPORTED FILL MATERIAL WILL MEET CHEMICAL (NONRADIOLOGICAL AND RADIOLOGICAL) ACCEPTANCE CRITERIA (SEE APPENDIX C).
2. DEMARCATION LAYER WILL CONSIST OF MAGNETIC MARKING TAPE AND ORANGE–COLORED GEOTEXTILE.
3. EXISTING SOIL PLACED ON TOP OF LANDFILL DURING PRELIMINARY CLOSURE ACTIVITIES IN 1974 AND 2000 (AFTER MILITARY OPERATIONS CEASED).
4. LOCATIONS OF COVER TYPES PRESENTED ON FIGURE 13.

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SYM	DESCRIPTION	DATE	APPR.

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PM/CM:	DB

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FINAL COVER DETAILS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25–049
CONSTR. CONTR. NO.	N68711–05–C–6011
DRAWING NO.	C18

SHEET 20 OF 41 SHEETS

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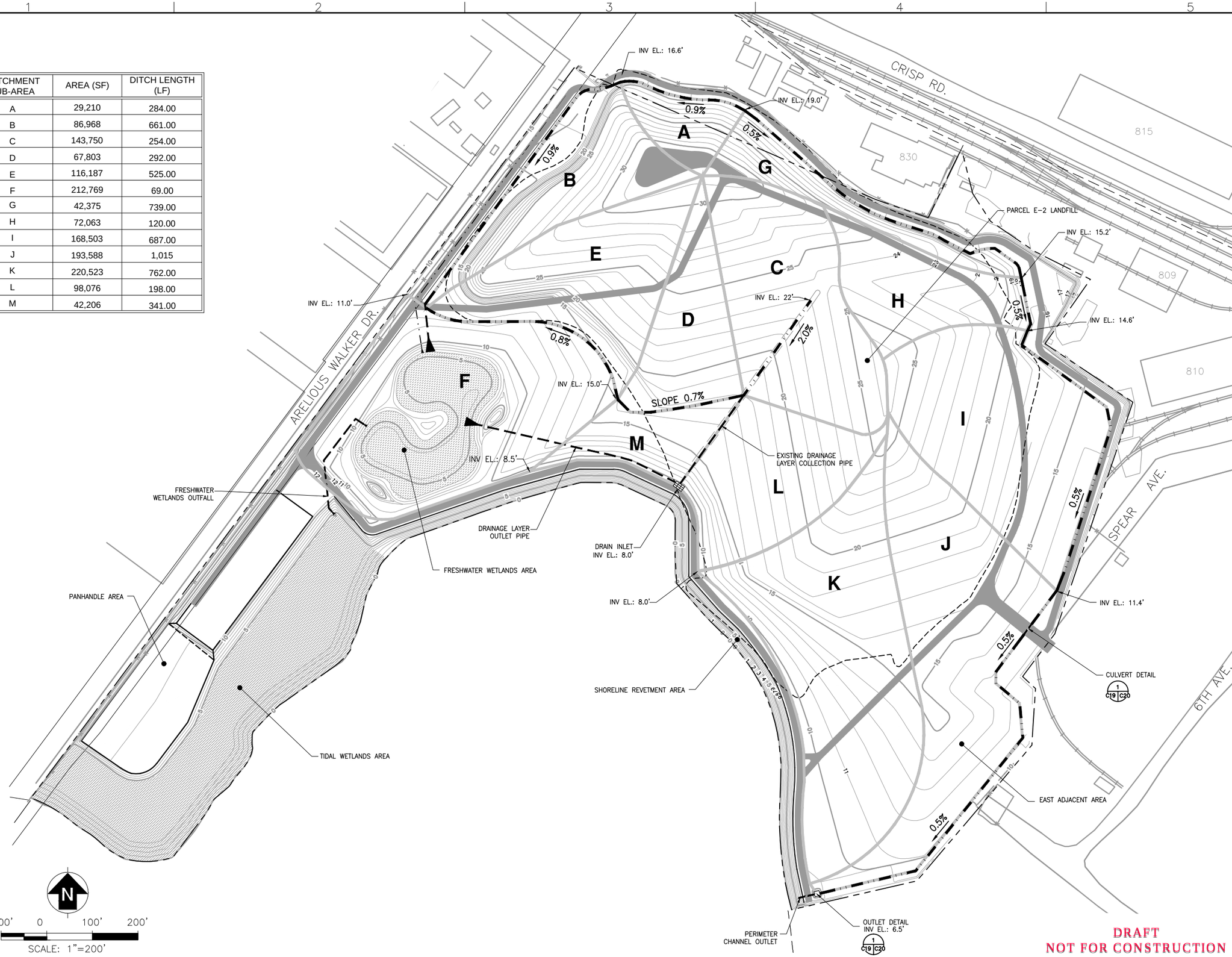
CATCHMENT SUB-AREA	AREA (SF)	DITCH LENGTH (LF)
A	29,210	284.00
B	86,968	661.00
C	143,750	254.00
D	67,803	292.00
E	116,187	525.00
F	212,769	69.00
G	42,375	739.00
H	72,063	120.00
I	168,503	687.00
J	193,588	1,015
K	220,523	762.00
L	98,076	198.00
M	42,206	341.00



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SYM	DESCRIPTION	DATE	APPR.

Department of the Navy
Naval Facilities Engineering Command
Base Realignment and Closure Program Management Office West
San Diego, CA

PREPARED FOR:

PREPARED BY:
Engineering Remediation Resources Group, Inc.
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San Francisco, California 94104
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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

SURFACE WATER CONTROL PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C19
SHEET 21 OF 41 SHEETS

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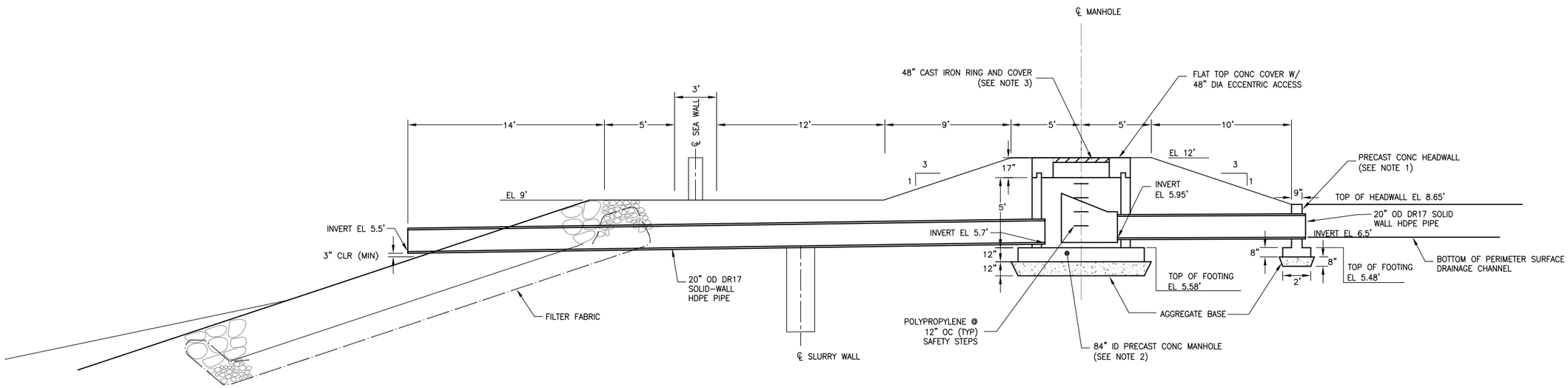
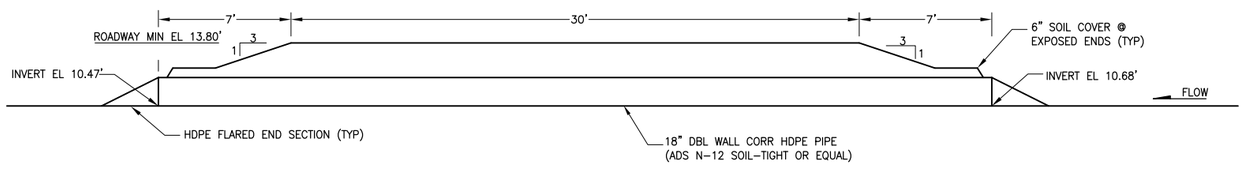


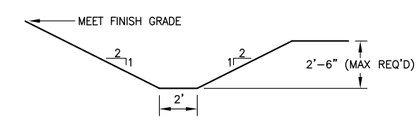
NOTES:

1. HEADWALL SHALL BE A SINGLE PIPE HEADWALL AS MANUFACTURED BY JENSEN PRECAST, OR APPROVED EQUAL TO MEET CALTRANS D89 STANDARD PLANS. FOR NOMINAL 18" ID PIPE. CONFIRM THAT PIPE OPENING FITS 20" OD HDPE PIPE.
2. MANHOLE AND FLAT COVER SHALL BE 84" ø MANHOLE COMPONENTS AND A FLAT TOP CONCRETE COVER WITH ECCENTRIC 48" ø OPENING AS MANUFACTURED BY JENSEN PRECAST OR APPROVED EQUAL.
3. CAST IRON COVER SHALL BE AS MANUFACTURED BY JENSEN PRECAST OF APPROVED EQUAL. CAST IRON COVER SHALL BE JENSEN TYPE C-2669 24" INNER GRATE INSIDE A JENSEN TYPE A-1428-R3 48" MANHOLE RING WITH SOLID OFFSET ADAPTER COVER.

1 C19 C20 PERIMETER SURFACE CHANNEL OUTLET CROSS-SECTION
NOT TO SCALE



2 C19 C20 PERIMETER DRAINAGE CHANNEL CULVERT SECTION
NOT TO SCALE



PERIMETER DRAINAGE CHANNEL TYPICAL SECTION-UPSTREAM OF ROADWAY CULVERT
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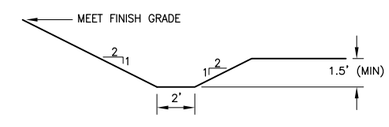

PERIMETER DRAINAGE CHANNEL TYPICAL SECTION-DOWNSTREAM OF ROADWAY CULVERT
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

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PM/CM: DB

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SURFACE WATER CONTROL SECTIONS AND DETAIL

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C20
SHEET 22 OF 41 SHEETS

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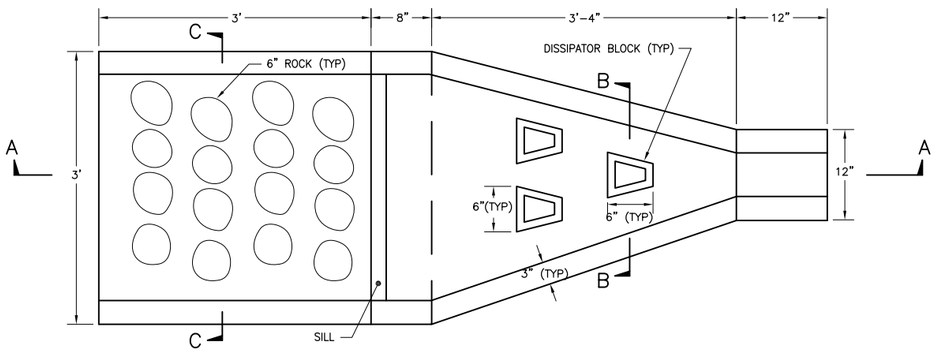
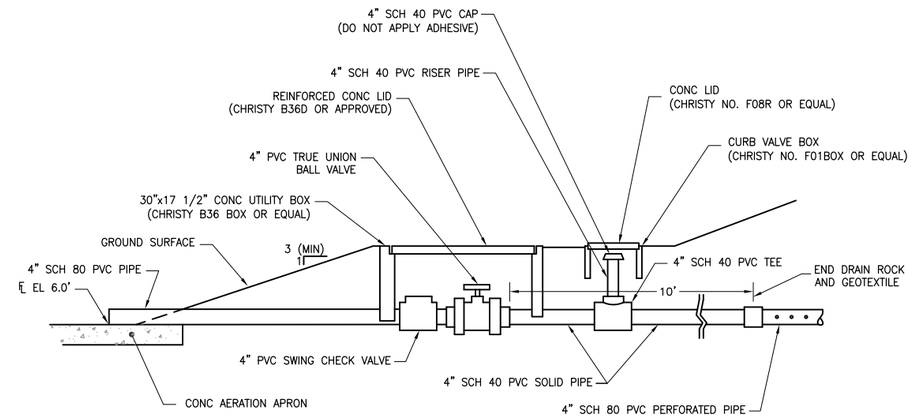
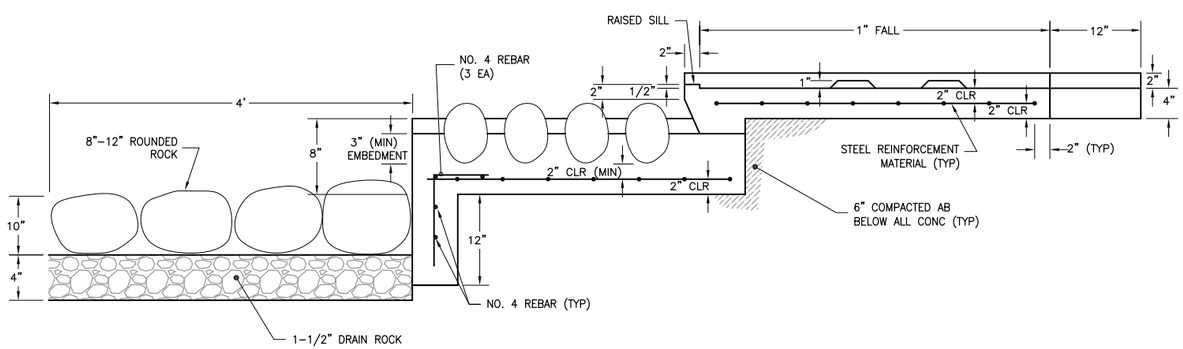


1 / C13 C21 AERATION APRON DETAIL
NOT TO SCALE



1A / – – FRENCH DRAIN OUTLET SECTION
NOT TO SCALE



A / – – AERATION APRON SECTION
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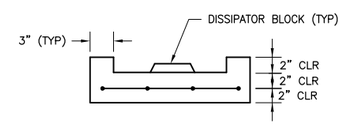

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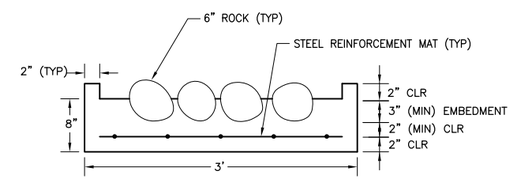

C / – – AERATION APRON SECTION
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

Department of the Navy
Naval Facilities Engineering Command
Base Realignment and Closure
Program Management Office West
San Diego, CA

PREPARED FOR:

PREPARED BY:
Engineering/Remediation
Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 956-0414
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SAN FRANCISCO, CA

FRENCH DRAIN OUTLET SECTIONS AND DETAIL

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C21

SHEET 23 OF 41 SHEETS

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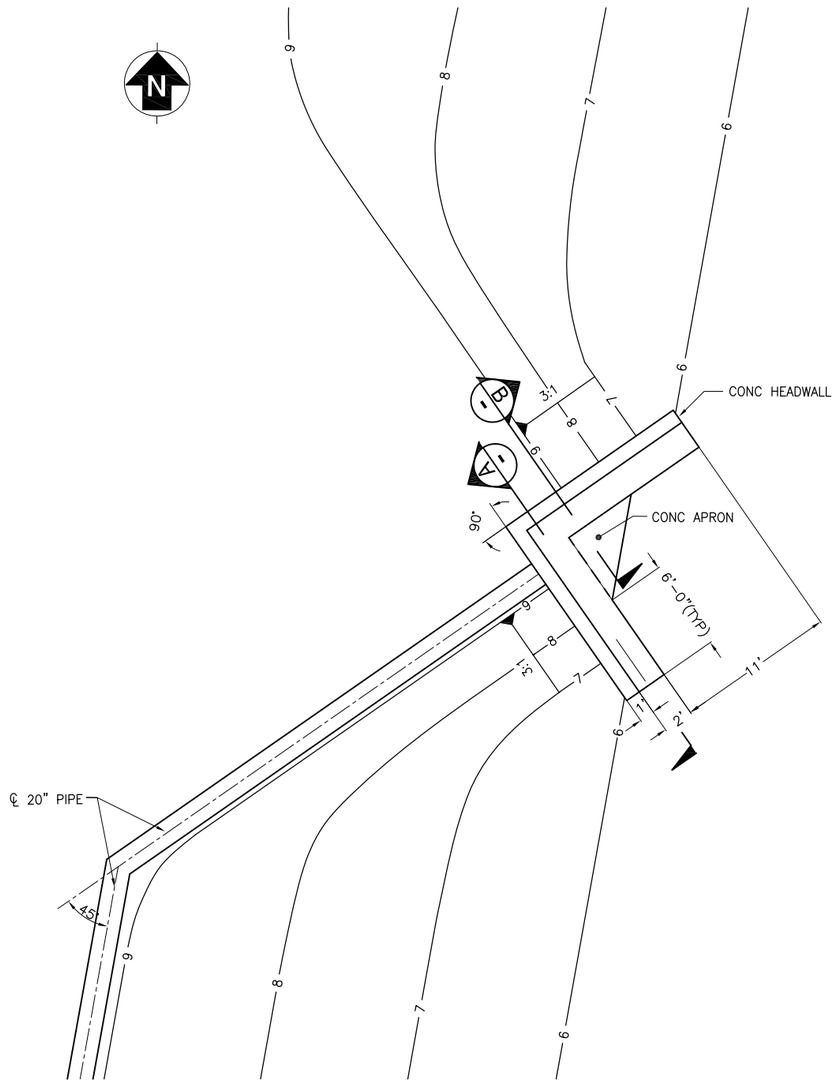
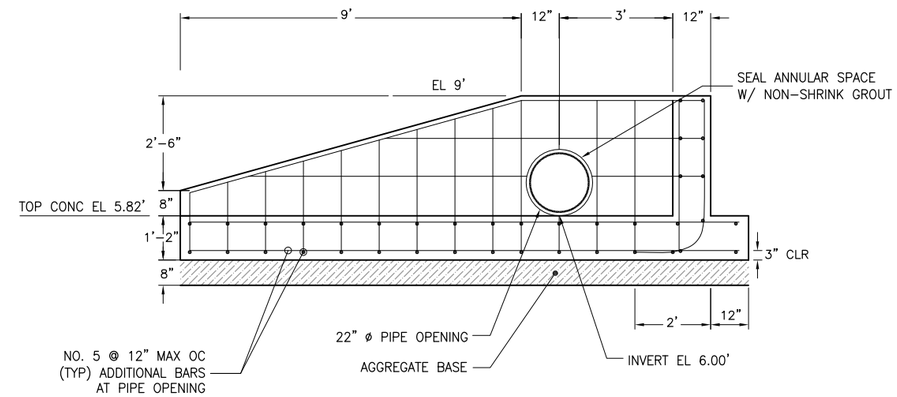


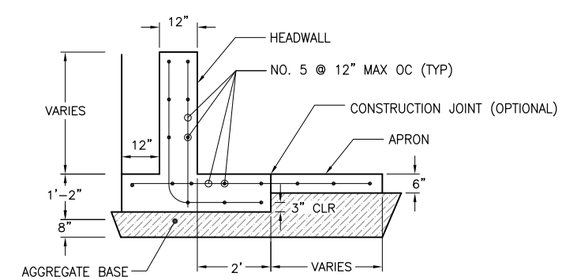
2 C13 C22 FRESHWATER WETLAND OUTLET HEADWALL DETAIL
SCALE = 5'-0"



NOTES:

1. CONSTRUCTION FOR ADJACENT WALL IS SIMILAR–WITHOUT PIPE OPENING.
2. PLACE CONCRETE MONOLITHICALLY (SINGLE POUR), 6" THICK APRON MAY BE PLACED SEPARATELY.
3. 2" CLEAR EMBEDMENT ON REBAR EXCEPT WHERE NOTED OTHERWISE.

A – – FRESHWATER WETLAND OUTLET HEADWALL SECTION
SCALE = 2'-0"



NOTE:
1. 2" CLEAR EMBEDMENT ON A REBAR EXCEPT WHERE NOTED OTHERWISE.

B – – FRESHWATER WETLAND OUTLET HEADWALL/ APRON SECTION
SCALE = 2'-0"

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 705-0674, ERRG

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SAN FRANCISCO, CA

FRESHWATER WETLAND OUTLET HEADWALL SECTIONS AND DETAIL

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C22

SHEET 24 OF 41 SHEETS

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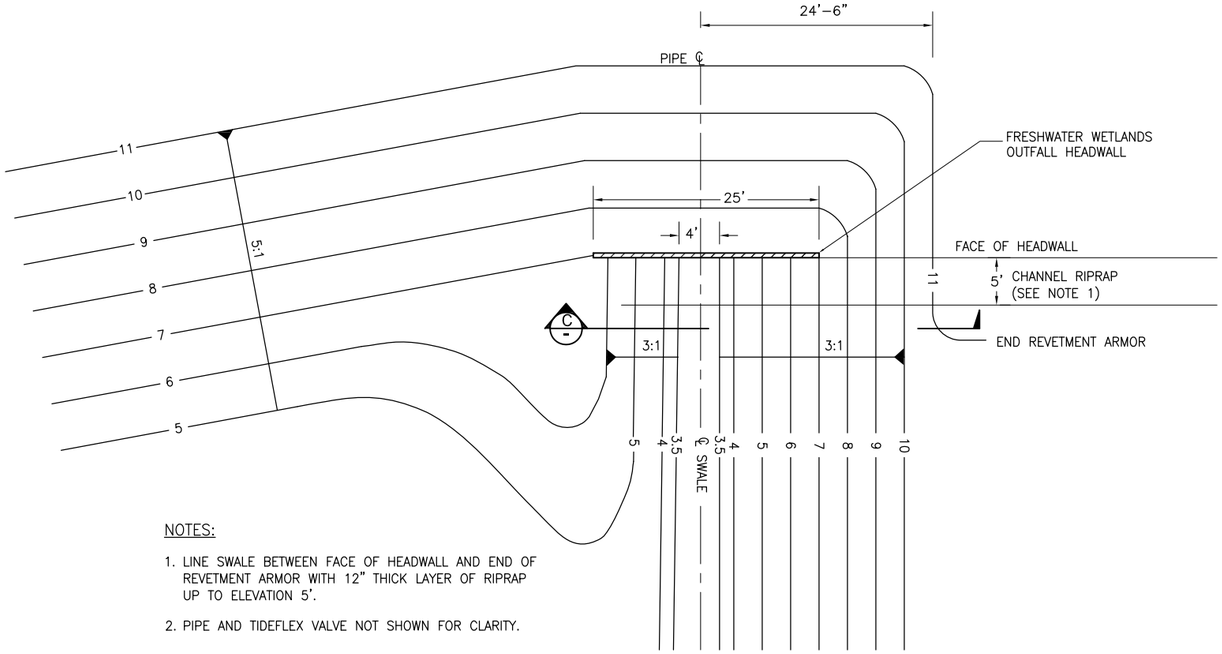
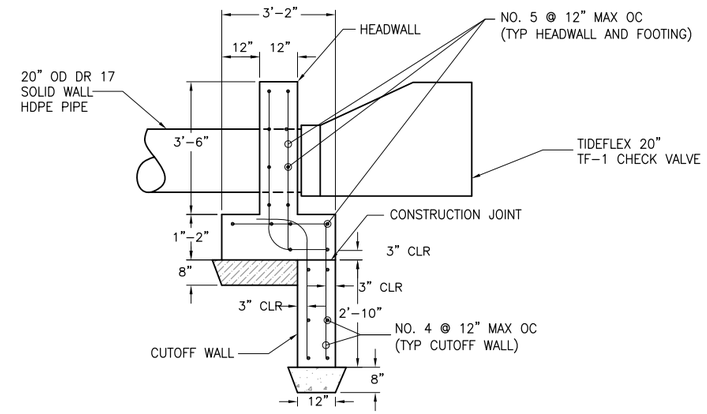


NOTES:

1. LINE SWALE BETWEEN FACE OF HEADWALL AND END OF REVETMENT ARMOR WITH 12" THICK LAYER OF RIPRAP UP TO ELEVATION 5'.
2. PIPE AND TIDEFLEX VALVE NOT SHOWN FOR CLARITY.

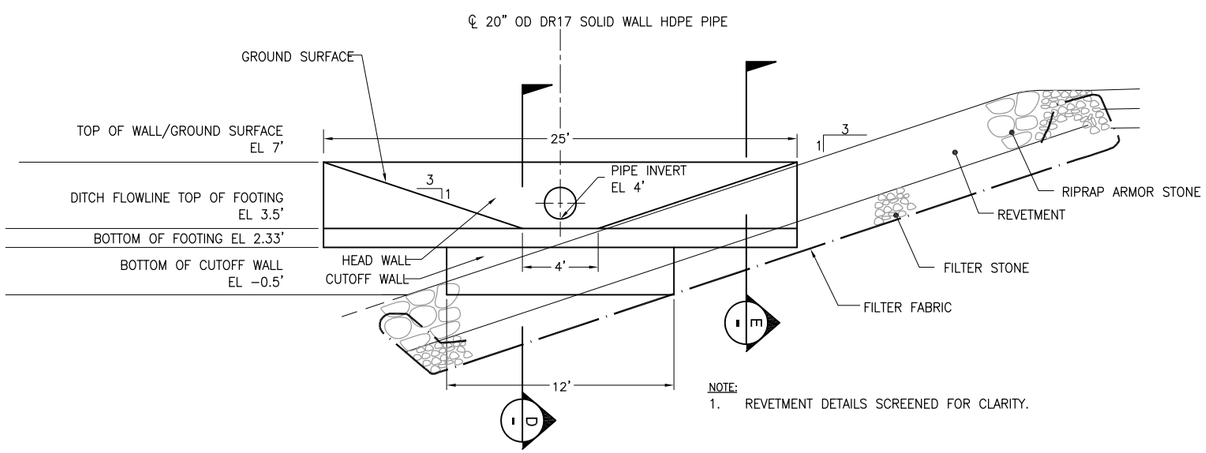
3 / C13 C23 FRESHWATER WETLAND OUTFALL DETAIL
SCALE: 1"= 2'-0"



NOTES:

1. PLACE CONCRETE MONOLITHICALLY (SINGLE POUR), EXCEPT AT CUTOFF WALL.
2. 2" CLEAR EMBEDMENT ON ALL REBAR EXCEPT WHERE OTHERWISE NOTED.

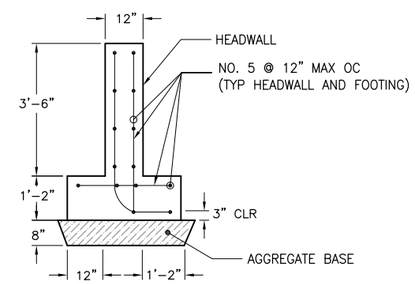
D / – – FRESHWATER WETLAND OUTFALL HEADWALL SECTION
SCALE: 1"= 2'-0"



NOTE:

1. REVETMENT DETAILS SCREENED FOR CLARITY.

C / – – FRESHWATER WETLAND OUTFALL HEADWALL SECTION
SCALE: 1"= 2'-0"



NOTES:

1. PLACE CONCRETE MONOLITHICALLY (SINGLE POUR).
2. 2" CLEAR EMBEDMENT ON ALL REBAR EXCEPT WHERE NOTED OTHERWISE.

E / – – FRESHWATER WETLAND OUTFALL HEADWALL SECTION
SCALE: 1"= 2'-0"

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SYM	DESCRIPTION	DATE	APPR.

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SAN FRANCISCO, CA

FRESHWATER WETLAND OUTFALL SECTIONS AND DETAIL

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C23
SHEET 25 OF 41 SHEETS	

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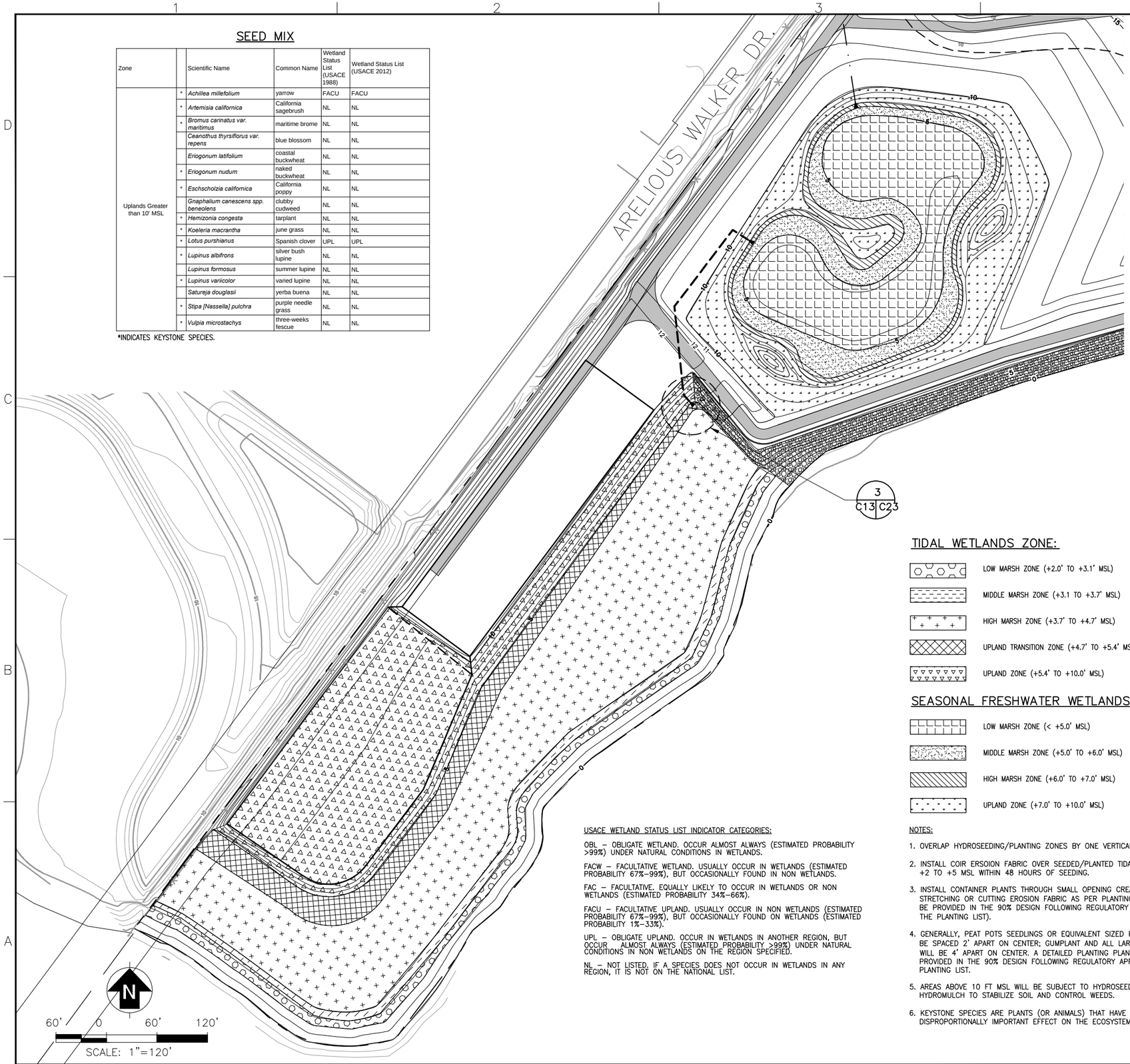
SEED MIX

Zone		Scientific Name	Common Name	Wetland Status List (USACE 1988)	Wetland Status List (USACE 2012)
Uplands Greater than 10' MSL	*	*Achillea millefolium*	yarrow	FACU	FACU
	*	*Artemisia californica*	California sagebrush	NL	NL
	*	*Bromus carinatus var. maritimus*	maritime brome	NL	NL
		Ceanothus thyrsiflorus var. repens	blue blossom	NL	NL
		Eriogonum latifolium	coastal buckwheat	NL	NL
	*	*Eriogonum nudum*	naked buckwheat	NL	NL
	*	*Eschscholzia californica*	California poppy	NL	NL
		Gnaphalium canescens spp. beneolens	clubby cudweed	NL	NL
	*	*Hemizonia congesta*	tarplant	NL	NL
	*	*Koeleria macrantha*	june grass	NL	NL
	*	*Lotus purshianus*	Spanish clover	UPL	UPL
	*	*Lupinus albifrons*	silver bush lupine	NL	NL
		Lupinus formosus	summer lupine	NL	NL
	*	*Lupinus variicolor*	varied lupine	NL	NL
		Satureja douglasii	yerba buena	NL	NL
	*	*Stipa [Nassella] pulchra*	purple needle grass	NL	NL
	*	*Vulpia microstachys*	three-weeks fescue	NL	NL

*INDICATES KEYSTONE SPECIES.



TIDAL WETLANDS ZONE:

- LOW MARSH ZONE (+2.0' TO +3.1' MSL)
- MIDDLE MARSH ZONE (+3.1 TO +3.7' MSL)
- HIGH MARSH ZONE (+3.7' TO +4.7' MSL)
- UPLAND TRANSITION ZONE (+4.7' TO +5.4' MSL)
- UPLAND ZONE (+5.4' TO +10.0' MSL)

SEASONAL FRESHWATER WETLANDS ZONE:

- LOW MARSH ZONE (< +5.0' MSL)
- MIDDLE MARSH ZONE (+5.0' TO +6.0' MSL)
- HIGH MARSH ZONE (+6.0' TO +7.0' MSL)
- UPLAND ZONE (+7.0' TO +10.0' MSL)

USACE WETLAND STATUS LIST INDICATOR CATEGORIES:

OBL – OBLIGATE WETLAND. OCCUR ALMOST ALWAYS (ESTIMATED PROBABILITY >99%) UNDER NATURAL CONDITIONS IN WETLANDS.

FACW – FACULTATIVE WETLAND. USUALLY OCCUR IN WETLANDS (ESTIMATED PROBABILITY 67%–99%), BUT OCCASIONALLY FOUND IN NON WETLANDS.

FAC – FACULTATIVE. EQUALLY LIKELY TO OCCUR IN WETLANDS OR NON WETLANDS (ESTIMATED PROBABILITY 34%–66%).

FACU – FACULTATIVE UPLAND. USUALLY OCCUR IN NON WETLANDS (ESTIMATED PROBABILITY 67%–99%), BUT OCCASIONALLY FOUND ON WETLANDS (ESTIMATED PROBABILITY 1%–33%).

UPL – OBLIGATE UPLAND. OCCUR IN WETLANDS IN ANOTHER REGION, BUT OCCUR ALMOST ALWAYS (ESTIMATED PROBABILITY >99%) UNDER NATURAL CONDITIONS IN NON WETLANDS ON THE REGION SPECIFIED.

NL – NOT LISTED. IF A SPECIES DOES NOT OCCUR IN WETLANDS IN ANY REGION, IT IS NOT ON THE NATIONAL LIST.

NOTES:

1. OVERLAP HYDROSEEDING/PLANTING ZONES BY ONE VERTICAL FOOT.
2. INSTALL COIR ERSOION FABRIC OVER SEEDED/PLANTED TIDAL AREAS FROM +2 TO +5 MSL WITHIN 48 HOURS OF SEEDING.
3. INSTALL CONTAINER PLANTS THROUGH SMALL OPENING CREATED BY STRETCHING OR CUTTING EROSION FABRIC AS PER PLANTING DETAILS (TO BE PROVIDED IN THE 90% DESIGN FOLLOWING REGULATORY APPROVAL OF THE PLANTING LIST).
4. GENERALLY, PEAT POTS SEEDLINGS OR EQUIVALENT SIZED PROPAGULES WILL BE SPACED 2' APART ON CENTER; GUMPLANT AND ALL LARGER PLANTS WILL BE 4' APART ON CENTER. A DETAILED PLANTING PLAN WILL BE PROVIDED IN THE 90% DESIGN FOLLOWING REGULATORY APPROVAL OF THE PLANTING LIST.
5. AREAS ABOVE 10 FT MSL WILL BE SUBJECT TO HYDROSEEDING ONLY WITH HYDROMULCH TO STABILIZE SOIL AND CONTROL WEEDS.
6. KEYSTONE SPECIES ARE PLANTS (OR ANIMALS) THAT HAVE A LARGE OR DISPROPORTIONALLY IMPORTANT EFFECT ON THE ECOSYSTEM.

CONTAINER PLANTS

Zone		Scientific Name	Common Name	Wetland Status List (USACE 2012)
Tidal Wetland Lower Marsh		*Bolboschoenus [Scirpus] maritimus*	saltmarsh bulrush	OBL
	*	*Spartina foliosa*	Pacific cordgrass	OBL
Tidal Wetland Middle Marsh	*	*Jaumea carnosa*	fleshy jaumea	OBL
	*	*Salicornia [Sarcocornia] pacifica [virginica]*	pickleweed	OBL
Tidal Wetland High Marsh	*	*Atriplex patula [triangularis]*	fat hen	FACW
		Cressa truxillensis	cressa	FACW
	*	*Distichlis spicata*	salt grass	FAC/FACW
	*	*Frankenia salina*	alkali heath	FACW
		Grindelia hirsutula var. hirsutula	gumplant	FACW
	*	*Grindelia stricta var. angustifolia*	marsh gumplant	FACW
	*	*Jaumea carnosa*	fleshy jaumea	OBL
	*	*Juncus arcticus ssp. balticus*	wire rush	FACW
	*	*Lasthenia glabrata*	smooth goldfields	FACW
	*	*Limonium californicum*	sea lavender	FACW/OBL
	*	*Plantago maritima*	sea plantain	FACW
	*	*Pluchea odorata [purpurascens]*	salt marsh fleabane	FACW
		Rumex fueginus [maritimus]	golden dock	FACW
		Salicornia [Sarcocornia] pacifica [virginica]	pickleweed	OBL
	*	*Spergularia salina [marina]*	saltmarsh sand-spurrey	OBL
	*	*Triglochin maritima*	common arrow-grass	OBL
		Triglochin striata	three-ribbed arrow-grass	OBL
Tidal Wetland Transition		*Amsinckia menziesii*	fiddleneck	FACU?
	*	*Atriplex patula [triangularis]*	fat hen	FACW
	*	*Centromadia pungens*	spikeweed	FAC/UPL
	*	*Distichlis spicata*	salt grass	FAC/FACW
	*	*Euthamia occidentalis*	western goldenrod	FACW
	*	*Frankenia salina*	alkali heath	FACW
	*	*Grindelia stricta var. angustifolia*	marsh gumplant	FACW
	*	*Heliotropium curassavicum*	heliotrope	FACU/OBL
		Iva axilaris	deer root, poverty weed	FAC
	*	*Juncus arcticus ssp. balticus*	wire rush	FACW
		Juncus arcticus ssp. mexicanus	Mexican rush	FACW
	*	*Lasthenia glabrata*	smooth goldfields	FACW
	*	*Leymus triticoides*	creeping wildrye	FAC
	*	*Rumex fueginus [maritimu]*	golden dock	FACW
		Sesuvium verrucosum	western sea-purslane	FACW
		Spergularia macrotheca	sticky sand-spurrey	FAC
	*	*Symphyotrichum [Aster] chilense*	common aster	FAC
Tidal Wetland Uplands	*	*Achillea millefolium*	yarrow	FACU
	*	*Ambrosia psilostachya*	western ragweed	FACU
	*	*Amsinckia menziesii*	fiddleneck	FACU?
	*	*Atriplex lentiformis ssp. lentiformis*	big saltbush	FAC
		Carex tumulicola	slender sedge	FACU
	*	*Danthonia californica*	California oatgrass	FACU/FAC
		Distichlis spicata	salt grass	FAC/FACW
	*	*Elymus glaucus*	blue wild-rye	FACU
	*	*Festuca idahoensis*	Idaho fescue	FACU
		Heteromeles arbutifolia	toyon	NL
		Iris douglasiana	Douglas iris	NL
	*	*Ranunculus californicus*	California buttercup	FACU/FAC
Freshwater Wetland Low Marsh	*	*Schoenoplectus [Scirpus] acutus*	bulrush	OBL
	*	*Schoenoplectus [Scirpus] californicus*	California bulrush	OBL
Freshwater Wetland Middle Marsh		*Anemopsis californica*	yerba manza	OBL
	*	*Baccharis douglasii*	marsh baccharis	OBL
	*	*Euthamia occidentalis*	western goldenrod	FACW
	*	*Juncus arcticus ssp. balticus*	wire rush	FACW
		Juncus bufonius	toad rush	FACW
	*	*Juncus effusus*	common rush	FACW
	*	*Juncus xiphioides*	iris-leaved rush	OBL
Freshwater Wetland High Marsh	*	*Hordeum brachyantherum ssp. brachyantherum*	meadow barley	FACW
	*	*Juncus patens*	spreading rush	FACW
	*	*Sisyrinchium bellum*	blue-eyed grass	FACW
Freshwater Wetland Uplands		*Agrostis exarata*	spike bent grass	FACW
	*	*Artemisia douglasiana*	mugwort	FACW
		Carex praegracilis	meadow sedge	FACW
	*	*Deschampsia caespitosa var. holciformis*	Pacific hairgrass, tufted hairgrass	FACW
	*	*Festuca rubra var. Molate*	red fescue	FAC
	*	*Hordeum brachyantherum ssp. californicum*	meadow barley	FAC
	*	*Juncus patens*	spreading rush	FACW
	*	*Leymus triticoides*	creeping wildrye	FAC
		Scrophularia californica	bee-plant	FAC
		Symphyotrichum [Aster] chilense	common aster	FAC
	*	*Trifolium willdenovii*	tomcat clover	FACW/FACU

*INDICATES KEYSTONE SPECIES.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: EngineeringRemediation Resources Group, Inc., 1111 Broadway, Suite 300, San Francisco, California 94104, (415) 399-9974

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DESIGN BY:	EJ
CHIEF ENG:	DB
PM/CM:	DB

ENGINEERING/ REMEDIATION RESOURCES GROUP, INC.
SAN FRANCISCO, CA

WETLANDS PLANTING PLAN AND DETAILS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25–049
CONSTR. CONTR. NO.	N68711–05–C–6011
DRAWING NO.	C24

SHEET 26 OF 41 SHEETS

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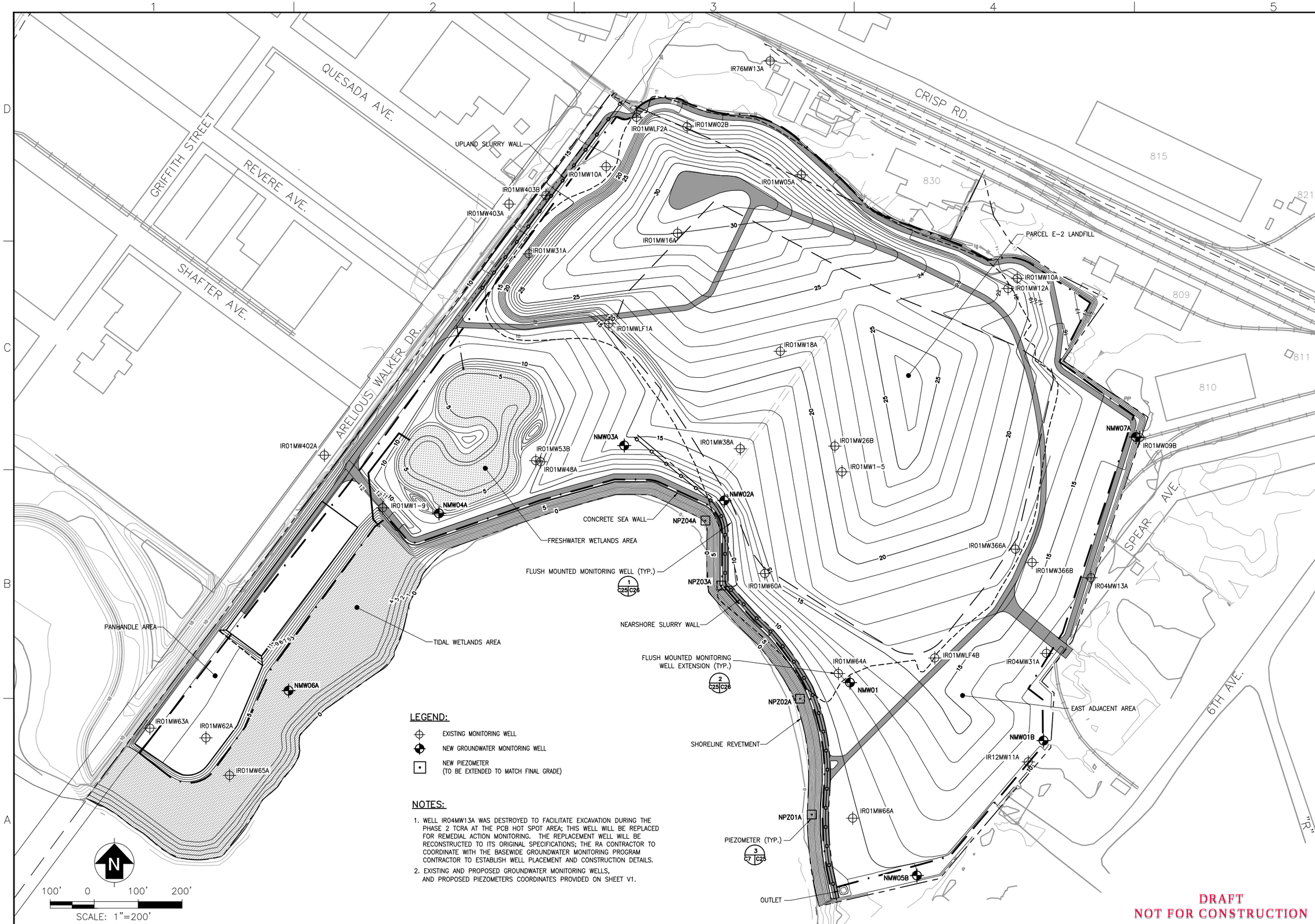

LEGEND:

- EXISTING MONITORING WELL
- NEW GROUNDWATER MONITORING WELL
- NEW PIEZOMETER (TO BE EXTENDED TO MATCH FINAL GRADE)

NOTES:

1. WELL IR04MW13A WAS DESTROYED TO FACILITATE EXCAVATION DURING THE PHASE 2 TCRA AT THE PCB HOT SPOT AREA; THIS WELL WILL BE REPLACED FOR REMEDIAL ACTION MONITORING. THE REPLACEMENT WELL WILL BE RECONSTRUCTED TO ITS ORIGINAL SPECIFICATIONS; THE RA CONTRACTOR TO COORDINATE WITH THE BASEWIDE GROUNDWATER MONITORING PROGRAM CONTRACTOR TO ESTABLISH WELL PLACEMENT AND CONSTRUCTION DETAILS.
2. EXISTING AND PROPOSED GROUNDWATER MONITORING WELLS, AND PROPOSED PIEZOMETERS COORDINATES PROVIDED ON SHEET V1.

SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 399-9974, ERRG

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

GROUNDWATER MONITORING WELL PLAN

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C25
SHEET 27 OF 41 SHEETS	

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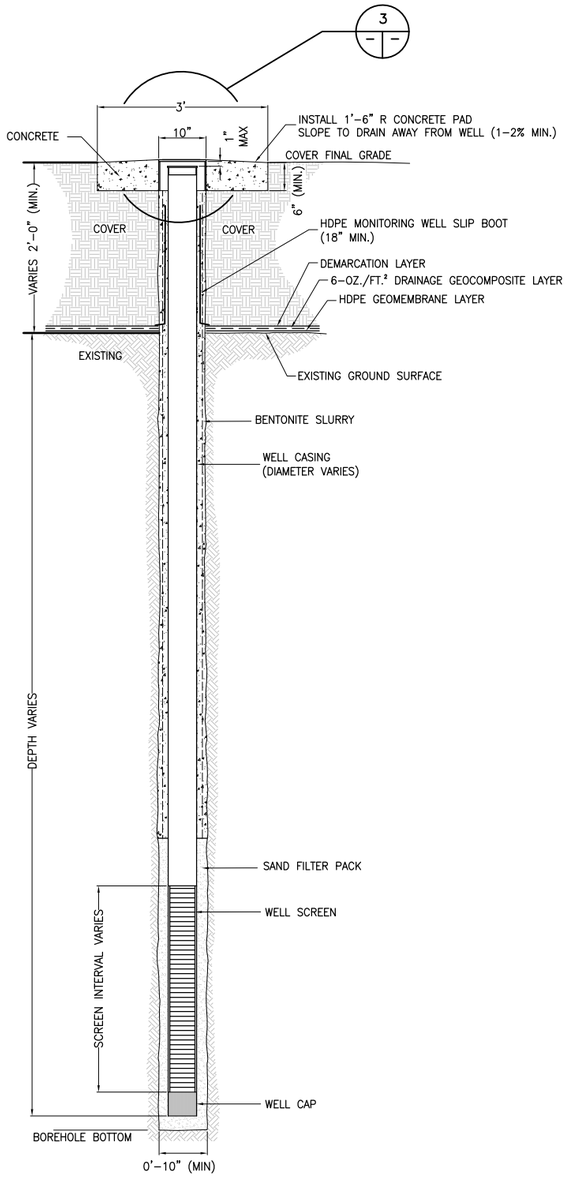
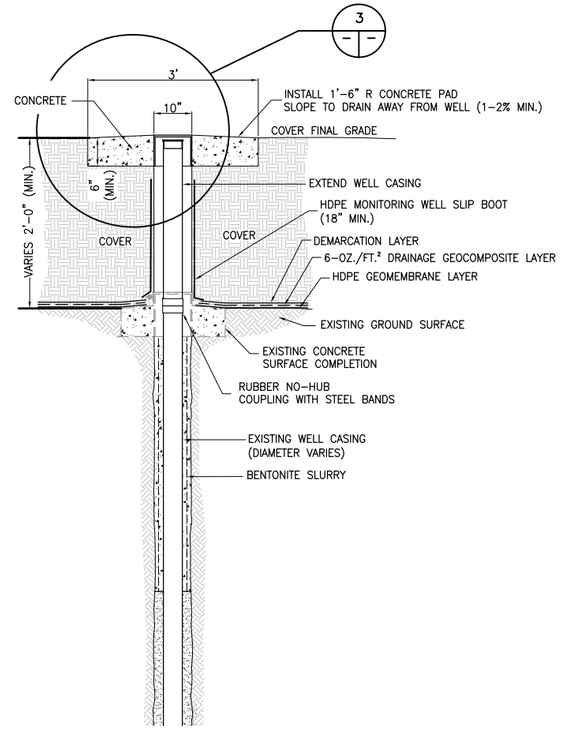


1 C26 C25 NEW FLUSH MOUNTED GROUNDWATER MONITORING WELL (TYP.)

NOT TO SCALE

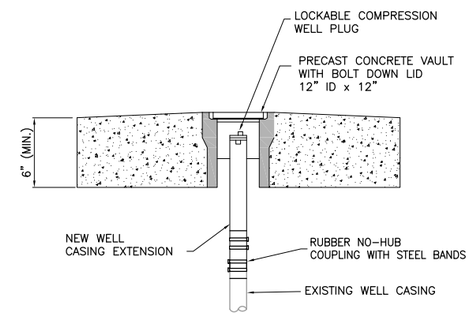


NOTES:

1. ACTUAL CONSTRUCTION MAY VARY DEPENDING ON WELL LOCATION.
2. MONITORING WELL CASING AND SCREEN MATERIAL FLUSH THREADED SCHEDULE 40 PVC PIPING UNLESS NOTED OTHERWISE.
3. GROUNDWATER MONITORING WELLS NOT DESIGNATED TO BE ABANDONED WILL BE EXTENDED AS NEEDED OR REPLACED TO MEET THE FINAL SURFACE GRADE WITH EQUIVALENT MATERIALS.
4. WELL HEAD VAULTS AND SURFACE COMPLETIONS WILL BE REPLACED IN ACCORDANCE WITH DRAWING C26, DETAILS 2 AND 3.
5. CONCRETE SURFACE COMPLETIONS CAN REMAIN IN PLACE IF NOT OBSTRUCTIVE TO THE EXTENSION.

2 C26 C25 FLUSH MOUNTED GROUNDWATER MONITORING WELL EXTENTION (TYP) FOR ALL EXISITNG WELLS

NOT TO SCALE



3 COMPLETION DETAILS FOR WELLS LOCATED WITHIN CAP FOOTPRINT

NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0974, ERRG

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GROUNDWATER MONITORING WELL DETAILS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C26
SHEET 28 OF 41 SHEETS

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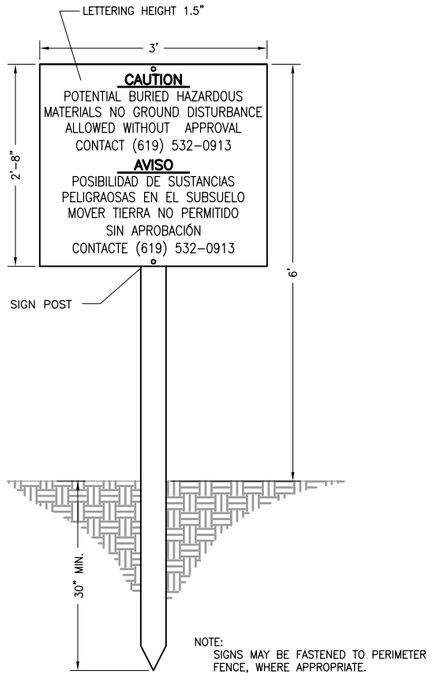
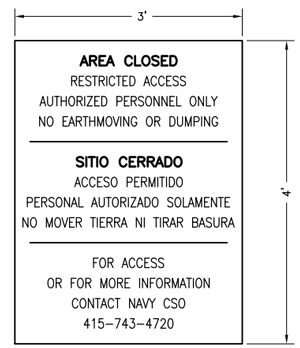


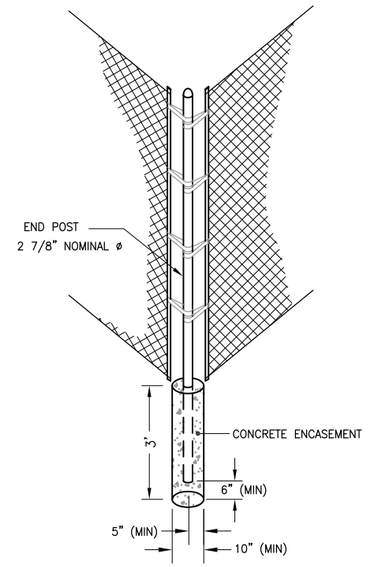
NOTE:
SIGNS MAY BE FASTENED TO PERIMETER FENCE, WHERE APPROPRIATE.

1 WARNING SIGN
SCALE: 1" = 1'-0"

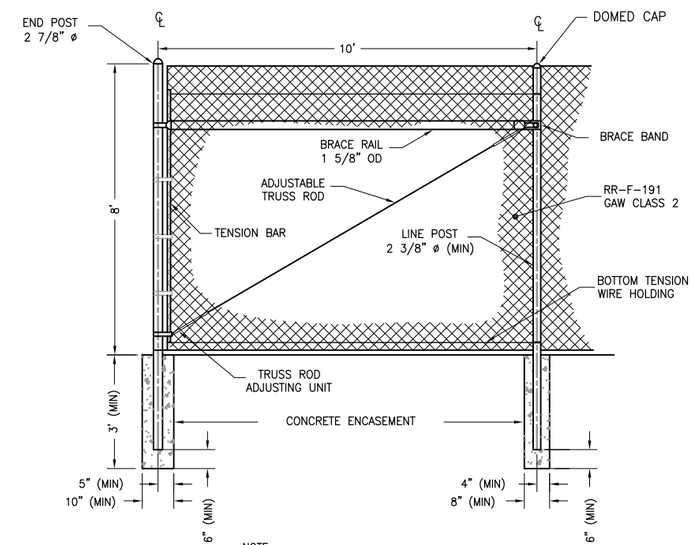


NOTE:
SECURE SIGN TO FENCE NEAR SITE ENTRANCE.

2 ENTRANCE SIGN
SCALE: 1" = 1'-0"

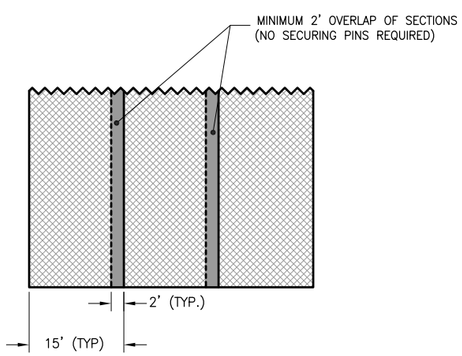


3 FENCE POST DETAIL
SCALE: 1/2" = 1'-0"

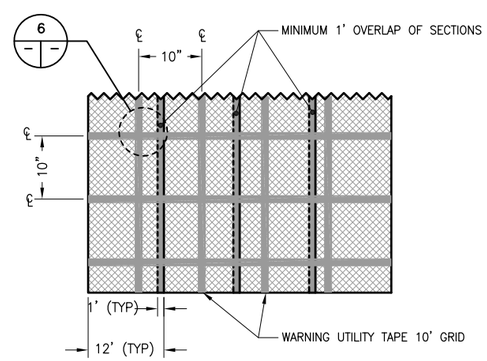


NOTE:
FENCE SEPARATING NAVY AND NON-NAVY PROPERTY SHOULD INCLUDE RAZOR WIRE ALONG TOP.

4 FENCE DETAIL
SCALE: 1/2" = 1'-0"

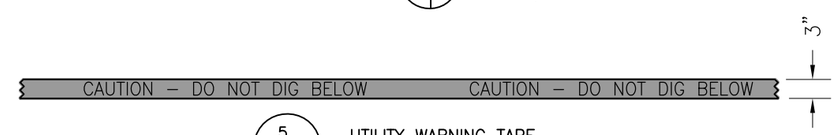


6 FILTER FABRIC DETAIL – REVETMENT
SCALE: 1" = 1'-0"

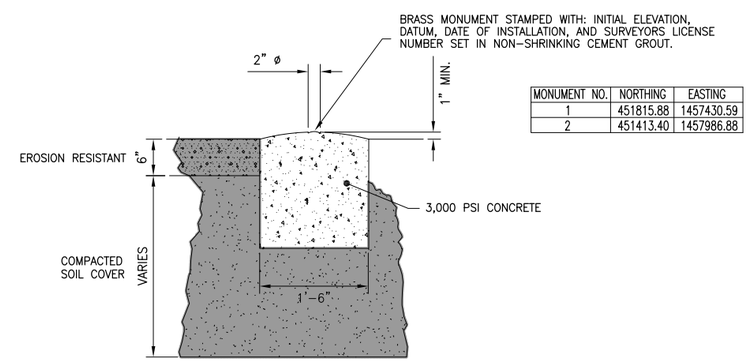


NOTE:
FABRIC AND UTILITY TAPE SECURED TO SOIL USING SECURING PINS (ONE PIN PER 10' IN ALL DIRECTIONS).

7 DEMARCATON LAYER – EXTENT OF RESTRICTIONS RELATED TO RADIONUCLIDES
SCALE: 1" = 1'-0"



5 UTILITY WARNING TAPE
NOT TO SCALE



MONUMENT NO.	NORTHING	EASTING
1	451815.88	1457430.59
2	451413.40	1457986.88

8 MONUMENT (TYP.)
SCALE: 1" = 1'-0"

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SYM	DESCRIPTION	DATE	APPR.

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PERIMETER FENCE, SIGN AND SETTLEMENT MONUMENT DETAILS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C27
SHEET 29 OF 41 SHEETS

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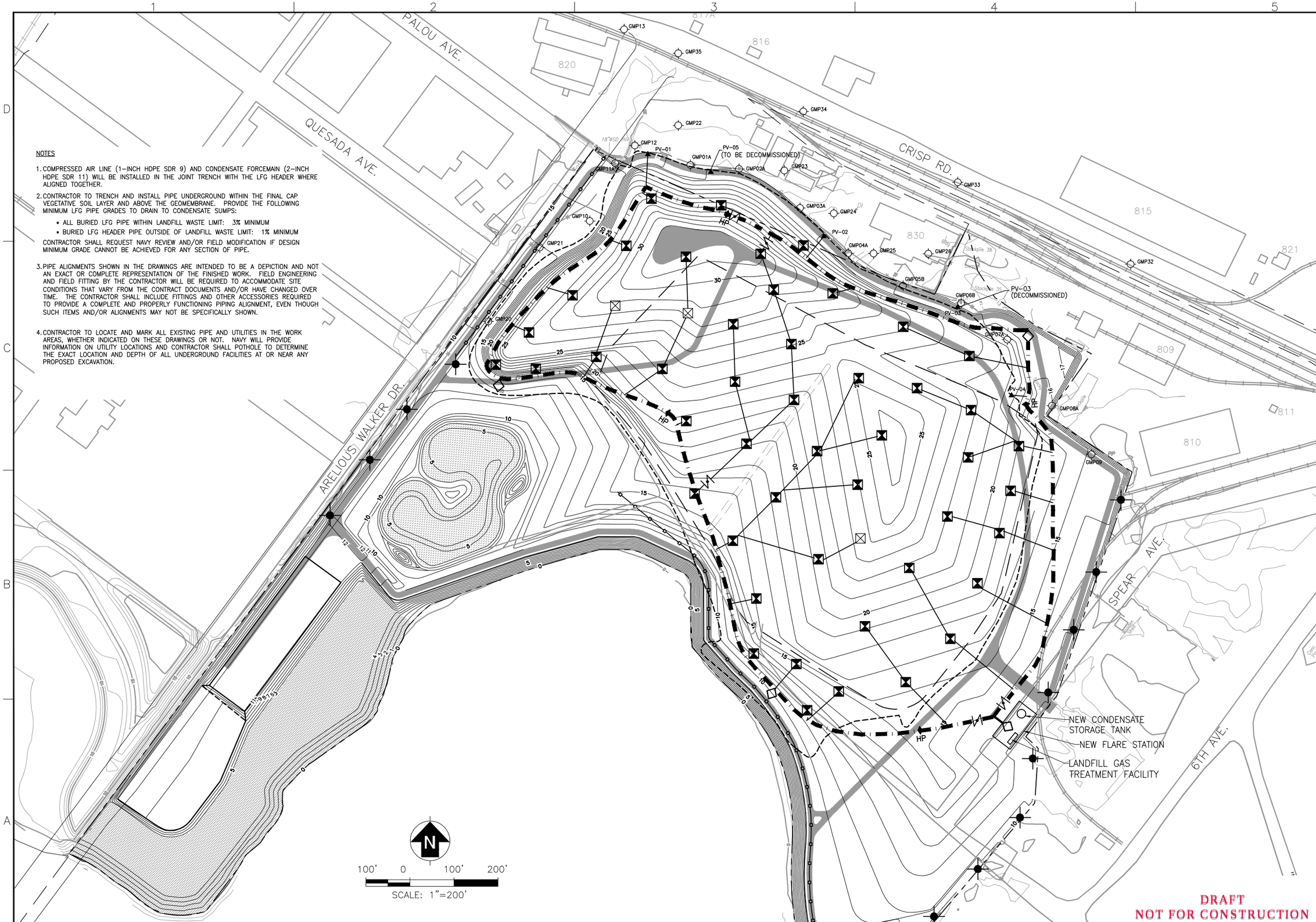
NOTES

1. COMPRESSED AIR LINE (1-INCH HDPE SDR 9) AND CONDENSATE FORCEMAIN (2-INCH HDPE SDR 11) WILL BE INSTALLED IN THE JOINT TRENCH WITH THE LFG HEADER WHERE ALIGNED TOGETHER.
2. CONTRACTOR TO TRENCH AND INSTALL PIPE UNDERGROUND WITHIN THE FINAL CAP VEGETATIVE SOIL LAYER AND ABOVE THE GEOMEMBRANE. PROVIDE THE FOLLOWING MINIMUM LFG PIPE GRADES TO DRAIN TO CONDENSATE SUMPS:
   - ALL BURIED LFG PIPE WITHIN LANDFILL WASTE LIMIT: 3% MINIMUM
   - BURIED LFG HEADER PIPE OUTSIDE OF LANDFILL WASTE LIMIT: 1% MINIMUM

   CONTRACTOR SHALL REQUEST NAVY REVIEW AND/OR FIELD MODIFICATION IF DESIGN MINIMUM GRADE CANNOT BE ACHIEVED FOR ANY SECTION OF PIPE.
3. PIPE ALIGNMENTS SHOWN IN THE DRAWINGS ARE INTENDED TO BE A DEPICTION AND NOT AN EXACT OR COMPLETE REPRESENTATION OF THE FINISHED WORK. FIELD ENGINEERING AND FIELD FITTING BY THE CONTRACTOR WILL BE REQUIRED TO ACCOMMODATE SITE CONDITIONS THAT VARY FROM THE CONTRACT DOCUMENTS AND/OR HAVE CHANGED OVER TIME. THE CONTRACTOR SHALL INCLUDE FITTINGS AND OTHER ACCESSORIES REQUIRED TO PROVIDE A COMPLETE AND PROPERLY FUNCTIONING PIPING ALIGNMENT, EVEN THOUGH SUCH ITEMS AND/OR ALIGNMENTS MAY NOT BE SPECIFICALLY SHOWN.
4. CONTRACTOR TO LOCATE AND MARK ALL EXISTING PIPE AND UTILITIES IN THE WORK AREAS, WHETHER INDICATED ON THESE DRAWINGS OR NOT. NAVY WILL PROVIDE INFORMATION ON UTILITY LOCATIONS AND CONTRACTOR SHALL POTHOLE TO DETERMINE THE EXACT LOCATION AND DEPTH OF ALL UNDERGROUND FACILITIES AT OR NEAR ANY PROPOSED EXCAVATION.



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SYM	DESCRIPTION	DATE	APPR.

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LFG COLLECTION SYSTEM PLAN

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C28
SHEET 30 OF 41 SHEETS	

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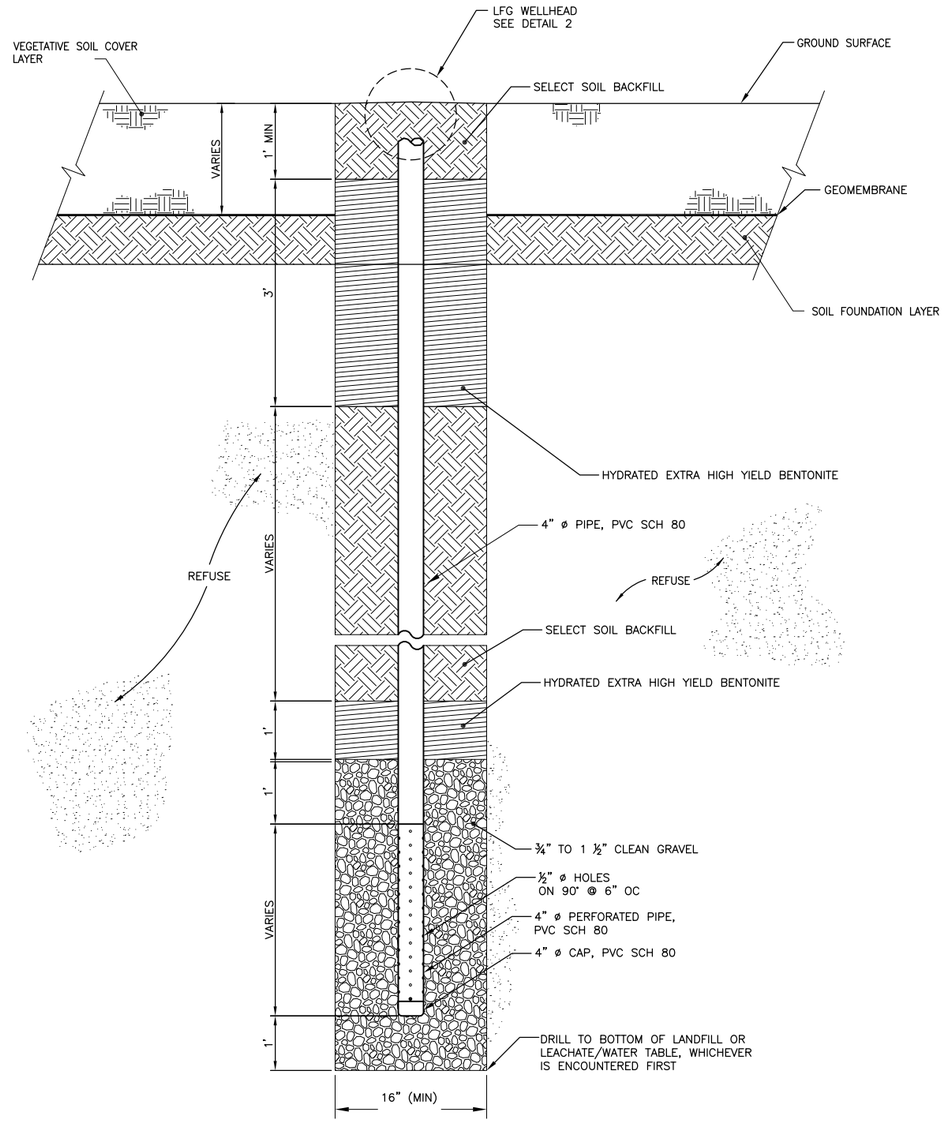
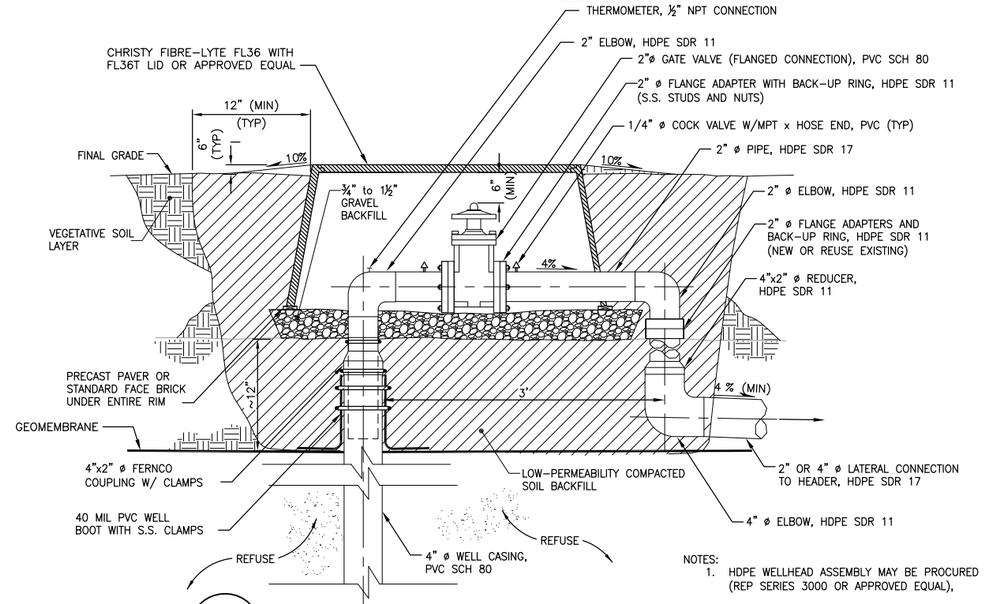
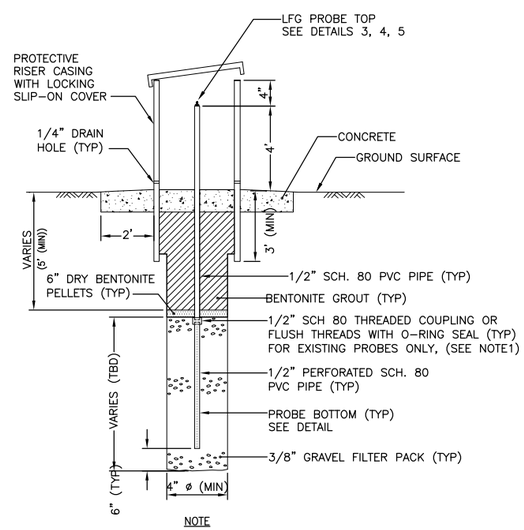


1 — LFG EXTRACTION WELL DETAIL
NOT TO SCALE



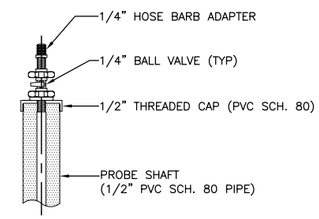
NOTES:
1. HDPE WELLHEAD ASSEMBLY MAY BE PROCURED PRE-FABRICATED (REP SERIES 3000 OR APPROVED EQUAL),
2. POSITION UTILITY BOX AND LID TO MAXIMIZE VALVE AND SAMPLE PORT ACCESS THROUGH HANDHOLES.

2 — LFG WELLHEAD BELOW GROUND DETAIL
NOT TO SCALE

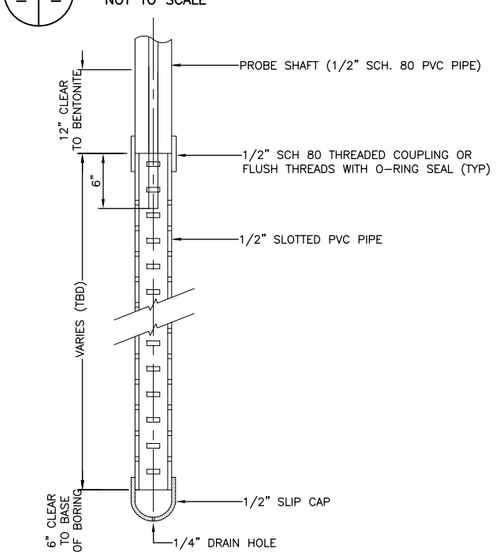


NOTE
1. LFG MONITORING PROBES NOT DESIGNATED TO BE ABANDONED WILL BE EXTENDED AS NEEDED OR REPLACED TO MEET THE FINAL SURFACE GRADE WITH EQUIVALENT MATERIALS.

3 — SINGLE-LEVEL LFG MONITORING PROBE DETAIL
NOT TO SCALE



4 — LFG PROBE TOP
NOT TO SCALE



5 — LFG PROBE BOTTOM DETAIL
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 3950874

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LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 1

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	C29
SHEET 31 OF 41 SHEETS	

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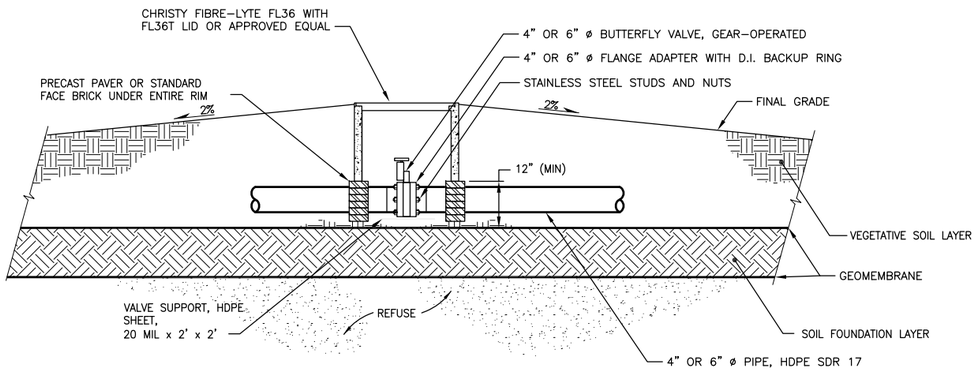
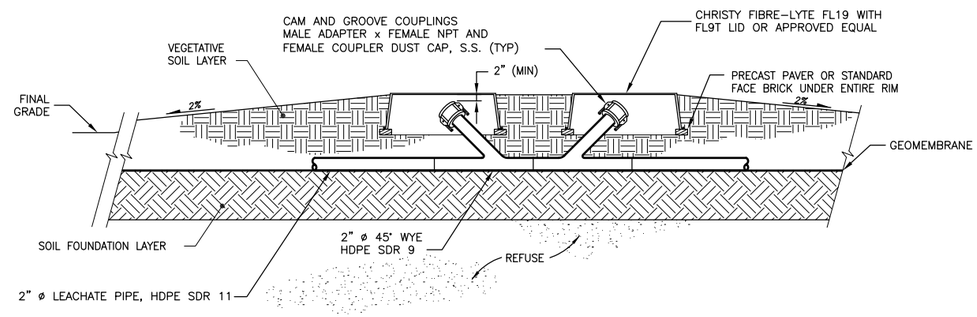


9 — BUTTERFLY VALAVE BELOW GROUND DETAIL
NOT TO SCALE



12 — CONDENSATE PIPE CLEAN-OUT DETAIL
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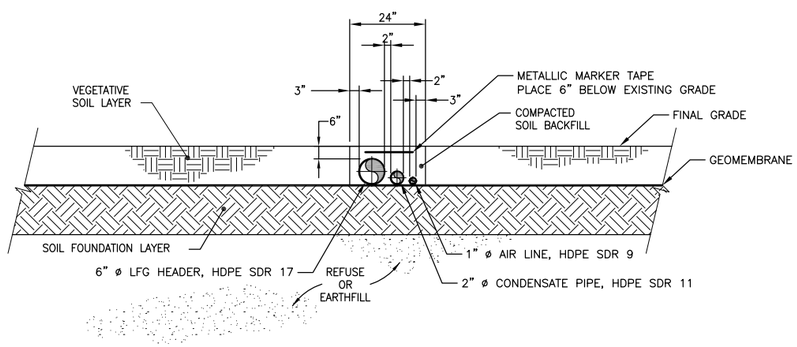

10 — BURIED PIPE TRENCH DETAIL
NOT TO SCALE

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LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 2

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C30
SHEET 32 OF 41 SHEETS

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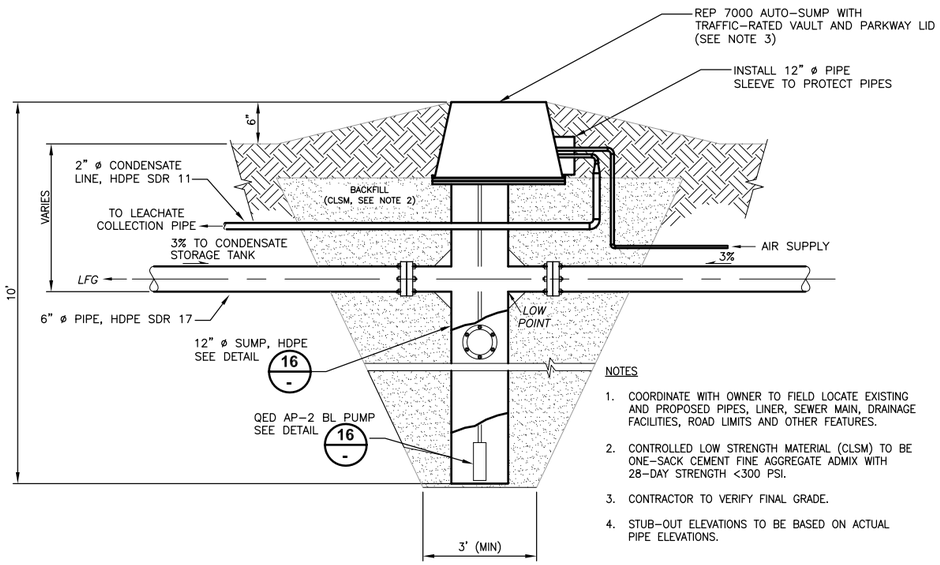
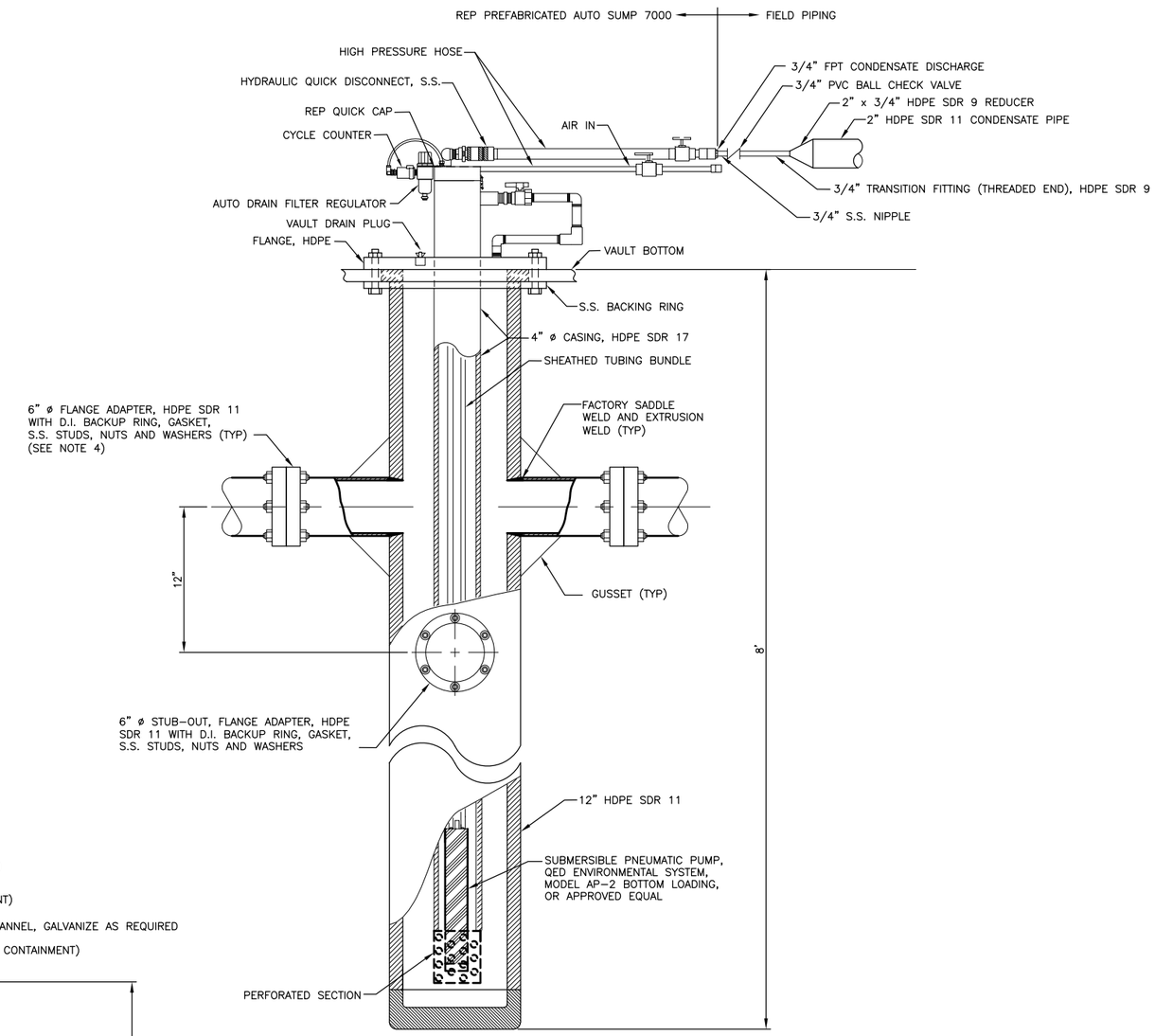


NOTES

1. COORDINATE WITH OWNER TO FIELD LOCATE EXISTING AND PROPOSED PIPES, LINER, SEWER MAIN, DRAINAGE FACILITIES, ROAD LIMITS AND OTHER FEATURES.
2. CONTROLLED LOW STRENGTH MATERIAL (CLSM) TO BE ONE-SACK CEMENT FINE AGGREGATE ADMIX WITH 28-DAY STRENGTH <300 PSI.
3. CONTRACTOR TO VERIFY FINAL GRADE.
4. STUB-OUT ELEVATIONS TO BE BASED ON ACTUAL PIPE ELEVATIONS.

15 — TYPICAL CONDENSATE SUMP
REP AUTO SUMP 7000 OR APPROVED EQUAL
NOT TO SCALE



16 — CONDENSATE SUMP PUMP
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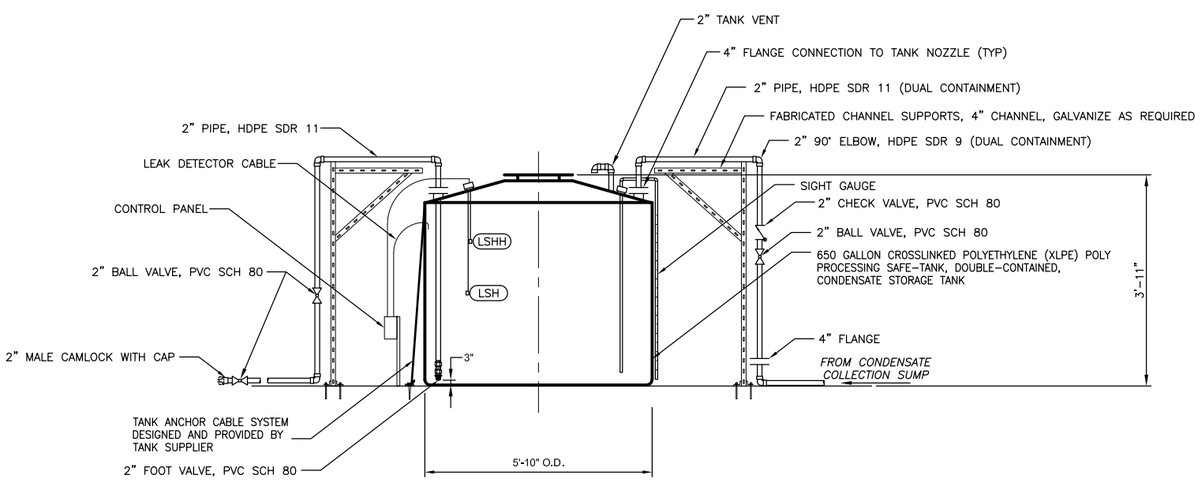

17 — CONDENSATE STORAGE TANK
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

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LFG CONDENSATE EXTENSION WELL MISCELLANEOUS DETAILS 3

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. C31
SHEET 33 OF 41 SHEETS

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INSTRUMENT OR FUNCTION SYMBOLS

LOCALLY MOUNTED	PANEL MOUNTED FRONT	PANEL MOUNTED BACK	
TAG NO	TAG NO	TAG NO	INSTRUMENT
TAG NO	TAG NO	TAG NO	SHARED DISPLAY, SHARED CONTROL
TAG NO	TAG NO	TAG NO	COMPUTER FUNCTION
TAG NO	TAG NO	TAG NO	PLC CONTROL

R RESET P PURGE I INTERLOCK

TAG NO TAG NO INSTRUMENTS SHARING COMMON HOUSING

PIPING & INSTRUMENT LINE SYMBOLS

- FLOW DIRECTION
- MAIN FLOW
- SECONDARY FLOW
- ELECTRIC SIGNAL
- BOUNDARY
- SUPPLIED BY OTHERS

VALVES, REGULATORS, AND OTHER DEVICES

- BALL VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- THREE WAY VALVE
- MANUALLY OPERATED VALVE
- S SOLENOID OPERATED VALVE
- M ELECTRIC MOTOR OPERATED VALVE
- PRESSURE REDUCING REGULATOR
- PRESSURE RELIEF VALVE
- FLANGED CONNECTION
- FLEXIBLE CONNECTION
- REDUCER
- VENTURI TUBE
- ORIFICE PLATE
- UNION
- FLAME ARRESTER
- DAMPER (AUTOMATED)
- BLOWER OR PUMP
- LIGHT

EQUIPMENT SCHEDULE

TAG	NO.	DESCRIPTION	CAPACITY	SERVICE
BL	101	LFG Blower	50 to 150 scfm	LFG
BL	102	LFG Blower	50 to 150 scfm	LFG
GAC	301	GAC Vessel	50 to 150 scfm	LFG
GAC	302	GAC Vessel	50 to 150 scfm	LFG
PZ	301	Permanganate Zeolite Vessel	50 to 150 scfm	LFG
PZ	302	Permanganate Zeolite Vessel	50 to 150 scfm	LFG
EF	200	Enclosed Clean Emission Burner	0.2 to 1.7 MMbtu/hr	LFG
FA	213	Flame Arrestor	0 to 150 cfm	LFG
KOP	-	Condensate Knock-out Pot	0 to 150 cfm	LFG
PMP	201	Combustion Air Blower	400 to 1,200 scfm	Air
CP	400	Condensate Pump, Pneumatic	8 gpm	Cond.
CS	400	Condensate Sump	50 gal	Cond.
CRS	401	Compressor, Rotary Screw	20 scfm, 80 gal	Air
CST	402	Condensate Storage Tank	500 gal	Cond.
SIC	110	Speed Control (VSD)	2500 to 4500 rpm	LFG

INSTRUMENTATION SCHEDULE

TAG	NO.	DESCRIPTION	RANGE	SERVICE
BE	203	Flame Detection Element	0 to 5v	UV
BIA	203	Flame-out Indicating Alarm	0 to 5v	UV
FCZC	200	Flow Valve Position Closed	O/C	LFG
FCZO	200	Flow Valve Position Open	O/C	LFG
FCZC	300	Flow Valve Position Closed	O/C	LFG
FCZO	300	Flow Valve Position Open	O/C	LFG
FIT	200	Flow Indicating Transmitter	0 to 180 cfm	LFG
FLS	202	Combustion Air Flow Switch (Low)	O/C	Air
LHA	100	Level Alarm (Hi)	O/C	Cond.
LHA	400	Level Alarm (Hi)	O/C	Cond.
LI	100	Level Indicator	-	Cond.
PI	100	Pressure Indicator (Gauge)	0 to 100" wcg	LFG
PI	212	Diff. Pressure Indicator (Gauge)	0 to 10" wcg	LFG
VI	301	Vacuum Indicator (Gauge)	0 to -40" wcg	LFG
PIT	200	Pressure Indicating Transmitter	0 to 100" wcg	LFG
PIT	300	Pressure Indicating Transmitter	0 to 100" wcg	LFG
QIR	200	Quantity Indicating Recorder	Various	Various
TAH	204	Temperature Alarm (Hi)	100 to 600°F	LFG
TCZ	202	Temperature Controlling Positioner	O/C	Air
TE	203	Temperature Element	1000 to 2200°F	Burner
TE	206	Temperature Element	1000 to 2200°F	Stack
THS	203	Temperature Switch (Hi)	1000 to 2200°F	Burner
THS	207	Temperature Switch (Hi)	1000 to 2200°F	Stack
THS	203	Temperature Switch (Hi)	1000 to 2200°F	Burner
THS	207	Temperature Switch (Hi)	1000 to 2200°F	Stack
TIC	202	Temperature Indicating Controller	100 to 2200°F	Stack
TLS	203	Temperature Switch (Low)	100 to 1600°F	Burner
TLS	208	Temperature Switch (Low)	100 to 1600°F	Stack
VI	100	Vacuum Indicator (Gauge)	0 to -40" wcg	LFG
VIS	101	Vibration Switch (Hi)	tbd	-
VIS	102	Vibration Switch (Hi)	tbd	-
VIT	100	Vacuum Indicating Transmitter	0 to -40" wcg	LFG

CONTROL VALVE SCHEDULE

TAG	NO.	DESCRIPTION	SIZE	SERVICE
CV	110	Check Valve	3"	LFG
EJ	110	Expansion Joint	3"	LFG
FCV	200	Flow Control (Butterfly) Valve	4"	LFG
HV	101	Butterfly Valve	6"	LFG
HV	103	Butterfly Valve	3"	LFG
HV	110	Butterfly Valve	4"	LFG
HV	111	3-way (L) Ball Valve	1/4"	LFG
HV	301	Ball Valve	2"	LFG
HV	302	Butterfly Valve	4"	LFG
HV	401	Ball Valve	1"	Cond.
HV	402	Ball Valve	1/2"	Cond.
PRR	210	Pressure Reducing Regulator	1"	Propane
PRV	210	Pressure Relief Valve	1"	Propane
S	-	Solenoid Valve	1"	Propane
TLV	201	Temperature Louver Control	TBD	Air

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0674

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SAN FRANCISCO, CA

LFG LEGEND AND TABLES

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. M1
SHEET 34 OF 41 SHEETS

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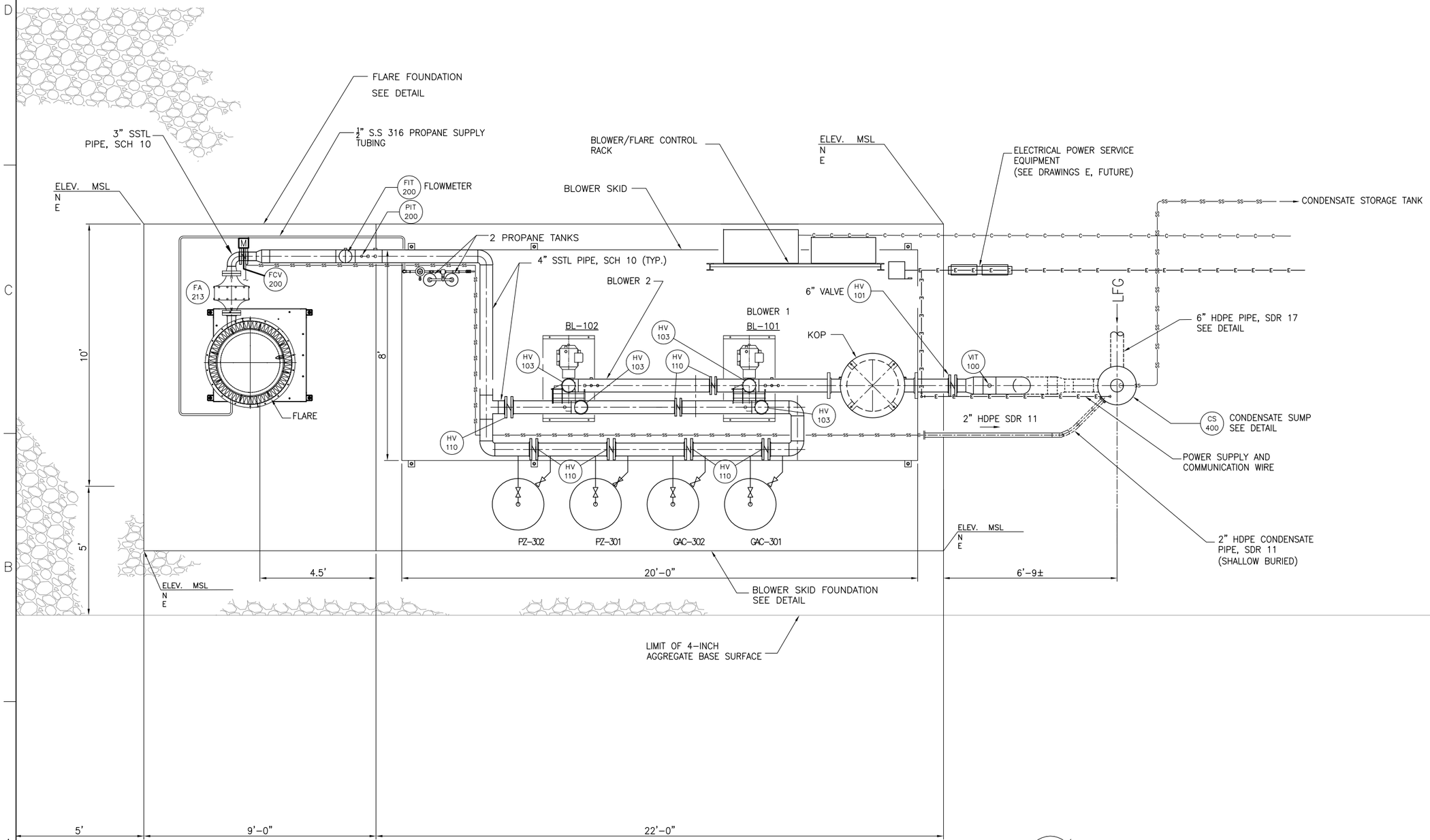

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SYM	DESCRIPTION	DATE	APPR.

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SAN FRANCISCO, CA

LFG BLOWER FLARE FACILITY

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	M2

SHEET 35 OF 41 SHEETS

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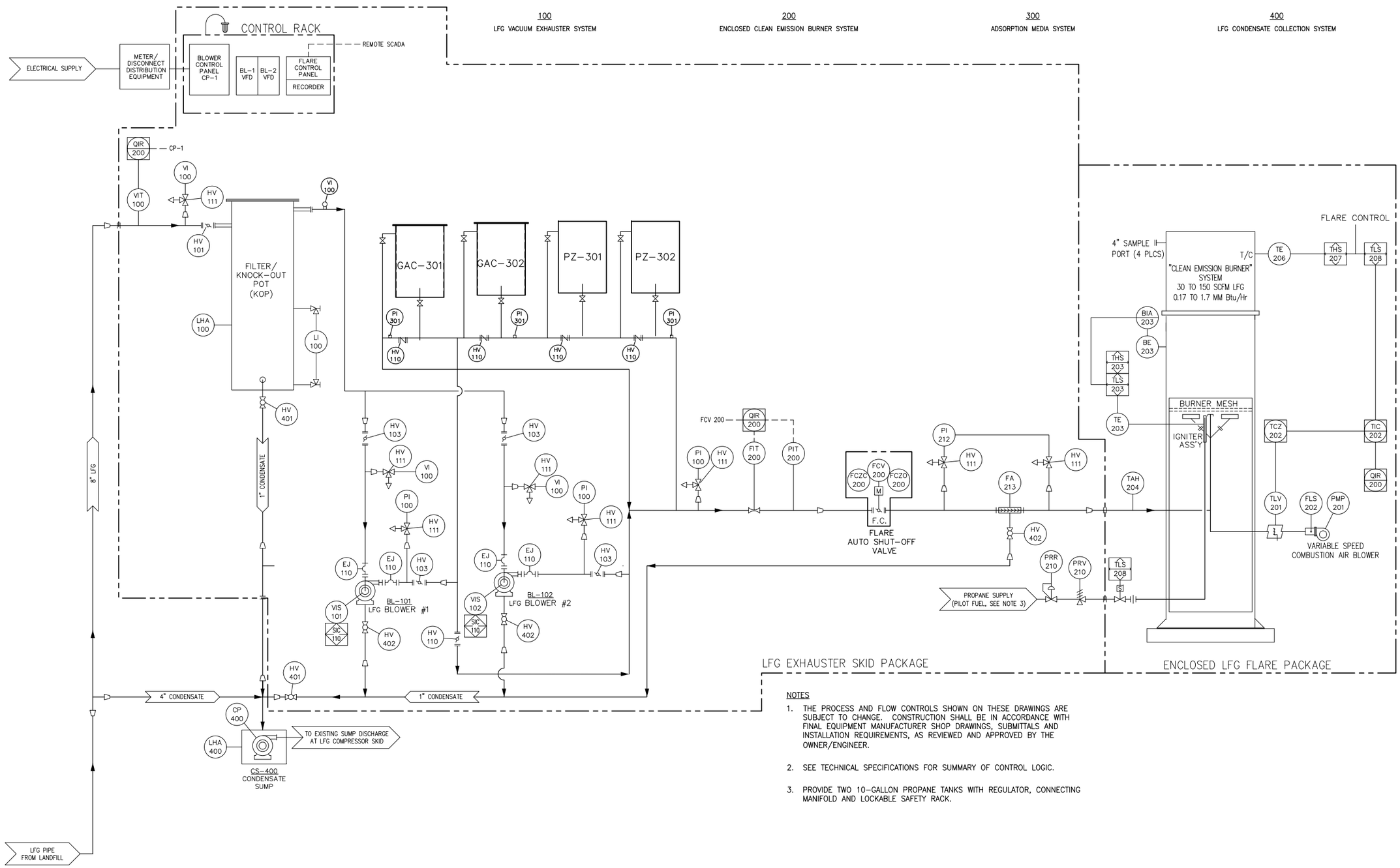

NOTES

1. THE PROCESS AND FLOW CONTROLS SHOWN ON THESE DRAWINGS ARE SUBJECT TO CHANGE. CONSTRUCTION SHALL BE IN ACCORDANCE WITH FINAL EQUIPMENT MANUFACTURER SHOP DRAWINGS, SUBMITTALS AND INSTALLATION REQUIREMENTS, AS REVIEWED AND APPROVED BY THE OWNER/ENGINEER.

2. SEE TECHNICAL SPECIFICATIONS FOR SUMMARY OF CONTROL LOGIC.

3. PROVIDE TWO 10-GALLON PROPANE TANKS WITH REGULATOR, CONNECTING MANIFOLD AND LOCKABLE SAFETY RACK.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 705-0674

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LFG BLOWER FLARE PFD

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	M3

SHEET 36 OF 41 SHEETS

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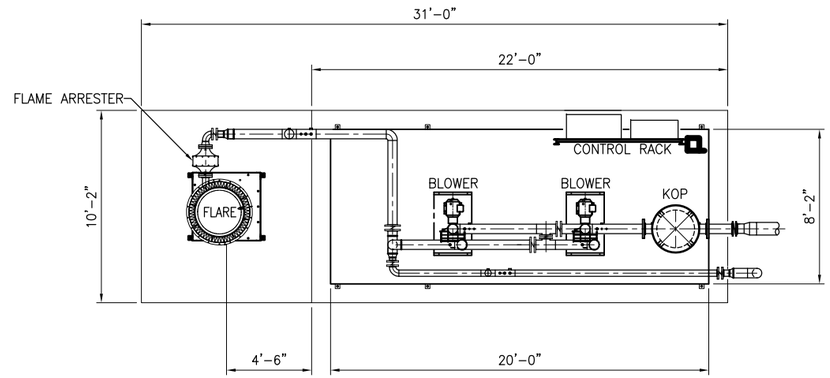
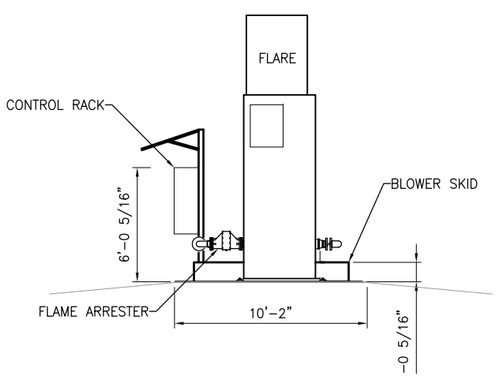
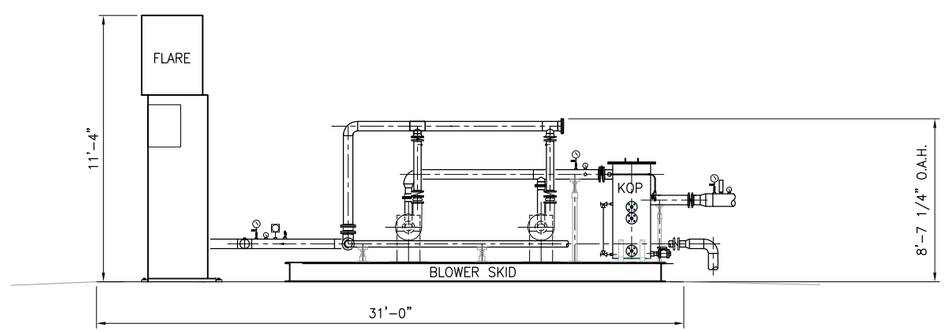


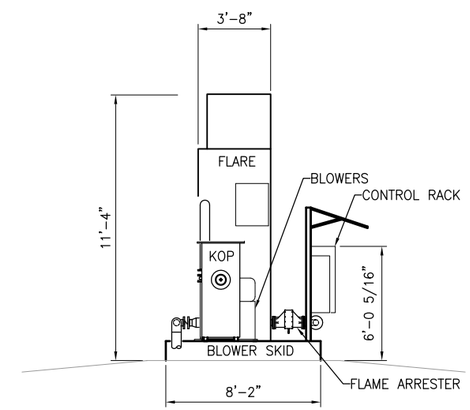
PLAN VIEW



LEFT ELEVATION



FRONT ELEVATION



RIGHT ELEVATION

4' 0 2' 4'

SCALE: 1"=4'

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SAN FRANCISCO, CA

LFG FLARE VIEWS

BRAC PMO WEST
SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	M4

SHEET 37 OF 41 SHEETS

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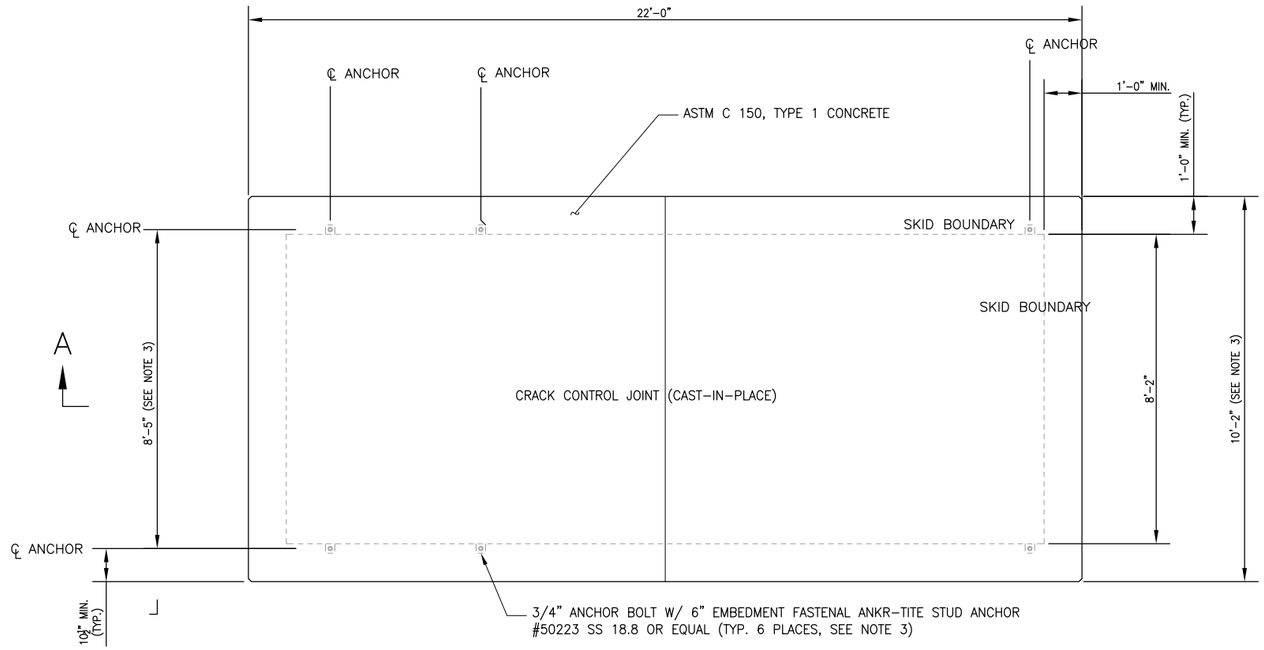
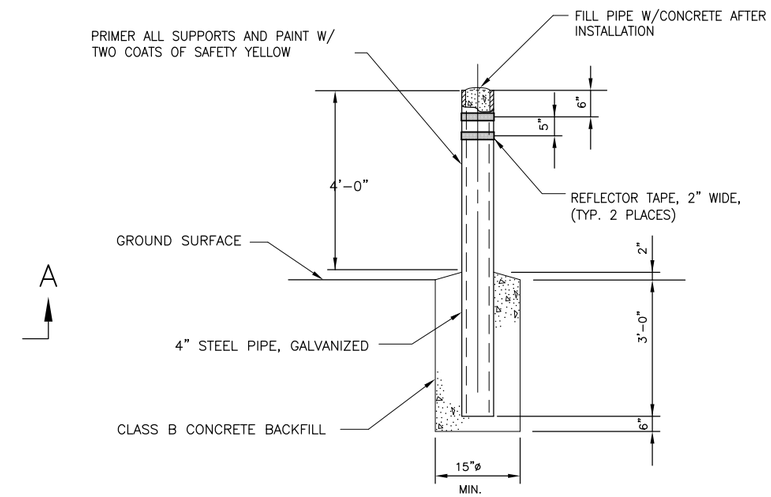
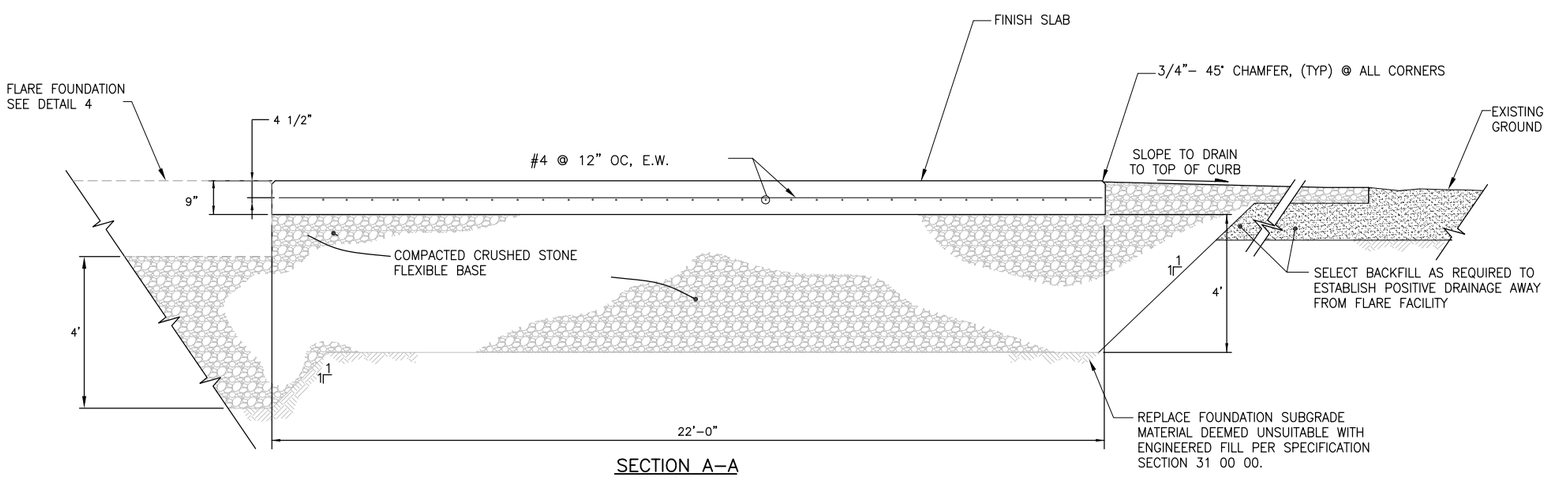


PLAN



3 M2 M5 BOLLARD DETAIL
NOT TO SCALE



SECTION A-A

2 M2 M5 BLOWER SKID FOUNDATION DETAIL
NOT TO SCALE

NOTES

1. CONTRACTOR TO POTHOLE TO LOCATE ALL EXISTING UNDERGROUND UTILITIES.
2. CONTRACTOR TO PROTECT ALL UTILITIES.
3. FOUNDATION AND ANCHOR BOLT DIMENSIONS MAY VARY BASED ON FINAL EQUIPMENT SHOP DRAWINGS.

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

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LFG BLFL FLARE SKID DETAILS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. M5
SHEET 38 OF 41 SHEETS

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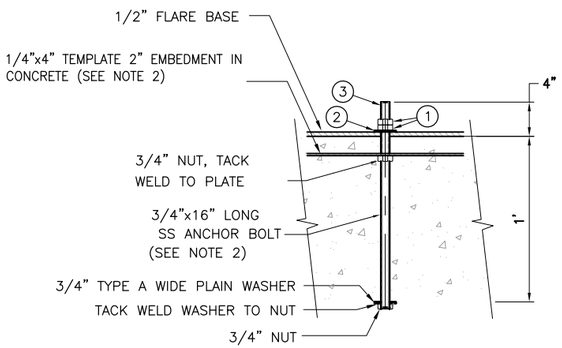
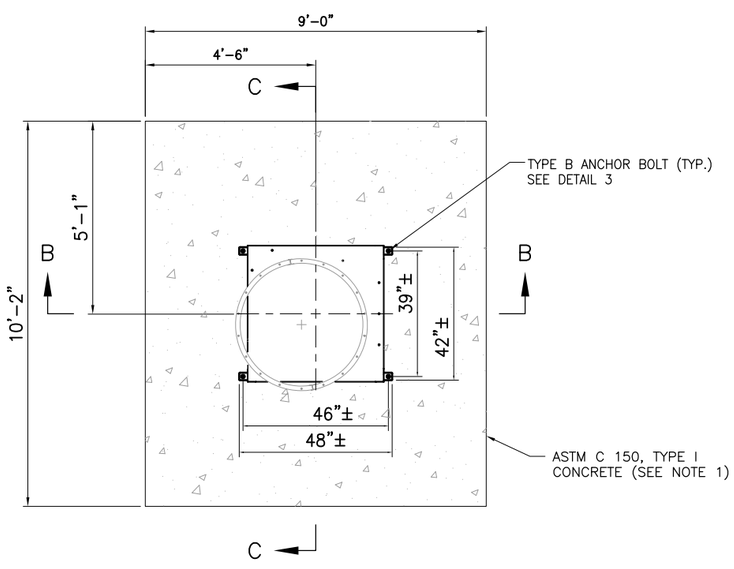
BILL OF MATERIAL		
ITEM	QTY	DESCRIPTION
1	16	NUT SS 1-8UNC
2	8	WASHER SS FOR 1-8UNC BOLT
3	4	ANCHOR BOLT ASSEMBLY SS



3 — TYPE B ANCHOR BOLT
NOT TO SCALE



PLAN
N.T.S.

NOTES

1. DESIGN CRITERIA

   WIND DESIGN:
   100 MPH ASCE7 AND 2007 CBC
   ALLOWABLE SOIL BEARING:
   1000 PSF

   CONCRETE STRENGTH:
   f'c=4000 PSI @ 28 DAYS

   CEMENT:
   ASTM C150 TYPE I

   REINFORCING STEEL:
   ASTM A615 GRADE 60 DEFORMED BAR

   SUBGRADE COMPACTION:
   90 PERCENT MODIFIED PROCTOR MAXIMUM DENSITY

   FLARE WEIGHT:
   2,600 LBS

   BASE SHEAR:
   3.9 kips

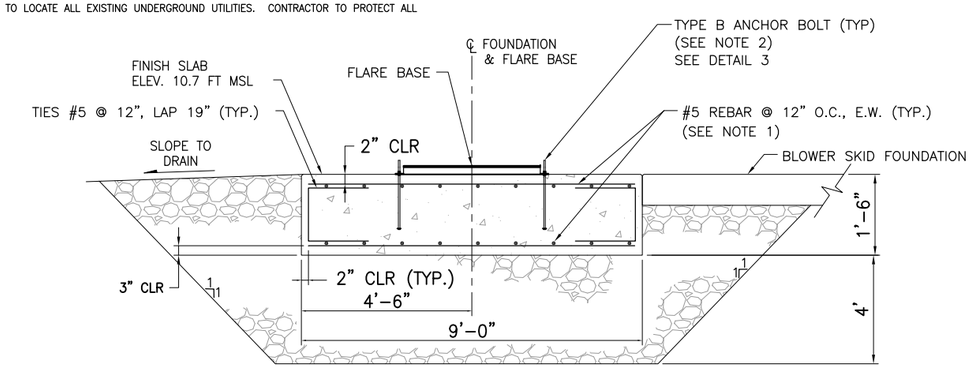
   MOMENT:
   37.8 ft.-kips

2. ANCHOR BOLT TEMPLATE TO BE PROVIDED BY FLARE MANUFACTURER. ANCHOR BOLT SIZE TO BE VERIFIED WITH MANUFACTURER'S SHOP PATTERN DRAWINGS PRIOR TO CONSTRUCTION.

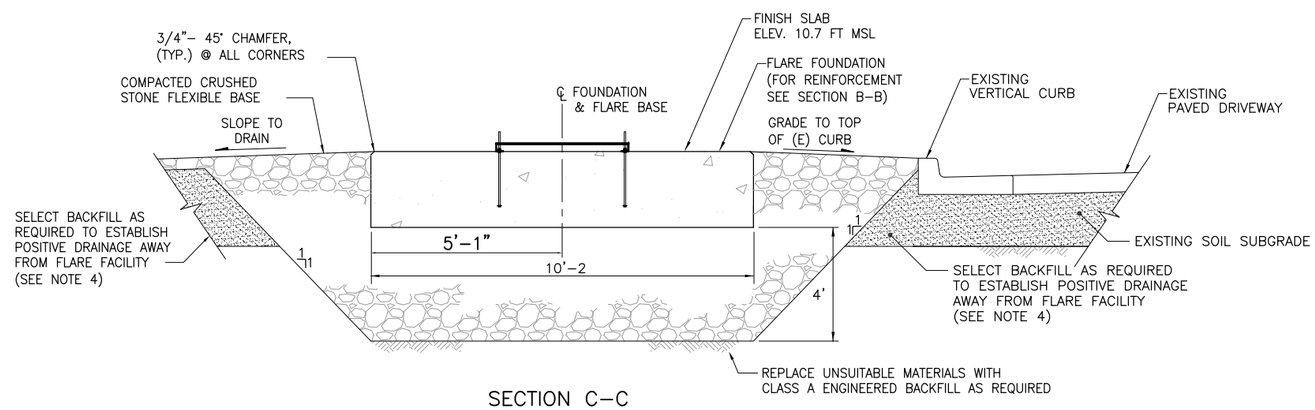
3. FOUR (4) CONCRETE TEST CYLINDERS SHALL BE TAKEN BY THE CONTRACTOR. ONE TEST CYLINDER SHALL BE TESTED AT 7 DAYS FOR 70 PERCENT OF DESIGN STRENGTH. TWO SHALL BE TESTED AT 28 DAYS FOR FULL DESIGN STRENGTH, AND ONE SHALL BE HELD UNTIL THE FINAL ACCEPTANCE OF THE PROJECT.

4. FINISH GRADE TO DRAIN. PLACE EARTHFILL PER SPECIFICATIONS SECTION 31 00 00.

5. CONTRACTOR TO POTHOLE TO LOCATE ALL EXISTING UNDERGROUND UTILITIES. CONTRACTOR TO PROTECT ALL UTILITIES.



SECTION B–B



SECTION C–C

4 M2 — 4 M3 — FLARE FOUNDATION DETAIL
NOT TO SCALE

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SYM	DESCRIPTION	DATE	APPR.

PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

PREPARED BY: Engineering/Remediation Resources Group, Inc., 115 Sansome Street, Suite 200, San Francisco, California 94104, (415) 395-0674, ERRG

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CHIEF ENG:	DB
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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

LFG BLFL FLARE FOUNDATION DETAILS

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE:	22" X 34"
SCALE:	AS NOTED
PROJ. NO.	25-049
CONSTR. CONTR. NO.	N68711-05-C-6011
DRAWING NO.	M6

SHEET 39 OF 41 SHEETS

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General Structural Notes

GENERAL

All construction and materials shall be in accordance with the requirements of the 2010 California Building Code and the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318–95) hereinafter collectively termed the "Code." Where explicit details and/or specifications are not shown or described, the most stringent requirements of the Code shall apply. Where conflicts occur between these notes and the requirements set forth in the Code, the latter shall govern. If interpretation of the structural drawings is necessary, the structural design engineer shall be contacted in writing for clarification, prior to commencing said work.

The Contractor shall verify existing conditions and dimensions prior to starting construction. The Engineer shall be notified of any discrepancies or inconsistencies found.

The Contractor shall notify the Engineer 48 hours prior to starting work so that inspection may be provided.

The Contractor shall be responsible for restoration of any improvements that are disturbed or damaged during the construction at no cost to the Owner.

The Contractor shall verify existence and location of all utilities before commencing work. Location of all existing utilities are shown per available record drawings obtained during design. The Contractor shall contact appropriate agencies to obtain revised updated or record information available just prior to construction. The Contractor shall take precautionary measures to protect and maintain utility lines shown and any others not of record or shown on these drawings.

The Contractor shall be responsible for enforcement of safety measures and regulations. The Contractor shall design and maintain safety devises including shoring and shall be solely responsible for conforming to all local, state and federal safety and health standards and regulations.

Upon completion of each day's work, the Contractor shall be responsible for leaving the work area free of hazards and shall provide all necessary temporary signs, warning devices and barricades.

The Contractor shall keep accurate and legible records on a set of project blueline prints of all changes of work which occur during construction. Prior to field acceptance, the Contractor shall deliver this Record Drawing information to the Engineer.

The Contractor shall perform all surveying necessary to construct the work to the lines, elevations and grades shown on the Drawings and for the Engineer's use in checking such work. All survey work on dry land shall be performed by a Land Surveyor registered in the State of California. All survey work for submerged areas shall be performed by a hydrographic surveyor certified by the American Congress of Surveying and Mapping.

Representatives of the Owner shall be allowed access to all parts of the construction.

DESIGN LOADS

The structure and portions thereof were designed to sustain, within the stress and deflection limits specified in the Code, applicable combinations of dead loads with the loads noted below:

Condition	Loading
Live Load (sidewalk)	100 psf
Wind	UBC – 80 mph; Exposure "B"
Seismic	UBC – Zone 4

FOUNDATIONS

All footings shall be founded on approved compacted fill and/or undisturbed native ground suitable for support of the planned foundation. Footing excavations are subject to review and approval by the Navy prior to placement of steel and concrete.

CONCRETE

Concrete shall have a 28 day compressive strength of 5,000 psi

The water–cement ratio shall not exceed 0.40 in accordance with Section 4.5 of ACI 318 Concrete in Corrosive Environments.

Portland cement shall be ASTM C150, type V with maximum alkali content of 0.6%. Pozzolan shall be used to replace a maximum of 20% of the required portland cement in the concrete. Pozzolan shall conform to the requirements of ASTM C618, Class F, except that the loss on ignition for Class F pozzolan shall not exceed 4%. Aggregate shall be ASTM C33, size number 3/4–inch. Aggregate shall meet Los Angeles rattler values of 75 per ASTM C131 and C535. Calcium nitrate and plasticizing admixtures shall conform to ASTM C494. Air entrainment admixtures shall conform to ASTM C260. Minimum air entrainment shall be 5% by volume. Air entrainment agents shall not exceed 6% by volume of the concrete mix.

Calcium Nitrate Corrosion Inhibitor DCI or DCI–S, manufactured by W.R. Grace & Company, shall be added to all concrete walkway components at the rate of 4 gallons per cubic yard of concrete. The corrosion inhibitor shall contain 32% of calcium nitrate by weight.

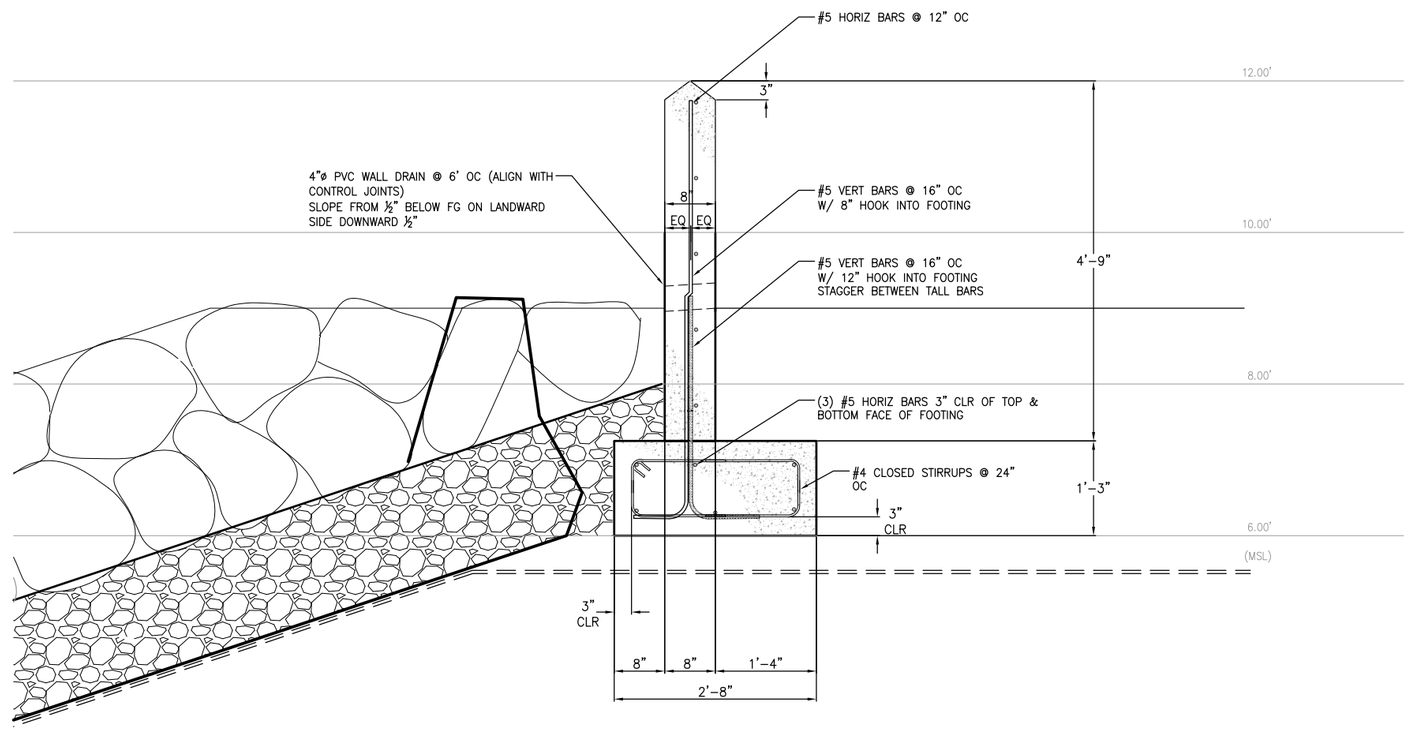
Rheocrete CNI, as manufactured by Master Builders, Inc., may be used as an alternate calcium nitrate corrosion inhibitor at the contractor's option.

Damp cure concrete work for a period of not less than 7 days after the work is completed to prevent rapid drying.

Walls shall be divided into separate panels with vertical control joints installed at nearly equal intervals not exceeding 24–feet. To the extent practicable, locate control joints near corners and intersecting walls, and at changes in wall heights. Wall panel ends shall be reinforced with (2) #5 vertical bars, minimum. To allow longitudinal movement, discontinue horizontal reinforcement, separate grout with a bond–breaker and eliminated end–mortar between masonry units at the control joint. Install backer rod and joint sealant, on both faces, between wall panels at all control joints.

REINFORCING STEEL

Reinforcing bars shall comply with ASTM A615, Grade 60, except that Number 4 and smaller bars shall be Grade 40. All bars shall be epoxy–coated per ASTM A 934. Reinforcing steel shall be prefabricated to the size and shape shown and securely tied in place with #16 double annealed PVC coated iron wire. Lap all reinforcing bars 30 bar diameters at splices. Unless noted otherwise on the drawings, concrete cover for reinforcing shall be 3" for concrete poured against earth and 3" for formed concrete exposed to earth.



1 – – SHORELINE REVTEMENT WALL DETAIL
SCALE: 1" = 1'–0"

SPECIAL INSPECTION REQUIREMENTS
STRUCTURAL (REVETMENT WALKWAY)

Special Inspector shall perform inspection provisions required by Chapter 17 of the California Building Code, the constriction documents and approved submittals. The following items are subject to special inspection:

1. CONCRETE
a. Verify use of required design mix (Fc = 5000 PSI)
b. Inspection of reinforcing steel (Fy = 60 KSI, Epoxy coated)
c. At the time fresh concrete is sampled to fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.
d. Inspection of concrete placement for proper application techniques.
e. Inspection for maintenance of specified curing temperature and techniques.

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

SHORELINE REVETMENT WALL DETAIL AND NOTES

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25–049
CONSTR. CONTR. NO. N68711–05–C–6011
DRAWING NO. S1
SHEET 40 OF 41 SHEETS

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HOT SPOT AREA EXCAVATION COORDINATES		
AREA	EASTING	NORTING
T1EX1A1-1	1457792.01	450573.54
T1EX1A1-2	1457792.01	450478.54
T1EX1A1-3	1457749.47	450480.73
T1EX1A1-4	1457752.04	450573.26
T1EX1A2-1	1457869.46	450257.23
T1EX1A2-2	1457908.41	450266.34
T1EX1A2-3	1457910.69	450256.60
T1EX1A2-4	1457871.72	450247.59
T2EX2A1-1	1457416.46	451151.12
T2EX2A1-2	1457493.34	451114.86
T2EX2A1-3	1457503.15	451135.66
T2EX2A1-4	1457471.50	451150.59
T2EX2A1-5	1457467.23	451141.55
T2EX2A1-6	1457422.01	451162.88
T2EX2A2-1	1457521.39	451090.46
T2EX2A2-2	1457520.98	451010.47
T2EX2A2-3	1457562.13	451010.36
T2EX2A2-4	1457562.34	451090.36
T2EX3A-1	1456563.10	450802.27
T2EX3A-10	1456550.67	450764.22
T2EX3A-2	1456601.14	450789.79
T2EX3A-3	1456675.41	450765.08
T2EX3A-4	1456660.03	450715.40
T2EX3A-5	1456599.20	450668.64
T2EX3A-6	1456589.11	450630.14
T2EX3A-7	1456589.37	450558.51
T2EX3A-8	1456541.43	450547.57
T2EX3A-9	1456505.07	450645.02
T2EX3B-1	1456563.09	450802.27
T2EX3B-2	1456601.14	450789.79
T2EX3B-3	1456588.72	450751.84
T2EX3B-4	1456550.67	450764.22
T2EX3C-1	1456560.73	450679.08
T2EX3C-2	1456599.20	450668.64
T2EX3C-3	1456589.11	450630.14
T2EX3C-4	1456550.46	450640.42
T2EX3D-1	1456541.43	450547.57
T2EX3D-2	1456589.37	450558.51
T2EX3D-3	1456577.96	450540.83
T2EX3D-4	1456555.33	450512.88
T2EX4-1	1456460.58	450525.42
T2EX4-2	1456500.15	450531.31
T2EX4-3	1456506.04	450491.75
T2EX4-4	1456466.47	450485.86

HOT SPOT AREA EXCAVATION COORDINATES		
AREA	EASTING	NORTING
T2EX5-1	1456759.88	451146.17
T2EX5-2	1456793.01	451168.59
T2EX5-3	1456815.43	451135.46
T2EX5-4	1456782.30	451113.04
T3EX11-1	1458309.83	451080.83
T3EX11-2	1458361.18	451111.87
T3EX11-3	1458345.65	451137.54
T3EX11-4	1458294.31	451106.50
T3EX21-1	1458184.56	450900.75
T3EX21-2	1458169.21	450881.02
T3EX21-3	1458174.73	450876.72
T3EX21-4	1458190.08	450896.45
T3EX22A-1	1458202.53	450931.44
T3EX22A-2	1458236.04	450909.59
T3EX22A-3	1458246.96	450926.35
T3EX22A-4	1458213.45	450948.19
T3EX22B-1	1458190.35	450897.60
T3EX22B-2	1458223.86	450875.75
T3EX22B-3	1458242.97	450905.07
T3EX22B-4	1458209.46	450926.92
T4EX1-1	1457343.74	451285.95
T4EX1-2	1457381.11	451300.23
T4EX1-3	1457395.39	451262.87
T4EX1-4	1457358.02	451248.58
T4EX2-1	1457201.42	451240.51
T4EX2-2	1457239.08	451254.00
T4EX2-3	1457252.56	451216.34
T4EX2-4	1457214.90	451202.86
T4EX3-1	1456963.91	451168.05
T4EX3-2	1457146.35	451223.65
T4EX3-3	1457158.35	451185.49
T4EX3-4	1456974.70	451129.54
T4EX4-1	1456798.80	451160.55
T4EX4-2	1456831.93	451182.97
T4EX4-3	1456854.35	451149.84
T4EX4-4	1456821.22	451127.43
T5EX1-1	1456418.13	450885.74
T5EX1-2	1456457.75	450937.20
T5EX1-3	1456505.07	450901.12
T5EX1-4	1456464.26	450848.48
T5EX21-1	1458317.04	451006.96
T5EX21-2	1458339.47	450980.10
T5EX21-3	1458371.04	450907.96
T5EX21-4	1458348.84	450887.78
T5EX21-5	1458285.75	450935.22
T5EX21-5	1458285.75	450935.22
T5EX21-6	1458263.31	450962.09

EXISTING MONITORING WELL COORDINATES			
POINT	EASTING	NORTING	ELEVATION (FT.)
IR01MW02B	1457476.01	451997.50	19.90
IR01MW03B	1457473.14	452007.01	20.79
IR01MW05A	1457735.96	451888.54	23.14
IR01MW09B	1458505.39	451290.82	10.31
IR01MW10A	1457292.06	451907.02	15.11
IR01MW10A	1458240.18	451637.57	18.60
IR01MW11A	1458216.10	451641.33	18.16
IR01MW11A	1458252.58	450553.80	16.23
IR01MW1-2	1458317.88	451135.36	13.69
IR01MW12A	1458205.87	451630.00	18.62
IR01MW1-5	1457828.20	451213.23	24.46
IR01MW16A	1457454.14	451755.59	24.94
IR01MW18A	1457687.80	451487.25	23.86
IR01MW1-9	1456783.29	451131.18	8.86
IR01MW20A	1457062.17	451678.97	12.48
IR01MW26B	1457811.83	451271.75	24.25
IR01MW31A	1457116.55	451709.01	14.00
IR01MW31A	1458293.35	450800.36	12.79
IR01MW366A	1458222.66	451037.32	17.55
IR01MW366B	1458260.65	451007.20	13.16
IR01MW36A	1458527.81	451298.80	10.21
IR01MW38A	1457596.95	451265.67	17.49
IR01MW402A	1456651.00	451251.00	N/A
IR01MW403A	1457071.53	451820.68	4.23
IR01MW403B	1457154.81	451841.71	11.09
IR01MW42A	1458140.92	450889.75	13.87
IR01MW48A	1457143.10	451235.85	11.19
IR01MW53B	1457131.51	451238.77	10.48
IR01MW60A	1457652.69	450982.10	14.50
IR01MW62A	1456381.74	450608.60	8.09
IR01MW63A	1456254.12	450630.55	8.07
IR01MW64A	1457820.09	450754.84	14.32
IR01MW65A	1456435.14	450523.25	9.13
IR01MW66A	1457852.57	450425.93	10.96
IR01MWLF1A	1457298.01	451550.12	21.41
IR01MWLF2A	1457360.85	452019.12	20.06
IR01MWLF4B	1458040.22	450788.85	14.87
IR01PO4A	1457476.89	451986.83	21.58
IR04MW31AB	1458315.48	450771.13	N/A
IR72MW33A	1458760.00	451478.00	N/A
IR75MW05B	1457022.00	452234.00	N/A
IR76MW13A	1457665.00	452147.00	N/A

SITE BOUNDARY CONTROL POINTS COORDINATES		
POINT	EASTING	NORTING
BCP1	1456109.75	450470.67
BCP2	1457299.61	452070.23
BCP5	1457959.40	451782.10
BCP7	1458075.42	451741.53
BCP8	1458144.53	451884.55
BCP9	1458151.63	451881.16
BCP10	1458173.13	451794.69
BCP11	1458212.12	451734.16
BCP12	1458307.38	451668.84
BCP14	1458431.16	451606.58
BCP15	1458331.50	451465.56
BCP16	1458524.14	451337.75
BCP17	1458353.04	450830.04
BCP18	1458282.38	450736.62
BCP19	1458310.78	450710.32
BCP20	1458302.81	450586.19
BCP22	1458050.75	450288.73
BCP23	1457776.23	450225.98
BCP24	1457753.96	450346.88
BCP25	1457749.46	450429.27
BCP26	1457752.88	450546.24
BCP27	1457727.30	450675.86
BCP28	1457681.92	450762.96
BCP29	1457640.12	450817.23
BCP30	1457524.46	450939.77
BCP31	1457518.39	451093.10
BCP32	1457396.96	451158.92
BCP33	1457313.38	451161.49
BCP34	1457093.80	451095.48
BCP35	1456931.40	451037.70
BCP36	1456877.68	450985.37
BCP37	1456793.68	450775.55
BCP37	1456595.56	450615.22
BCP38	1456588.96	450559.01
BCP39	1456510.86	450468.21
BCP40	1456494.96	450440.36
BCP41	1456420.87	450342.12
BCP42	1456370.30	450331.19
BCP43	1456325.06	450334.79
BCP44	1456214.09	450407.09

SURVEY CONTROL POINTS				
POINT #	EASTING	NORTHING	ELEVATION	DESCRIPTION
1	1458759.53	450825.89	6.61	SET RBR
2	1458375.58	451144.91	12.94	SET RBR
3	1458249.55	451176.26	17.17	SET 80D NAIL
4	1458000.62	451414.16	26.17	SET X ON CONC
5	1457696.04	450983.21	15.43	SET 80D NAIL
6	1457454.55	451378.40	17.43	SET 80D NAIL
7	1456940.27	451558.86	7.81	SET 80D NAIL
8	1456356.70	450781.31	N/A	SET RBR
9	1457598.94	451748.85	29.56	SET X ON CONC
10	1457908.81	451810.35	15.82	SET RBR
11	1457330.02	451550.09	20.16	SET 60D NAIL
12	1456273.48	450480.43	17.05	SET 80D NAIL
13	1458048.03	450624.67	10.85	SET 80D NAIL
14	1457653.34	450982.52	11.21	SET X ON CONC
15	1457610.12	450902.85	11.48	SET P/K NAIL
16	1456273.48	450480.43	17.05	SET 80D NAIL
17	1456802.82	451239.27	7.03	SET GINN
18	1457843.38	450419.31	6.37	SET GINN

PROPOSED WELL COORDINATES		
POINT	EASTING	NORTING
NMW01	1457846.14	450734.03
NMW01B	1458286.55	450601.97
NMW02A	1457560.67	451148.15
NMW03A	1457332.90	451272.86
NMW04A	1456911.66	451118.81
NMW05B	1457998.49	450295.40
NMW06A	1456569.46	450715.83
NMW07A	1458496.83	451292.21

PROPOSED PIEZOMETER COORDINATES		
POINT	EASTING	NORTING
NPZ01A	1457759.34	450434.05
NPZ02A	1457732.71	450697.51
NPZ03A	1457554.03	450954.68
NPZ04A	1457517.59	451102.52

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PREPARED FOR: Department of the Navy, Naval Facilities Engineering Command, Base Realignment and Closure Program Management Office West, San Diego, CA

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ENGINEERING/ REMEDIATION RESOURCES GROUP, INC. SAN FRANCISCO, CA

SURVEY CONTROL POINTS AND COORDINATES

BRAC PMO WEST SAN DIEGO, CALIFORNIA

SIZE: 22" X 34"
SCALE: AS NOTED
PROJ. NO. 25-049
CONSTR. CONTR. NO. N68711-05-C-6011
DRAWING NO. V1
SHEET 41 OF 41 SHEETS

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Appendix C. Project Specifications

(Project specifications provided on CD only)

Summary of Construction Specifications

Section	Title
01 11 00	Summary of Work
01 30 00	Administrative Requirements
01 32 16.00 20	Construction Progress Documentation
01 33 00	Submittal Procedures
01 35 29.13	Health, Safety and Emergency Response Procedures for Contaminated Sites
01 35 45.00 10	Chemical Data Quality Control
01 42 00	Sources for Reference Publications
01 45 00.00 20	Quality Control
01 50 00	Temporary Construction Facilities and Controls
01 57 19.00 20	Temporary Environmental Controls
01 57 20.00 10	Environmental Protection
01 78 23	Operation and Maintenance Data
02 32 00	Subsurface Drilling, Sampling, and Testing
02 35 27	Soil-Bentonite (S-B) Slurry Trench
02 41 00	Site Clearing and Demolition
02 81 00	Transportation and Disposal of Hazardous Materials
03 30 00	Cast-in-place Concrete
03 40 00.00 10	Plant-Precast Concrete
09 90 00	Paints and Coatings
10 14 01	Exterior Signage
11 00 0	Landfill Gas Control System
11 10 0	Enclosed Landfill Gas Flare
11 20 0	Landfill Gas Blower Skid
11 30 0	Condensate Storage Tank
11 40 0	Pretreatment Vessels
26 00 00.00 20	Basic Electrical Materials and Methods
31 00 00	Earthwork
31 05 19	Geotextile
31 21 00	Piping; Landfill Gas
31 12 16	Hot-Mix Asphalt (HMA) for Roads
32 31 26	Wire Fences and Gates
32 92 19	Seeding and Planting
33 24 00.00 20	Gas Extraction Wells
33 24 13	Groundwater Monitoring Wells
33 60 01	Valves, Piping, and Equip. in Valve Boxes
35 31 19	Coastal Protection

Note: Construction specifications were produced to a 60% design stage. The specification sections included herein may be expanded, revised, or eliminated during the development of the Draft Final (90%) design submittal.

SECTION 01 11 00

SUMMARY OF WORK
03/13

PART 1 GENERAL

1.1 PROJECT DESCRIPTION

Excavate and dispose of contaminated soil, sediment, and debris impacted by metals, radionuclides, pesticides, polychlorinated biphenyls, semivolatile organic compounds, total petroleum hydrocarbons, and dioxins in selected areas. Consolidate and contain remaining contamination, including installing a soil cover over all of Parcel E-2 with a protective liner. Install below-ground barriers to limit groundwater flow from the landfill to San Francisco Bay. Remove and treat landfill gas to prevent it from moving beyond the Parcel E-2 boundary. Build a shoreline revetment. Monitor, maintain, and use institutional controls to protect human health and the environment to ensure the integrity of the remedial action.

Hunters Point Naval Shipyard (HPNS) is located in southeastern San Francisco on a peninsula that extends into San Francisco Bay. HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. In 1940, the Navy obtained ownership of HPNS for shipbuilding, repair, and maintenance activities. After World War II, activities at HPNS shifted to submarine maintenance and repair. HPNS was also the site of the Naval Radiological Defense Laboratory.

HPNS was deactivated in 1974 and remained relatively unused until 1976. Between 1976 and 1986, the Navy leased most of HPNS to Triple A Machine Shop, Inc., a private ship repair company. In 1987, the Navy resumed occupancy of HPNS. Because past shipyard operations left hazardous substances on site, HPNS property was placed on the National Priorities List in 1989 pursuant to CERCLA, as amended by SARA. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPNS involve conducting environmental remediation and making the property available for nondefense use.

Parcel E is one of six parcels (Parcels A through F) originally designated for environmental restoration. In September 2004, the Navy divided Parcel E into two parcels (Parcels E and E-2) to facilitate closure of the Parcel E-2 Landfill and its adjacent areas. Long-term use in Parcel E-2 consists of open space. Environmental investigations began at Parcel E, including Parcel E-2, in 1984.

1.2 SITE CONTAMINANTS

The Navy has removed significant amounts of contamination from certain areas of Parcel E-2; however, contamination remains elsewhere at Parcel E-2, and the Navy initiated two additional time-critical removal actions at the PCB Hot Spot Area and the Ship-Shielding Area to promptly address this contamination prior to the Remedial Design. Elevated concentrations of metals, SVOCs, VOCs, pesticides, PCBs, dioxins and furans, and petroleum hydrocarbons remain in soils and sediment at the site. The remedial action addresses these contaminants in soil and sediment by excavating hot spots and consolidating waste and eliminating the exposure pathway.

The Navy conducted a time-critical removal action to remove landfill gas

which had elevated methane concentrations and was present north of the Parcel E-2 Landfill. The removal was also successful in controlling future migration of landfill gas to off-site areas. Additional studies are planned as part of this remedial design to more thoroughly evaluate soil gas concentrations in the Panhandle Area and East Adjacent Area and to assess whether methane or non-methane organic compounds (NMOCs) are present in the areas at concentrations that may be hazardous to human health.

Metals, SVOCs, VOCs, pesticides, PCBs, petroleum hydrocarbons, and anions (such as ammonia and cyanide) remain in groundwater. Groundwater sampling results indicated that the concentrations and extent of contamination in the uppermost B-aquifer are less than observed in the A-aquifer because an aquitard is present beneath most of Parcel E-2. Primary potential migration pathways for contaminated groundwater include migration and discharge of A-aquifer groundwater into San Francisco Bay and wetlands and migration of A-aquifer groundwater (including the saturated waste layer) into the uppermost B-aquifer.The remedial action addresses these contaminants by monitoring and eliminating the exposure pathway.

The extent of radioactive contamination in subsurface soil and shoreline sediment has not been completely defined. However, the remedial action assumes potential radionuclides may be present in subsurface soil and shoreline sediment at Parcel E-2 which requires action. The remedial action addresses these contaminants in soil and sediment by removing materials with elevated radioactivity and eliminating the exposure pathway.

1.3 LOCATION

The work shall be located at Hunters Point Shipyard Parcel E-2, San Francisco, California, as shown on the Drawings.

1.4 SUBMITTALS

See Section 01 33 00 for submittal requirements and procedures.

1.5 CONTRACTOR ACCESS AND USE OF PREMISES

1.5.1 Base Regulations

Ensure that Contractor personnel employed on the base become familiar with and obey base regulations. Keep within the limits of the work and avenues of ingress and egress. Do not enter restricted areas unless required to do so and until cleared for entry. Permission to interrupt any station roads or utility services shall be requested in writing a minimum of 15 calendar days prior to the desired date of interruption. The Contractor's equipment shall be conspicuously marked for identification. Arrive and depart the work site at a location designated by the Contracting Officer.

1.5.2 Working Hours

Regular working hours shall consist of a period established by the Contracting Officer Monday through Saturday, excluding Government holidays.

1.5.3 Work Outside Regular Hours

Work outside regular working hours requires Contracting Officer approval. Provide written request 7 calendar days prior to such work to allow arrangements to be made by the Government for inspecting the work in progress. During episodes of darkness, work shall be lighted in a manner

approved by the Contracting Officer.

1.5.4 Unauthorized Access

Ensure that public and other unauthorized personnel do not have access to the area during the construction period.

1.6 EXISTING WORK

In addition to "FAR 52.236-9, Protection of Existing Vegetation, Structures, Equipment, Utilities, and Improvements":

a. Remove or alter existing work in such a manner as to prevent injury or damage to any portions of the existing work which remain.

b. Repair or replace portions of existing work which have been altered during construction operations to match existing or adjoining work, as approved by the Contracting Officer. At the completion of operations, existing work shall be in a condition equal to or better than that which existed before new work started.

1.7 LOCATION OF UNDERGROUND UTILITIES

The locations of existing underground utilities shown on the Drawings are only approximate. Verify the locations of the utilities shown and any other utilities that may be present. Scan the construction site with electromagnetic or sonic equipment, and mark the surface of the ground where existing underground utilities are discovered. Verify the locations and elevations of existing piping, utilities,and any other types of underground obstructions not indicated but discovered during scanning. Protect all utilities encountered during construction.

1.7.1 Notification Prior to Excavation

Notify the Contracting Officer at least 15 days prior to starting excavation work. Contact Underground Service Alert (USA) 48 hours prior to excavating. Contractor is responsible for marking all utilities not marked by USA.

1.8 SCHEDULE

Contractor shall schedule construction activity, in addition to other stated requirements, within the constraints and fulfilling the requirements of all other Sections. In all cases, construction shall be completed within 180 days of the start of clearing and grubbing.

1.9 DELAYS

Notify the Contracting Officer of delays or changes in construction schedule within 48 hours. Cessation of construction activities resulting from delays shall not constitute the release of Contractor's responsibility to maintain a tidy, secured, and protected site. In such case, Contractor shall protect all surfaces from erosion and all materials from degradation. When construction activities resume, Contractor shall return grades and installed items to their condition before construction ceased.

1.10 ESTIMATION OF EARTHWORK

Topographical and survey information on Drawings must be field verified.

Accurate cute and fill volume must be determined by the Contractor after clearing and grubbing and surface debris removal has been performed.

1.11 LIMITS OF RESPONSIBILITY

The designer and its subcontractors shall not be responsible for variances from the construction specifications, design drawings, and other requirements and recommendations unapproved by the designer.

1.12 WORK NOT INCLUDED

1.13 WORK SEQUENCES

Secure the site and conduct site clearing before other construction phases.

1.14 SALVAGE MATERIAL AND EQUIPMENT

Items designated by the Contracting Officer to be salvaged shall remain the property of the Government.

The salvaged property shall be segregated, itemized, delivered, and off-loaded at the Government designated storage area located within 5 miles of the construction site.

Contractor shall maintain property control records for material or equipment designated as salvage. Contractor's system of property control may be used if approved by the Contracting Officer. Contractor shall be responsible for storage and protection of salvaged materials and equipment until disposition by the Contracting Officer.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 01 30 00

ADMINISTRATIVE REQUIREMENTS
03/13

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

a. List of Subcontractors and Personnel; G

b. View location map; G

d. Contact Personnel List; G

e. Vehicle List; G

f. Site Specific Health and Safety Plan; G

g. Imported Fill Sampling Plan; G

h. Air Monitoring Plan; G

i. Construction Stormwater Pollution Prevention Plan; G

1.2 VIEW LOCATION MAP

Submit to the Contracting Officer, prior to or with the first submittals, a sketch or drawing indicating the required photographic locations. Update as required if the locations are moved.

1.3 SITE SPECIFIC HEALTH AND SAFETY PLAN

Prepare and submit to the Contracting Officer a Site Specific Health and Safety Plan (SSHSP). As part of the SSHSP, a section covering air monitoring may be included as the Air Monitoring Plan submittal.

1.4 IMPORTED FILL SAMPLING PLAN

A Sampling and Analysis Plan should be prepared and submitted which outlines the procedures used to ensure imported fill will meet the backfill acceptance criteria.

1.5 CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN

A SWPPP should be prepared and submitted, including procedures for submitting an Construction Stormwater Permit, as required under the National Pollutant Discharge Elimination System (NPDES) Construction General Permit Order 201-0014-DWQ.

1.6 MINIMUM INSURANCE REQUIREMENTS

Procure and maintain during the entire period of performance under this contract the following minimum insurance coverage:

a. Comprehensive general liability: $500,000 per occurrence

b. Automobile liability: $200,000 per person, $500,000 per occurrence for bodily injury, $20,000 per occurrence for property damage

c. Workmen's compensation as required by Federal and State workers' compensation and occupational disease laws.

d. Employer's liability coverage of $100,000, except in States where workers compensation may not be written by private carriers,

e. Others as required by State law.

1.7 CONTRACTOR SPECIAL REQUIREMENTS

1.7.1 List of Subcontractors and Personnel

Furnish a list of contact personnel of the Contractor and subcontractors including addresses and telephone numbers for use in the event of an emergency. As changes occur and additional information becomes available, correct and change the information contained in previous lists.

1.7.2 Contact Personnel List

Submit for approval, at least 15 days in advance of the desired date of entry, an original alphabetical list of personnel who require entry into Government property to perform work on the project. Furnish for each person:

a. Name
b. Date and place of birth
c. Citizenship
d. Home address

The request for personnel passes shall be accomplished with the following certification:

"I hereby certify that all personnel on this list are either born U.S. citizens or naturalized U.S. citizens with the naturalization number shown."

1.7.3 Identification Badges

Identification badges, if required, will be furnished without charge. Application for and use of badges will be as directed.

1.7.4 Contractor Personnel Requirements

Obtain entry badges and security approval for all site workers and staff in accordance with facility security procedures. Failure to obtain entry approval will not affect the contract price or time of completion.

1.8 Vehicle List

Provide a list of all vehicles (year, color, make, and model), as well as license plate number, to be used for the project to the Contracting Officer.

1.9 SUPERVISION

Have at least one qualified supervisor capable of reading, writing, and conversing fluently in the English language on the job site during working hours. In addition, if a Quality Control (QC) representative is required on the contract, then that individual shall also have fluent English communication skills.

1.10 PRECONSTRUCTION CONFERENCE

After award of the contract but prior to commencement of any work at the site, meet with the Contracting Officer to discuss and develop a mutual understanding relative to the administration of the value engineering and safety program, preparation of the schedule of prices, shop drawings, and other submittals, scheduling programming, prosecution of the work, and clear expectations of the "Interim DD Form 1354" Submittal. Major subcontractors who will engage in the work shall also attend.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 32 16.00 20

CONSTRUCTION PROGRESS DOCUMENTATION
03/13

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.1.1 SD-01 Preconstruction Submittals

a. Construction Schedule; G
b. Material Delivery Schedule; G

1.1.2 SD-06 Field Test Reports

a. Progress and Completion Pictures; G

1.2 CONSTRUCTION SCHEDULE

Within 21 days after receipt of the Notice of Award, prepare and submit to the Contracting Officer for approval a construction schedule in the form of a Bar Chart, including a completed list of definable features of work, in accordance with the terms in Contract Clause "FAR 52.236-15, Schedules for Construction Contracts," except as modified in this contract.

1.3 MATERIAL DELIVERY SCHEDULE

Within 21 calendar days after approval of the proposed construction schedule, submit for Contracting Officer approval a schedule showing procurement plans for materials and rental equipment. Submit in the format and content as prescribed by the Contracting Officer, and include as a minimum the following information:

a. Description
b. Date of the purchase order
c. Promised shipping date
d. Name of the manufacturer or supplier
e. Date delivery is expected
f. Date the material or equipment is required, according to the current construction schedule.

1.4 SCHEDULE FORMAT

1.4.1 Bar Chart Schedule

The Bar Chart shall show submittals, government review periods, material/equipment delivery, utility outages, on-site construction, inspection, testing, and closeout activities. The Bar Chart shall be time scaled and generated using an electronic spreadsheet program.

1.5 UPDATED SCHEDULES

Update the construction schedule and equipment delivery schedule at monthly intervals or when the schedule has been revised. Reflect any changes that occurred since the last update. Submit copies of the purchase orders and confirmation of the delivery dates as directed.

1.6 PROGRESS AND COMPLETION PICTURES

Progress and Completion Pictures document site conditions prior to start of construction operations. Provide at least weekly photographs showing the sequence and progress of work. Take a minimum of 40 photographs each week throughout the entire project from a minimum of ten views from points located by the Contracting Officer. Submit a view location sketch indicating points of view. Submit with the monthly invoice two sets of digital photographs each set on a separate CD-R, cumulative of all photos to date. Indicate photographs demonstrating environmental procedures. Photographs for each month shall be in a separate monthly directory and each file shall be named to indicate its location on the view location sketch. The view location sketch shall be provided on the CD as a digital file. All file names shall include a date designator. Cross reference submittals in the appropriate daily report. Photographs shall be provided for unrestricted use by the Government.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 01 33 00

SUBMITTAL PROCEDURES
03/13

PART 1 GENERAL

1.1 DEFINITIONS

1.1.1 Submittal

Shop Drawings, product data, samples, and administrative submittals presented for review and approval. Contract Clauses "FAR 52.236-5, Material and Workmanship," paragraph (b) and "FAR 52.236-21, Specifications and Drawings for Construction," paragraphs (d), (e), and (f) apply to all "submittals."

1.1.2 Types of Submittals

All submittals are classified as indicated in Paragraph 1.2, Schedule of Submittal Descriptions. The submittals also are grouped as follows:

a. Shop Drawings: As used in this section, drawings, schedules, diagrams, and other data prepared specifically for this Contract, by the Contractor, or through the Contractor by way of a subcontractor, manufacturer, supplier, distributor, or other lower-tier contractor, to illustrate a portion of the work.

b. Product data: Preprinted material such as illustrations, standard schedules, performance charts, instructions, brochures, diagrams, manufacturer's descriptive literature, catalog data, and other data to illustrate a portion of the work, but not prepared exclusively for this Contract.

c. Samples: Physical examples of products, materials, equipment, assemblies, or workmanship that are physically identical to a portion of the work, illustrate a portion of the work, or establish standards for evaluating the appearance of the finished work or both.

d. Administrative submittals: Data presented for review and approval to ensure that the administrative requirements of the project are adequately met but not to ensure directly that the work is in accordance with the design concept and in compliance with the Contract documents.

1.2 SCHEDULE OF SUBMITTAL DESCRIPTIONS (SD)

<u>SD-01 Preconstruction Submittals</u>

Certificates of insurance
Surety bonds
List of Subcontractors and Personnel
View Location Map
Progress and completion pictures
Contact Personnel List
Vehicle List
Construction progress schedule
Network Analysis Schedule (NAS)

Submittal register
Schedule of prices
Accident Prevention Plan
Site Specific Health and Safety Plan
Air Monitoring Plan
Work plan
Quality Control(QC) plan
Spill and discharge control/containment procedures
Imported Fill Sampling Plan
Construction Stormwater Pollution Prevention Plan
Environmental protection plan, including ecological management and mitigation procedures

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Work Zones

Decontamination Facilities

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

Warning Sign

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

Site Control Log

Employee Certificates

Sampling and Analysis Plan

SD-04 Samples

Physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards by which the ensuring work can be judged. Includes

assemblies or portions of assemblies which are to be incorporated into the project and those which will be removed at the conclusion of the work.

SD-05 Design Data

Calculations, mix designs, analyses or other data pertaining to a part of work.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. (Testing must have been within three years of date of contract award for the project.)

Report which includes findings of a test required to be performed by the Contractor on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports.

Daily checklists.

Final acceptance test and operational test procedure.

Air Sampling Results

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Contractor, or of a manufacturer, supplier, installer or Subcontractor through Contractor, the purpose of which is to further the quality of orderly progression of a portion of the work by documenting procedures, acceptability of methods or personnel qualifications.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and Material Safety Data Sheets concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification of actions taken by the manufacturer's representative to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and must state

the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data that is furnished by the manufacturer, or the system provider, to the equipment operating and maintenance personnel, including manufacturer's help and product line documentation necessary to maintain and install equipment. This data is needed by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

Data intended to be incorporated in an operations and maintenance manuals.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

As-built Drawings
As-built Field Summary Report
Special warranties
Posted operating instructions
Training plan
Safety and Health Phase-Out Report

1.2.1 Approving Authority

The person authorized to approve a submittal.

1.2.2 Work

As used in this section, on- and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor QC approval. Submit the following in accordance with this section.

SD-11 Closeout Submittals

a. Submittal Register; G
a. As-built Drawings; G
b. As-built Field Summary Report; G

1.4 USE OF SUBMITTAL REGISTER OR DATABASE

Prepare and maintain a submittal register as work progresses. Use the electronic submittal register program furnished by the Government or any other format. Do not change data which are output in columns (c), (d), (e), and (f) as delivered by the Government; retain data which are output in columns (a), (g), (h), and (i) as approved.

1.4.1 Submittal Register

Submit a hard copy of the submittal register and also as an electronic database. Submit with the quality control plan and the project schedule required by Section 01 45 00.00 20 QUALITY CONTROL and Section 01 32 16.00 20 CONSTRUCTION PROGRESS DOCUMENTATION. Do not change data in columns (c), (d), (e), and (f) as delivered by the Government. Verify that all submittals required for the project are listed and add missing submittals. Complete the following on the register:

Column (a) Activity Number: Activity number from the project schedule.

Column (g) Contractor Submit Date: Scheduled date for the approving authority to receive submittals.

Column (h) Contractor Approval Date: Date the Contractor needs approval of the submittal.

Column (i) Contractor Material: Date the Contractor needs material delivered to Contractor control.

1.4.2 Contractor Use of the Submittal Register

Update the following fields in the submittal register:

Column (b) Transmittal Number: Contractor assigned list of consecutive numbers.

Column (j) Action Code: Contractor assigned action code.

Column (k) Date of Action: Date of action used to record Contractor's review when forwarding submittals to quality control (QC).

Column (l): List date of submittal transmission.

Column (q): List date approval is received.

1.4.3 Approving Authority Use of the Submittal Register

Update the following fields in the submittal register:

Column (l): List date of submittal receipt.

Column (m) through (p)

Column (q): List date returned to Contractor.

1.4.4 Contractor Action Code and Action Code

Entries used will be as follows:

NR - Not received

AN - Approved as noted

A - Approved

RR - Disapproved, Revised, and Resubmit

1.4.5 Copies Delivered to the Government

Deliver one copy of the submitted register updated by the Contractor the Government with each invoice request. Delivery in electronic format, unless a paper copy is requested by the Contracting Officer.

1.5 PROCEDURES FOR SUBMITTALS

1.5.1 Reviewing, Certifying, Approving Authority

The QC Manager, in accordance with Section 01 45 00.00 20 Quality Control, shall be responsible for reviewing and certifying that submittals are in compliance with contract requirements. The approving authority on submittals is the QC Manager unless otherwise specified for the specific submittal. At each "Submittal" paragraph in the individual specification sections, the notation "G" following a submittal item indicates that the Contracting Officer is the approving authority.

1.5.2 Constraints

a. Submittals listed or specified in this Contract shall conform to the provisions of this section, unless explicitly stated otherwise.

b. Submittals shall be complete for each definable feature of work; components of the definable feature interrelated as a system shall be submitted at the same time.

c. When acceptability of a submittal is dependent on conditions, items, or materials included in separate, subsequent submittals, the submittal will be returned without review.

d. Approval of a separate material, product, or component does not imply approval of the assembly in which the item functions.

1.5.3 Scheduling

a. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of the work so that work will not be delayed by submittal processing. Allow for potential requirements to resubmit

b. Except as specified otherwise, allow a review period, beginning with receipt by the approving authority, that includes at least 15 working days for submittals for QC Manager approval and 20 working days for submittals for Contracting Officer approval. The period of review for submittals with Contracting Officer approval begins when the Government receives the submittal from the QC Manager. The period of review for each resubmittal is the same as for the initial submittal.

1.5.4 Variations

Variations from contract requirements require Government approval pursuant to Contact Clause "FAR 42.236-21, Specifications and Drawings for Construction," and will be considered where advantageous to the Government.

When proposing a variation, submit a written request to the Contracting Officer, with documentation of the nature and features of the variation and an explanation why the variation is desirable and beneficial to the Government. If lower cost is a benefit, also include an estimate of the cost saving. Identify the proposed variation separately and include documentation for the proposed variation along with the required submittal for the item.

1.5.4.1 Variation Is Compatible

The Contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of the work.

1.5.4.2 Review Schedule Is Modified

In addition to normal submittal review period, a period of 10 working days will be allowed for consideration by the Government of submittals with variations.

1.5.5 Contractor's Responsibilities

a. Determine and verify field measurements, materials, field construction criteria; review each submittal; and check and coordinate each submittal with requirements of the work and Contract documents.

b. Transmit submittals to the QC Manager in orderly sequence; in accordance with the approved submittal register; and to prevent delays in the work, delays to the Government, or delays to separate contractors.

c. Advise the Contracting Officer of the variation, as required by Paragraph 1.5.4, Variations.

d. Correct and resubmit as directed by the approving authority. When resubmitting disapproved transmittals or transmittals noted for resubmittal, the Contractor shall provide a copy of the transmittal submitted previously, including all reviewer comments, for use by the approving authority. Direct specific attention, in writing or on resubmitted submittal, to revisions not requested by the approving authority on previous submissions.

e. Furnish additional copies of submittals when requested by the Contracting Officer, to a limit of 20 copies per submittal.

f. Complete work that must be accomplished as a basis of a submittal in time to allow the submittal to occur as scheduled.

g. Ensure no work has begun until submittals for that work have been returned as "approved," or "approved as noted" or "approved except as noted; resubmission not required," except to the extent that a portion of the work must be accomplished as a basis for the submittal.

1.5.6 QC Manager Responsibilities

a. Note the date the submittal was received from the Contractor on each submittal.

b. Review each submittal and check and coordinate each submittal with requirements of the work and Contract documents.

c. Review submittals for conformance with project design concepts and compliance with Contract documents.

d. Act on submittals, determining the appropriate action based on the QC Manager's review of the submittal.

(1) When the QC Manager is the approving authority, take the appropriate action on the submittal ffrom the possible actions defined in Paragraph 1.5.8, Actions Possible.

(2) When the Contracting Officer is the approving authority or when a variation has been proposed, forward the submittal to the Government with the certifying statement or return the submittal marked "not reviewed" or "revise and resubmit" as appropriate. The QC Manager's review of the submittal determines the appropriate action.

e. Ensure that material is clearly legible.

f. Stamp each sheet of each submittal with the QC certifying statement or approving statement, except that data submitted in bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only.

(1) When the approving authority is the Contracting Officer, the QC Manager will certify submittals forwarded to the Contracting Officer with the following certifying statement:

"I hereby certify that the (equipment) (material)(article) shown and marked in this submittal is that proposed to be incorporated with the Contract Number XXX, is in compliance with the Contract Drawings and Specification, can be installed in the allocated spaces, and is ___ approved for use."

Certified by Submittal Reviewer _____ Date _____
(Signature when applicable)

Approved by QC Manager _____ Date _____
(Signature)

(2) When the approving authority is the QC Manager, the QC Manager will use the following approval statement when returning submittals to the Contractor as "approved" or "approved as noted."

"I hereby certify that the (material) (equipment) (article) shown and marked in this submittal an proposed to be incorporated with the Contract Number XXX, is in compliance with the Contract Drawings and Specification, can be installed in the allocated spaces, and is _____ approved for use."

Certified by Submittal Reviewer _____ Date _____
(Signature when applicable)

Approved by QC Manager _____ Date _____
(Signature)

g. Sign the certifying statement or approval statement. The person signing the certifying statements shall be the QC Manager member designated in the approved QC Plan. The signatures shall be original and in ink. Stamped signatures are not acceptable.

h. Update the submittal register as submittal actions occur and maintain the submittal register at the project site until final acceptance of all work by the Contracting Officer.

i. Retain a copy of approved submittals at the project site, including the Contractor's copy of approved samples.

1.5.7 Government's Responsibilities

When the approving authority is the Contracting Officer, the Government will:

a. Note the date the submittal was received from the QC Manager on each submittal for which the Contracting Officer is approving authority.

b. Review submittals for approval within the scheduling period specified and only for conformance with project design concepts and compliance with Contract documents.

c. Identify returned submittals with one of the actions defined in Paragraph 1.5.8, Actions Possible, and with markings appropriate for the action indicated.

1.5.8 Actions Possible

Submittals will be returned with one of the following notations:

a. Submittals marked "not reviewed" will indicate the submittal has been previously reviewed and approved, is not required as a submittal, does not show evidence of being reviewed and approved by the Contractor, or is not complete. A submittal marked "not reviewed" will be returned with an explanation of the reason it is not reviewed. Returned submittals deemed to lack review by the Contractor or to be incomplete shall be resubmitted with the appropriate action, coordination, or change.

b. Submittals marked "approved" or "approved as submitted" authorize the Contractor to proceed with the work covered.

c. Submittals marked "approved as noted" or "approved except as noted; resubmission not required" authorize teh Contractor to proceed with the work as noted provided the Contractor takes no exception to the notations.

d. Submittals marked "revise and resubmit" or "disapproved" indicate that the submittal is incomplete or does not comply with the design concept or the requirements of the Contract documents and shall be resubmitted with appropriate changes. No work shall proceed for this item until the resubmittal is approved.

1.6 FORMAT OF SUBMITTALS

1.6.1 Transmittal Form

Transmit each submittal, except sample installations and sample panels, to the office of the approving authority. Transmit submittals with a transmittal form that is prescribed by the Contracting Officer and standard for the project. The transmittal form shall identify the Contractor, indicate the date of the submittal, and include information prescribed by the transmittal form and required in Paragraph 1.6.2, Identifying Submittals. Process transmittal forms to record actions regarding sample panels and sample installations.

1.6.2 Identifying Submittals

Identify submittals, except sample panel and sample installation, with the following information permanently adhered to or noted on each separate component of each submittal and noted on the transmittal form. Mark each copy of each submittal identically, with the following:

a. Project title and location.

b. Construction Contract number.

c. The section number of the specification section by which the submittal is required.

d. The submittal description (SD) number of each component of the submittal.

e. When a resubmission, an alphabetic suffix on the submittal description, for example, SD-10A, to indicate the resubmission.

f. The name, address, and telephone number of the subcontractor, supplier, manufacturer, and any other second-tier contractor associated with the submittal.

g. Product identification and location in project.

1.6.3 Format for Product Data

a. Present product data submittals for each section as a complete, bound volume. Include a table of contents listing page and catalog item numbers for product data.

b. Indicate, by prominent notation, each product that is being submitted; indicate the specification section number and paragraph number to which it pertains.

c. Supplement product data with material prepared for the project to satisfy submittal requirements for which product data do not exist. Identify this material as developed specifically for the project.

1.6.4 Format for Shop Drawings

a. Shop Drawings shall not be less than A4, 8 1/2 by 11 inches, nor more than AO, 30 by 42 inches.

b. Present Shop Drawings as a part of the bound volume for the submittals

required by the section. Present larger Drawings in sets.

c. Include on each Drawing the Drawing title, number, date, and revision numbers and dates, in addition to the information required in Paragraph 1.6.2, Identifying Submittals.

d. Dimension Drawings, except diagrams and schematic Drawings, prepare Drawings demonstrating interface with other trades to scale. Dimensions of shop Drawings shall be the same unit of measure as indicated on the contract Drawings. Identify materials and products for work shown.

1.6.5 Format of Samples

a. Furnish samples in teh sizes below, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

(1) Color Selection Samples: 2 inches by 4 inches.

1.6.6 Format of Administrative Submittals

a. When the submittal includes a document that is to be used in teh project or will become a part of the project record, other than as a submittal, do not apply the Contractor's approval stamp to the document, but to a separate sheet accompanying the document.

1.7 QUANTITY OF SUBMITTALS

1.7.1 Number of Copies of Product Data

a. Submit six copies of submittals of product data requiring review and approval only by the QC Manager and seven copies of product data requiring review and approval by the Contracting Officer.

1.7.2 Number of Copies of Shop Drawings

Submit Shop Drawings in compliance with the quantity requirements specified for product data.

1.7.3 Number of Samples

a. Submit two samples, or two sets of samples showing range of variation, of each required item. One approved sample or set of samples will be retained by the approving authority, and one will be returned to the Contractor.

1.7.4 Number of Copies of Administrative Submittals

a. Unless otherwise specified, submit the administrative submittals in compliance with the quantity requirements specified for product data.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 35 29.13

HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)

ANSI/ISEA Z358.1	(2009) American National Standard for Emergency Eyewash and Shower Equipment

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

NIOSH 85-115	(1985) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 20	Standards for Protection Against Radiation
29 CFR 1904	Recording and Reporting Occupational Injuries and Illnesses
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
29 CFR 1926	Safety and Health Regulations for Construction
29 CFR 1926.65	Hazardous Waste Operations and Emergency Response

1.2 DESCRIPTION OF WORK

This section requires Contractors to implement practices and procedures for working safely and in compliance with OSHA and USACE regulation while performing cleanup activities on uncontrolled hazardous waste sites.

See 01 11 00 SUMMARY OF WORK.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

a. Accident Prevention Plan; G

b. Site Specific Health and Safety Plan. Submit in accordance with the requirements contained in Section C, Part 3 of the Response Action Contractor (RAC) Contract (29 CFR 1910) and include the Exposure Monitoring/Air Sampling Program; G

c. Spill and discharge control/containment procedures; G

SD-02 Shop Drawings

a. Work Zones; G

b. Decontamination Facilities; G

SD-03 Product Data

a. Site Control Log

b. Employee Certificates

SD-06 Field Test Reports

a. Air Sampling Results

SD-11 Closeout Submittals

a. Safety and Health Phase-Out Report

1.4 REGULATORY REQUIREMENTS

Comply with EM 385-1-1, OSHA requirements in 29 CFR 1910 and 29 CFR 1926 with work performed under this contract, especially OSHA's Standards 29 CFR 1926.65 and 29 CFR 1910.120 and state specific OSHA requirements where applicable. Submit to the Contracting Officer for resolution matters of interpretation of standards before starting work. The most stringent requirements apply where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary.

1.5 PRECONSTRUCTION SAFETY CONFERENCE

Conduct a preconstruction safety conference prior to the start of site activities and after submission of the Contractor's APP/SSHSP. The objective of the meeting will be to discuss health and safety concerns related to the impending work, discuss project health and safety organization and expectations, review and answer comments and concerns regarding the APP/SSHSP or other health and safety concerns the Contractor may have. Ensure that those individuals responsible for health and safety at the project level are available and attend this meeting.

1.6 ACCIDENT PREVENTION PLAN/SITE SPECIFIC HEALTH AND SAFETY PLAN (APP/SSHSP)

Develop and implement a Site Specific Health and Safety Plan and attach to the Accident Prevention Plan (APP) as an appendix (APP/SSHSP). Address all occupational safety and health hazards (traditional construction as well as contaminant-related hazards) associated with cleanup operations within the APP/SSHSP. Cover each SSHSP element in section 28.A.01 of EM 385-1-1 and each APP element in Appendix A of EM 385-1-1. There are overlapping elements in Section 28.A.01 and Appendix A of EM 385-1-1. SSHSP appendix elements that overlap with APP elements need not be duplicated in the APP/SSHSP provided each SOH issue receives adequate attention and is documented in the APP/SSHSP. The APP/SSHSP is a dynamic document, subject to change as project operations/execution change. The APP/SSHSP will require modification to address changing and previously unidentified health and safety conditions. It is the Contractor's responsibility to ensure that the APP/SSHSP is updated accordingly. Submit amendments to the APP/SSHSP to the COR as the APP/SSHSP is updated. For long duration projects resubmit the APP/SSHSP to the COR annually for review. The APP/SSHSP must contain all updates.

1.6.1 Acceptance and Modifications

Prior to submittal, the APP/SSHSP must be signed and dated by the Safety and Health Manager and the Site Superintendent. Submit for review 14 days prior to the Preconstruction Safety Conference. Deficiencies in the APP/SSHSP will be discussed at the preconstruction safety conference, and be revised to correct the deficiencies and resubmitted for acceptance. Onsite work must not begin until the plan has been accepted. Maintain a copy of the written APP/SSHSP onsite. Changes and modifications to must be made with the knowledge and concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Bring to the attention of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer any unforeseen hazard that becomes evident during the performance of the work, through the Site Safety and Health Officer (SSHO) for resolution as soon as possible. In the interim, take necessary action to re-establish and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted APP/SSHSP will be cause for stopping work until the matter has been rectified.

1.6.2 Availability

Make available the APP/SSHSP in accordance with 29 CFR 1910.120, (b)(1)(v) and 29 CFR 1926.65, (b)(1)(v).

1.7 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

1.7.1 Project/Site Conditions

Refer to the following reports and information for the site description and contamination characterization.

ERRG. 2012. "Record of Decision for Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." November 26.

1.8 TASK SPECIFIC HAZARDS, INITIAL PPE, HAZWOPER MEDICAL SURVEILLANCE AND TRAINING APPLICABILITY

Task specific occupational hazards, task specific HAZWOPER medical surveillance and training applicability and task specific initial PPE requirements for the project are listed on the Task Hazard and Control Sheets at the end of this section. It is the Contractor's responsibility to reevaluate occupational safety and health hazards as the work progresses and to adjust the PPE and onsite operations, if necessary, so that the work is performed safely and in compliance with occupational safety and health regulations.

1.9 STAFF ORGANIZATION, QUALIFICATION AND RESPONSIBILITIES

1.9.1 Safety and Health Manager

Safety and Health Manager must be a health physicist certified by the American Board of Health Physicists.

1.9.1.1 Additional Qualifications

The Safety and Health Manager must have the following additional qualifications:

a. A minimum of 3 years experience in developing and implementing safety and health programs at hazardous waste sites.

b. Documented experience in supervising professional and technician level personnel.

c. Documented experience in developing worker exposure assessment programs and air monitoring programs and techniques.

d. Documented experience in managing personal protective equipment programs and conducting PPE hazard evaluations for the types of activities and hazards likely to be encountered on the project.

e. Working knowledge of state and Federal occupational safety and health regulations.

1.9.1.2 Responsibilities and Duties

The Safety and Health Manager shall:

a. Be responsible for the development, implementation, oversight, and enforcement of the APP/SSHSP.

b. Sign and date the APP/SSHSP prior to submittal.

c. Conduct initial site-specific training.

d. Be present onsite during the first 3 days of remedial activities and at the startup of each new major phase of work.

e. Visit the site as needed and at least once per week for the duration of activities, to audit the effectiveness of the APP/SSHSP.

f. Be available for emergencies.

g. Provide onsite consultation as needed to ensure the APP/SSHSP is fully implemented.

h. Coordinate any modifications to the APP/SSHSP with the Site Superintendent, the SSHO, and the Contracting Officer.

i. Provide continued support for upgrading/downgrading of the level of personal protection.

j. Be responsible for evaluating air monitoring data and recommending changes to engineering controls, work practices, and PPE.

k. Review accident reports and results of daily inspections.

l. Serve as a member of the Contractor's quality control staff.

1.9.2 Additional Certified Health and Safety Support Personnel

Retain as necessary industrial hygiene support from an industrial hygienist certified by the American Board of Industrial Hygiene to develop occupational health practices for the APP/SSHSP and, if necessary, visit the site to help implement APP/SSHSP requirements.

1.9.3 Site Safety and Health Officer

Designate an individual and one alternate as the Site Safety and Health Officer (SSHO). Include the name, qualifications (education and training summary and documentation), and work experience of the Site Safety and Health Officer and alternate in the APP/SSHSP.

1.9.3.1 Qualifications

The SSHO shall meet the following qualifications:

a. A minimum of 2 years experience in implementing safety and health programs at hazardous waste sites where Level C personal protective equipment was required.

b. Documented experience in construction techniques and construction safety procedures.

c. Working knowledge of Federal and state occupational safety and health regulations.

d. Specific training in personal and respiratory protective equipment, confined space entry and in the proper use of air monitoring instruments and air sampling methods including monitoring for ionizing radiation.

1.9.3.2 Responsibilities and Duties

The Site Safety and Health Officer shall:

a. Assist and represent the Safety and Health Manager in onsite training and the day to day onsite implementation and enforcement of the accepted APP/SSHSP.

b. Be assigned to the site on a full time basis for the duration of field activities. The SSHO can have collateral duties in addition to Safety

and Health related duties. If operations are performed during more than 1 work shift per day, a site Safety and Health Officer must be present for each shift and when applicable, act as the radiation safety officer (RSO) as defined in paragraph 06.E.02 of EM 385-1-1 on radioactive waste cleanup projects.

c. Have authority to ensure site compliance with specified safety and health requirements, Federal, state and OSHA regulations and all aspects of the APP/SSHSP including, but not limited to, activity hazard analyses, air monitoring, monitoring for ionizing radiation, use of PPE, decontamination, site control, standard operating procedures used to minimize hazards, safe use of engineering controls, the emergency response plan, confined space entry procedures, spill containment program, and preparation of records by performing a daily safety and health inspection and documenting results on the Daily Safety Inspection Log in accordance with 29 CFR 1904.

d. Have authority to stop work if unacceptable health or safety conditions exist, and take necessary action to re-establish and maintain safe working conditions.

e. Consult with and coordinate any modifications to the APP/SSHSP with the Safety and Health Manager, the Site Superintendent, and the Contracting Officer.

f. Serve as a member of the Contractor's quality control staff on matters relating to safety and health.

g. Conduct accident investigations and prepare accident reports.

h. Conduct daily safety inspection and document safety and health findings into the Daily Safety Inspection Log. Track noted safety and health deficiencies to ensure that they are corrected.

i. In coordination with site management and the Safety and Health Manager, recommend corrective actions for identified deficiencies and oversee the corrective actions.

1.9.4 Occupational Physician

Utilize the services of a licensed physician, who is certified in occupational medicine by the American Board of Preventative Medicine, or who, by necessary training and experience is Board eligible. The physician must be familiar with this site's hazards and the scope of this project. Include the medical consultant's name, qualifications, and knowledge of the site's conditions and proposed activities in the APP/SSHSP. The physician will be responsible for the determination of medical surveillance protocols and for review of examination/test results performed in compliance with 29 CFR 1910.120, (f) and 29 CFR 1926.65, (f) and paragraph MEDICAL SURVEILLANCE.

1.9.5 Persons Certified in First Aid and CPR

At least two persons who are currently certified in first aid and CPR by the American Red Cross or other approved agency must be onsite at all times during site operations. They must be trained in universal precautions and the use of PPE as described in the Bloodborne Pathogens Standard of 29 CFR 1910, Section 1030. These persons may perform other duties but will be immediately available to render first aid when needed.

1.9.6 Safety and Health Technicians

For each work crew in the exclusion zone, one person, designated as a Safety and Health technician, must perform activities such as air monitoring, decontamination, and safety oversight on behalf of the SSHO. They must have appropriate training equivalent to the SSHO in each specific area for which they have responsibility and report to and be under the supervision of the SSHO.

1.10 TRAINING

Meet the following requirements in the Contractor's training program for workers performing cleanup operations and who will be exposed to contaminants.

1.10.1 General Hazardous Waste Operations Training

All Personnel performing duties with potential for exposure to onsite contaminants must meet and maintain the following 29 CFR 1910.120/ 29 CFR 1926.65 (e) training requirements:

a. 40 hours of off site hazardous waste instruction.

b. 3 days actual field experience under the direct supervision of a trained, experienced supervisor.

c. 8 hours refresher training annually.

Onsite supervisors must have an additional 8 hours management and supervisor training specified in 29 CFR 1910.120/29 CFR 1926.65 (e) (4).

d. Specific site training based on the hazards present.

1.10.2 Pre-entry Briefing

Prior to commencement of onsite field activities, all site employees, including those assigned only to the Support Zone, must attend a site-specific safety and health training session. This session will be conducted by the Safety and Health Manager and the Site Safety and Health Officer to ensure that all personnel are familiar with requirements and responsibilities for maintaining a safe and healthful work environment. Thoroughly discuss procedures and contents of the accepted APP/SSHSP and Sections 01.B.02 and 28.D.03 of EM 385-1-1 . Each employee must sign a training log to acknowledge attendance and understanding of the training. Notify the Contracting Officer at least 5 days prior to the initial site-specific training session so government personnel involved in the project may attend.

1.10.3 Periodic Sessions

Conduct periodic onsite training by the SSHO at least daily for personnel assigned to work at the site during the following day. Address safety and health procedures, work practices, any changes in the APP/SSHSP, activity hazard analyses, work tasks, or schedule; results of previous week's air monitoring, review of safety discrepancies and accidents. Convene a meeting prior to implementation of the change must be convened should an operational change affecting onsite field work be made, to explain safety and health procedures. Conduct a site-specific training sessions for new

personnel, visitors, and suppliers by the SSHO using the training curriculum outlines developed by the Safety and Health Manager. Each employee must sign a training log to acknowledge attendance and understanding of the training.

1.10.4 Other Training

Site specific training for sites where radioactive wastes are to be cleaned up include:

a. Site specific procedures for handling and storing radioactive materials;

b. Health and safety hazards associated with exposure to the radioactive material that will be cleaned up or otherwise handled and the purpose and function of protective devices and precautions used to minimize exposures;

c. Elements of the APP/SSHSP and company specific procedures intended to provide protection from radiation exposure;

d. Worker responsibility to report any unsafe acts which might result in exposure to ionizing radiation;

e. Appropriate worker response procedures to events that may result in worker exposure to ionizing radiation;

f. Worker rights and responsibilities with respect to ionizing radiation exposure. Provide training as specified by 29 CFR 1910 Section 146, by the Safety and Health Manager shall for employees who are required to supervise, standby, or enter permit-required confined spaces.

1.11 PERSONAL PROTECTIVE EQUIPMENT

1.11.1 Site Specific PPE Program

Provide onsite personnel exposed to contaminants with appropriate personal protective equipment. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Use only respirators approved by NIOSH. Commercially available PPE, used to protect against chemical agent, must be approved by the director of Army Safety through the Chemical Agent Safety and Health Policy Action Committee (CASHPAC). Keep protective equipment and clothing clean and well maintained. Include site-specific procedures to determine PPE program effectiveness and for onsite fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE within the PPE section of the APP/SSHSP.

1.11.2 Levels of Protection

The Safety and Health Manager must establish and evaluate as the work progresses the levels of protection for each work activity. Also establish action levels for upgrade or downgrade in levels of PPE. Describe in the SSHSP the protocols and the communication network for changing the level of protection. Address air monitoring results, potential for exposure, changes in site conditions, work phases, job tasks, weather, temperature extremes, individual medical considerations, etc. within the PPE evaluation protocol.

1.11.2.1 Initial PPE Components

The following items constitute initial minimum protective clothing and equipment ensembles.

a. Level D.

Coveralls or appropriate work clothing, safety/steel toed boots, other PPE as needed (gloves, etc).

b. Modified Level D.

Includes provisions for Level D but including hard hat, safety glasses, and hearing protection as necessary.

c. Level C.

Full-face air purifying respirator (APR) with NIOSH-approved combination high-efficiency particulate air (HEPA)/organic vapor cartridges
Work clothing as prescribed by weather
Steel-toed boots
Chemical resistant boot covers and/or outer boots (PVC/Latex/Neoprene)
Tyvek® coveralls with hoods (as determined by the CHP), elastic writs and ankles (or equivalent cloth/synthetic fiber)
Nitrile, latex, or vinyl gloves (inner) or cloth liners
Nitrile gloves or PVC (outer) or leather palm gloves
Hearing protection (if necessary)
Cooling vest (if necessary)
Hard-hat
Splash shield (if necessary)
Openings at ankles, wrists, and hoods shall be taped (as directed by the CHP).

d. Level B.

Supplied air respirator
Work clothing (light or insulated) as prescribed by weather
Steel-toed boots
Chemical resistant boot covers and/or outer boots (as selected by a CIH)
Tyvek® coveralls with hoods (as determined by the CHP), elastic writs and ankles (or equivalent cloth/synthetic fiber)
Saranex® coveralls with hoods, elastic wrists, and ankles (as determined by a CIH)
Acid gear, splash unit, rain gear, etc. (as determined by a CIH)
Nitrile, latex, or vinyl gloves (inner) and/or cloth liners
Outer gloves (as selected by a CIH)
Hearing protection (if necessary)
Cooling vest (if necessary)
Hard-hat
Splash shield (if necessary)
Openings at ankles, wrists, and hoods shall be taped (as directed by the CHP).

Level D and Modified Level D PPE is anticipated for this project.

1.11.3 PPE for Government Personnel

Three clean sets of personal protective equipment and personal dosimeters for work on radioactive waste cleanup sites and clothing (excluding

air-purifying negative-pressure respirators and safety shoes, which will be provided by individual visitors), as required for entry into the Exclusion Zone and/or Contamination Reduction Zone, must be available for use by the Contracting Officer or official visitors. The items must be cleaned and maintained by the Contractor and stored in the clean room of the decontamination facility and clearly marked: "FOR USE BY GOVERNMENT ONLY." Provide basic training in the use and limitations of the PPE provided.

1.12 MEDICAL SURVEILLANCE PROGRAM

Meet 29 CFR 1910.120/29 CFR 1926.65 (f) and the following requirements for medical surveillance program for workers performing cleanup operations and who will be exposed to contaminants. Assure the Occupational Physician or the physician's designee performs the physical examinations and reviews examination results. Participation in the medical surveillance program will be without cost to the employee, without loss of pay and at a reasonable time and place.

1.12.1 Frequency of Examinations

Medical surveillance program participants must receive medical examinations and consultations on the following schedule:

a. Every 12 months

b. If and when the participant develops signs and symptoms indicating a possible overexposure due to an uncontrolled release of a hazardous substance on the project.

c. Upon termination or reassignment to a job where medical surveillance program participation is not required, unless his/her previous annual examination/consultation was less than 6 months prior to reassignment or termination.

d. On a schedule specified by the occupational physician.

1.12.2 Content of Physical Examinations/Consultation

Verify the following information about medical surveillance program participants:

a. Baseline health conditions and exposure history.

b. Allergies/sensitivity/susceptibility to hazardous substances exposure.

c. Ability to wear personal protective equipment inclusive of NIOSH certified respirators under extreme temperature conditions.

d. Fitness to perform assigned duties.

Provide the occupational physician with the following information for each medical surveillance program participant:

a. Information on the employee's anticipated or measured exposure.

b. A description of any PPE used or to be used.

c. A description of the employee's duties as they relate to the employee's exposures (including physical demands on the employee and heat/cold

stress).

d. A copy of 29 CFR 1910.120, or 29 CFR 1926.65.

e. Information from previous examinations not readily available to the examining physician.

f. A copy of Section 5.0 of NIOSH 85-115.

g. Information required by 29 CFR 1910 Section 134.

1.12.3 Physician's Written Opinion

Obtain and furnish to the Safety and Health Manager; and the employee before work begins, a copy of the physician's written opinion for each employee. Address the employee's ability to perform hazardous waste site remediation work and containing the following:

a. The physician's verification of the employee's fitness to perform duties as well as recommended limitations upon the employee's assigned work and/or PPE usage.

b. The physician's opinion about increased risk to the employee's health resulting from work; and

c. A statement that the employee has been informed and advised about the results of the examination.

1.12.4 Employee Certificates

Provided on employee certificates for each worker performing cleanup operations with potential for contaminant-related occupational exposure signed by the safety and health manager and the occupational physician indicating the workers meet the training and medical surveillance requirements of this contract.

1.12.5 Site Specific Medical Surveillance

Site Specific Medical Surveillance medical monitoring will be based on the direction of the Contracting Officer in accordance with current regulations and standards. Additional input will be provided.

1.13 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

Prepare and implement by the Safety and Health Manager an exposure monitoring/air sampling program to identify and quantify safety and health hazards and airborne levels of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment for affected site personnel. This program should be presented in the Site Specific Health and Safety Plan. Include action levels for upgrading/downgrading PPE in the program. Submit personnel exposure monitoring/sampling results.

1.13.1 Air Sampling and Dosimetry

Use dosimeters to evaluate occupational exposure to radioactive isotopes and ionizing radiation fields in coordination with current standards and procedures at the facility. Provide results to the California Department of Public Health.

1.13.1.1 Evaluation

Radiation dosimetry must be evaluated by an individual or company holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP). Electronic dosimetry may be used to assign external dose if approved by the Contracting Officer. Internal intake assessment and applicable monitoring must be evaluated by the CHP.

1.13.1.2 Documentation

Document employee exposure to external radiation. Include reviewing each employee's radiation exposure history in accordance with 10 CFR 20 Section .2104, for compliance with exposure standards prior to allowing the employee access to a restricted area. If the employee has no exposure history, the employee must provide a signed written statement to that effect.

1.13.1.3 Reporting

Furnish reports of exposure to ionizing radiation to the Contracting Officer as soon as available and to each employee annually, upon termination, and within 30 days of any personal request.

1.14 EVALUATION

Document in the APP/SSHSP and implement the procedures and practices in section 06.J. in EM 385-1-1 to monitor and manage heat stress.

1.15 SPILL AND DISCHARGE CONTROL/CONTAINMENT PROCEDURES

Develop and implement written Spill and discharge control/containment procedures. These procedures should be presented in the APP/SSHSP. Address radioactive wastes, shock sensitive wastes, laboratory waste packs, material handling equipment, as well as drum and container handling, opening, sampling, shipping and transport. Describe prevention measures, such as building berms or dikes; spill control measures and material to be used (e.g. booms, vermiculite); location of the spill control material; personal protective equipment required to cleanup spills; disposal of contaminated material; and who is responsible to report the spill. Storage of contaminated material or hazardous materials must be appropriately bermed, diked and/or contained to prevent any spillage of material on uncontaminated soil. If the spill or discharge is reportable, and/or human health or the environment are threatened, the National Response Center, the state, and the Contracting Officer must be notified as soon as possible.

1.16 SITE CONTROL MEASURES

1.16.1 Work Zones

Initial anticipated work zone boundaries (exclusion zone, contamination reduction zone, support zone, all access points and decontamination areas) are to be clearly delineated on the site drawings. Base delineation of work zone boundaries on the contamination characterization data and the hazard/risk analysis to be performed as described in paragraph: HAZARD/RISK ANALYSIS. As work progresses and field conditions are monitored, work zone boundaries may be modified (and site drawings modified) with approval of the Contracting Officer. Clearly identify work zones and marked in the field (using fences, tape, signs, etc.). Submit and post a site map, showing work zone boundaries and locations of decontamination facilities in the onsite office. Work zones must consist of the following:

a. Exclusion Zone (EZ): The exclusion zone is the area where hazardous contamination is either known or expected to occur and the greatest potential for exposure exists. Control entry into this area and exit may only be made through the CRZ.

b. Contamination Reduction Zone (CRZ): The CRZ is the transition area between the Exclusion Zone and the Support Zone. The personnel and equipment decontamination areas must be separate and unique areas located in the CRZ.

c. Support Zone (SZ): The Support Zone is defined as areas of the site, other than exclusion zones and contamination reduction zones, where workers do not have the potential to be exposed to hazardous substances or dangerous conditions resulting from hazardous waste operations. Secure the Support Zone against active or passive contamination. Site offices, parking areas, and other support facilities must be located in the Support Zone.

1.16.2 Site Control Log

A log of personnel visiting, entering, or working on the site must be maintained. Include the following: date, name, agency or company, time entering and exiting site, time entering and exiting the exclusion zone (if applicable). Before visitors are allowed to enter the Contamination Reduction Zone or Exclusion Zone, they must show proof of current training, medical surveillance and respirator fit testing (if respirators are required for the tasks to be performed) and fill out a Certificate of Worker or Visitor Acknowledgement. Record this visitor information, including date, in the log.

1.16.3 Communication

Provide and install an employee alarm system that has adequate means of on and off site communication in accordance with 29 CFR 1910 Section .165. The means of communication must be able to be perceived above ambient noise or light levels by employees in the affected portions of the workplace. The signals must be distinctive and recognizable as messages to evacuate or to perform critical operations. This includes: air horns, walkie talkies, and cell phones.

1.16.4 Site Security

Provide the following site security: warning signs and fences and site access procedures. Print signs in bold large letters on contrasting backgrounds. Signs must be visible from all points where entry might occur and at such distances from the restricted area that employees may read the signs and take necessary protective steps before entering.

1.17 PERSONAL HYGIENE AND DECONTAMINATION

Personnel entering the Exclusion or Contamination Reduction Zones or otherwise exposed to hazardous chemical vapors, gases, liquids, or contaminated solids must decontaminate themselves and their equipment prior to exiting the contamination reduction zone (CRZ) and entering the support zone. Consult Chapter 10.0 of NIOSH 85-115 when preparing decontamination procedures. Submit a detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers as part of the APP/SSHSP. Train employees in the procedures and enforce the

procedures throughout site operations.

1.17.1 Decontamination Facilities

Initially set up a decontamination line in the CRZ. Employees must exit the exclusion zone through the CRZ and implement the following decontamination procedures and techniques: Scrub and rinse water proof outer garments. Showers, if needed, must comply with 29 CFR 1910, Section.141 and EM 385-1-1, 02 C, Washing Facilities. It is the Site Safety and Health Officer's responsibility to recommend techniques to improve personnel decontamination procedures, if necessary.

1.17.2 Equipment Decontamination

Decontaminate the vehicles and equipment used in the EZ shall be decontaminated in the CRZ prior to leaving the site.

Provide a vehicle/equipment decontamination station within the CRZ for decontaminating vehicles and equipment leaving the EZ. Construct a decontamination station pad, which meets the site decontamination needs for all vehicles and larger equipment decontamination. Construct the pad to capture decontamination water, including overspray, and allow for collection and removal of the decontamination water using sumps, dikes and ditches as required. Or, a dry decontamination using a broom to remove dry/loose spilled materials on accessible surfaces. Provide a designated "clean area" in the CRZ for performing equipment maintenance. Use this area when personnel are required by normal practices to come in contact with the ground, i.e., crawling under a vehicle to change engine oil. Equipment within the EZ or CRZ must be decontaminated before maintenance is performed.

1.17.3 Procedures

Procedures for equipment decontamination must be developed and utilized to prevent the spread of contamination into the SZ and offsite areas. These procedures must address disposal of contaminated products and spent materials used on the site, including containers, fluids, oils, etc. Assume any item taken into the EZ to be contaminated and perform an inspection and decontaminate. Vehicles, equipment, and materials must be cleaned and decontaminated prior to leaving the site. Handle construction material in such a way as to minimize the potential for contaminants being spread and/or carried offsite. Prior to exiting the site, vehicles and equipment must be monitored to ensure the adequacy of decontamination.

1.18 EMERGENCY EQUIPMENT AND FIRST AID REQUIREMENTS

Maintain, as a minimum, the following items onsite and available for immediate use:

a. First aid equipment and supplies approved by the consulting physician.

b. Emergency eyewashes and showers that comply with ANSI/ISEA Z358.1.

c. Provide fire extinguishers of sufficient size and type at site facilities and in all vehicles and at any other site locations where flammable or combustible materials present a fire risk.

1.19 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

An Emergency Response Plan, that meets the requirements of 29 CFR 1910.120 (l) and 29 CFR 1926.65 (l), must be developed and implemented as a section of the APP/SSHSP. In the event of any emergency associated with remedial action, without delay, alert all onsite employees and as necessary offsite emergency responders that there is an emergency situation; take action to remove or otherwise minimize the cause of the emergency; alert the Contracting Officer; and institute measures necessary to prevent repetition of the conditions or actions leading to, or resulting in, the emergency. Train employees that are required to respond to hazardous emergency situations to their level of responsibility according to 29 CFR 1910.120 (q) and 29 CFR 1926.65 (q) requirements. Rehearse the plan regularly as part of the overall training program for site operations. Review the plan periodically and revised as necessary to reflect new or changing site conditions or information. Provide copies of the Emergency Response Portion of the accepted APP/SSHSP to the affected local emergency response agencies. Address, as a minimum, the following elements in the plan:

a. Pre-emergency planning. Coordinate with local emergency response providers during preparation of the Emergency Response Plan. At a minimum, coordinate with local fire, rescue, hazardous materials response teams, police and emergency medical providers to assure all organizations are capable and willing to respond to and provide services for on-site emergencies. Ensure the Emergency Response Plan for the site is compatible and integrated with the local fire, rescue, medical and police security services available from local emergency response planning agencies.

b. Personnel roles, lines of authority, communications for emergencies.

c. Emergency recognition and prevention.

d. Site topography, layout, and prevailing weather conditions.

e. Criteria and procedures for site evacuation (emergency alerting procedures, employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).

f. Specific procedures for decontamination and medical treatment of injured personnel.

g. Route maps to nearest pre-notified medical facility. Site-support vehicles must be equipped with maps. At the beginning of project operations, drivers of the support vehicles must become familiar with the emergency route and the travel time required.

h. Emergency alerting and response procedures including posted instructions and a list of names and telephone numbers of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, Federal, state, and local environmental agencies; as well as Safety and Health Manager, the Site Superintendent, the Contracting Officer and/or their alternates).

i. Criteria for initiating community alert program, contacts, and responsibilities.

j. Procedures for reporting incidents to appropriate government agencies. In the event that an incident such as an explosion or fire, or a spill or release of toxic materials occurs during the course of the project, the appropriate government agencies must be immediately notified. In addition, verbally notify the Contracting Officer and the local district safety office immediately and receive a written notification within 24 hours. Include within the report the following items:

(1) Name, organization, telephone number, and location of the Contractor.

(2) Name and title of the person(s) reporting.

(3) Date and time of the incident.

(4) Location of the incident, i.e., site location, facility name.

(5) Brief summary of the incident giving pertinent details including type of operation ongoing at the time of the incident.

(6) Cause of the incident, if known.

(7) Casualties (fatalities, disabling injuries).

(8) Details of any existing chemical hazard or contamination.

(9) Estimated property damage, if applicable.

(10) Nature of damage, effect on contract schedule.

(11) Action taken to ensure safety and security.

(12) Other damage or injuries sustained, public or private.

k. Procedures for critique of emergency responses and follow-up.

1.20 CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGEMENT

A copy of a Contractor-generated certificate of worker/visitor acknowledgement must be completed and submitted for each visitor allowed to enter contamination reduction or exclusion zones, and for each employee, following the example certificate at the end of this section.

1.21 INSPECTIONS

Attach to and submit with the Daily Quality Control reports the SSHO's Daily Inspection Logs. Include with each entry the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer.

1.22 SAFETY AND HEALTH PHASE-OUT REPORT

Submit a Safety and Health Phase-Out Report in conjunction with the project close out report and will be received prior to final acceptance of the work. Include the following minimum information :

a. Summary of the overall performance of safety and health (accidents or incidents including near misses, unusual events, lessons learned, etc.).

b. Final decontamination documentation including procedures and techniques used to decontaminate equipment, vehicles, and on site facilities.

c. Summary of exposure monitoring and air sampling results accomplished during the project.

d. Signatures of Safety and Health Manager and SSHO.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

Task Hazard and Control Requirements Sheet	
Task	
Initial Anticipated Hazards	
Initial PPE	
Initial Controls	
Initial Exposure Monitoring	
Yes	HAZWOPER Medical Surveillance Required
Yes	HAZWOPER Training Required

-- End of Section --

SECTION 01 35 45.00 10

CHEMICAL DATA QUALITY CONTROL
03/13

PART 1 GENERAL

1.1 SUMMARY OF WORK

Samples collected during the project must follow QA/QC procedures and protocols to maintain and provide data of adequate quality. This includes tasks associated with planning, sampling and analysis, validation, and reporting.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE (USACHPPM)

USACHPPM Protocol	(1993) Sampling Protocol Building Demolition Debris and Buildings Painted with Lead-Based Paint

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 200-1-1	(1994) Environmental Quality -- Validation of Analytical Chemistry Laboratories
EM 200-1-3	(2001) Engineering and Design -- Requirements for the Preparation of Sampling and Analysis Plans
EM 200-1-6	(1997) Environmental Quality -- Chemical Quality Assurance for HTRW Projects
ER 1110-1-263	(1998) Engineering and Design -- Chemical Data Quality Management for Hazardous, Toxic, Radioactive Waste Remedial Activities

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 540/R 94-008	(1999) USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 261	Identification and Listing of Hazardous

	Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 268	Land Disposal Restrictions
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
49 CFR 178	Specifications for Packagings

1.3 MEASUREMENT AND PAYMENT

Separate payment will not be made for providing and maintaining the chemical data quality requirements including the chemical data quality management, chemical data validation, minimum chemical data reporting requirements, and chemical data quality submittal requirements; these costs shall be included in the applicable unit prices or lump sum prices contained in the bidding schedule.

1.4 CHEMISTRY REQUIREMENTS

Chemical Data Quality Control (CDQC) shall be as defined in ER 1110-1-263; this ER, which integrates USACE guidance on the subject, shall be supplemented by EM 200-1-6 for detail technical guidance on CDQC. Tables and charts defining Design Analysis (DA), ROD, and remedial technology specific chemistry shall be according to or consistent with EM 200-1-3.

1.4.1 Site History

Hunters Point Naval Shipyard (HPNS) is located in southeaster San Francisco on a peninsula that extends into San Francisco Bay. HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. In 1940, the Navy obtained ownership of HPNS for shipbuilding, repair, and maintenance activities. After World War II, activities at HPNS shifted to submarine maintenance and repair. HPNS was also the site of the Naval Radiological Defense Laboratory.

HPNS was deactivated in 1974 and remained relatively unused until 1976. Between 1976 and 1986, the Navy leased most of HPNS to Triple A Machine Shop, Inc., a private ship repair company. In 1987, the Navy resumed occupancy of HPNS. Because past shipyard operations left hazardous substances on site, HPNS property was placed on the National Priorities List in 1989 pursuant to CERCLA, as amended by SARA. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPNS involve conducting environmental remediation and making the property available for non-defense use.

Parcel E is one of six parcels (Parcels A through F) originally designated for environmental restoration. In September 2004, the Navy divided Parcel E into two parcels (Parcels E and E-2) to facilitate closure of the Parcel E-2 Landfill and its adjacent areas. Long-term use in Parcel E-2 consists of open space. Environmental investigations began at Parcel E, including Parcel E-2, in 1984.

The Remedial Design (RD) was selected to remove or to consolidate and leave

in place and cover with clean soil and a protective liner soil where contaminant concentrations exceed soil remediation goals. The following are the components of the remedy for Parcel E-2: install below-ground barriers to limit groundwater flow from the landfill to San Francisco Bay, remove and treat landfill gas to prevent it from moving beyond the Parcel E-2 boundary, build a shoreline revetment, and monitor, maintain, and use institutional controls to protect human health and the environment to ensure the integrity of the remedial action.

1.4.2 Data Quality Objectives (DQO)

Sample acquisition, chemical analysis and chemical parameter measurements shall be performed so that the resulting data meet and support data use requirements. The chemical data shall be acquired, documented, verified and reported to ensure that the specified precision, accuracy, representativeness, comparability, completeness and sensitivity requirements are achieved.

1.4.3 Sampling, Analysis and Measurement

1.4.3.1 Soil/Sediment and Ground/Surface Water Samples

Soil/sediment and ground/surface water samples shall be collected and analyzed and/or shipped to a primary laboratory according to the following table:

1.4.3.2 Process Solid and Liquid Samples

Process solid and liquid samples shall be collected and analyzed and/or shipped to a primary laboratory according to the following table:

1.4.3.3 Borrow or Fill Material Samples

Borrow or fill material samples shall be collected and analyzed according to the following table:

1.4.3.4 Investigation Derived Waste Samples

Investigation derived waste (IDW) samples shall be collected and analyzed according to the following table:

1.4.3.5 Manifesting Samples

Material shipping manifesting shall be in accordance with 40 CFR 261, 40 CFR 262, 40 CFR 268, 49 CFR 172, and 49 CFR 178. Manifesting samples shall be collected and analyzed according to the following table:

1.4.3.6 Process Gas and Particulate Emission Samples

Process and emission gas and particulate matter samples shall be collected and analyzed and/or shipped to a primary laboratory according to the following table:

1.4.3.7 Real-Time Instrumental Measurement Samples

Real-time instrumental measurements shall be analyzed onsite for chemical parameters according to the following table:

1.4.3.8 Perimeter Air Monitoring Samples

Perimeter air monitoring samples shall be analyzed according to the following table:

1.4.3.9 Compatibility Field Testing for Bulking Operations

Samples for compatibility field testing for bulking operations shall be in accordance with the following table: Use appropriate compatibility field tests before any bulking operations. The compatibility testing system shall include procedures for: 1) tests conducted prior to drum opening; 2) tests conducted at the drum head; 3) sample acquisition; 4) compatibility tests on collected samples; 5) sample compositing; 6) bulking; and 7) limitations.

1.4.3.10 Demolition Samples

Sampling and analysis for demolition shall be according to USACHPPM Protocol.

1.4.3.11 Field Screening

Field screening shall include photoionization detectors, flame ionization detector, colorimetric, field gas chromatography, or similar methods.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Sampling and Analysis Plan; G

Submit no later than 30 days after receipt of notice to proceed. Include a Quality Assurance (QA) section for sample collection and analysis.

SD-06 Test Reports

Laboratory Analysis Report

Results from laboratory analysis not more than 40 calendar days after collecting samples. The report shall indicate the location, time, date, and purpose of the sample.

1.6 QUALITY ASSURANCE ELEMENTS

The Contractor shall be responsible for the following QA elements necessary to monitor and ensure the quality of chemical data produced.

1.6.1 Laboratory Validation Requirements

The Contractor shall propose the minimum number of laboratories that can attain or have attained U.S. Army Corps of Engineers (USACE) validation in accordance with EM 200-1-1 and consistent with contract required chemical data quality. The Contractor may propose laboratories that shall subsequently be validated by the USACE, or select currently validated USACE

laboratories. Identify all proposed project laboratories in the sampling and analysis plan (SAP). If a proposed analytical laboratory cannot meet specified analytical requirements or achieve the required validation, the Contractor shall select another laboratory. If not currently validated, the USACE laboratory validation process requires a nominal 120 day process.

1.6.2 Review of Primary Laboratory Data

The Contractor shall be responsible for the independent data review of the entire primary data set. The Laboratory Analysis Report shall be submitted for information only.

1.6.3 Validation of Data

The Contractor shall be responsible for validating 10 percent of the data in accordance with EPA 540/R 94-008. The data validation strategy shall be established at the beginning of the project to be consistent with project DQO.

1.7 QUALIFICATIONS

1.7.1 Chemical Quality Control Officer/Project Chemist

As a minimum, the Contractor's Chemical Quality Control Officer/Project Chemist shall have: a MS degree in Chemistry; 3 years of experience related to investigations, studies, design and remedial actions at HTRW sites; and 3 field seasons (or one continuous calendar year experience) in standard analytical chemistry methods common for analyzing soil, water, air and other materials for chemical contamination assessment, including hazardous waste manifesting. The Chemical Quality Control Officer/Project Chemist shall ensure that all chemistry related objectives including responsibilities for DQO definitions, sampling and analysis, project requirements for data documentation and validation, and final project reports are attained. The Chemical Quality Control Officer/Project Chemist need not be present onsite during routine sampling, but shall be available for consultation with Government and Contractor personnel.

1.7.2 Environmental Sampler

As a minimum, the Contractor's Environmental Sampler shall have: 1 year of experience in and knowledge of EPA methods for collecting environmental and hazardous waste samples; 1 year of experience in operation of field screening equipment (e.g. PID, FID, infrared spectrometer, immunoassay, etc.); and 1 field season of experience with the particular field screening techniques for use on this project. The Environmental Sampler shall collect all onsite samples and perform all field screening tests. The Environmental Sampler shall review the sampling results, and provide recommendations for the Contractor's sampling program. The Environmental Sampler shall be onsite during excavation and stockpiling operations involving contaminated soil or soil to be checked for contamination.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Provide chemical sample acquisition, sample analysis, instrumental measurements of chemical parameters for chemical data quality control. An effective chemical data quality control system shall be established that meets the requirements for the chemical measurement DQO applicable to the project. The system shall cover chemical measurements pertaining to and required for Contractor and subcontractor produced chemical data. Control field screening, sampling, and testing in conjunction with remedial activities to meet all DQO; minimize the amount of excavated material requiring temporary storage; prevent dilution of contaminated soils with clean soils; and ensure completion of work within the required time.

3.2 QUALITY CONTROL PLAN

3.2.1 Additional Requirements

In addition to the quality control requirements specified in Section 01 45 00.00 10 QUALITY CONTROL, the CQC Plan shall incorporate the qualifications, authority and responsibilities of all chemical quality management and support personnel. Chemical measurements including sampling and/or chemical parameter measurement will not be permitted to begin until after production and acceptance of the CQC Plan, and Government approval of the SAP.

3.2.2 Qualifications

Names, education, experience qualifications, authorities, and decision-making responsibilities of all chemical quality management and support personnel. The CQC Plan shall contain a copy of a letter from the project QC manager designating and authorizing a Chemical Quality Control Officer and chemical quality control organization staff.

3.3 SAMPLING AND ANALYSIS PLAN

The SAP shall be prepared in accordance with CDQC requirements and EM 200-1-3. The SAP shall be a two-part document that contains two distinct elements: FSP and QAPP. The SAP shall confirm the Contractor's understanding of the contract requirements for chemical data quality control, and shall describe procedures for field sampling and sample submittal for analysis, field chemical parameter measurement, data documentation, data assessment and data reporting requirements. The SAP shall delineate the methods the Contractor intends to use to accomplish the chemical quality control items to assure accurate, precise, representative, complete, legally defensible and comparable data. The SAP shall describe all chemical parameter measurements for all matrices for all phases of the remediation contract. As a single interrelated document, the SAP shall be provided to field and laboratory personnel. The Contractor may propose original/innovative approaches to chemical parameter measurements for cost reduction and remediation efficiency by abbreviated sampling, contingency sampling and/or contingency analysis, indicator or tracer analysis, onsite analytical services, equivalency or screening methods. The SAP shall clearly identify the Contractor obtained laboratories. The Contractor shall furnish copies of the Government approved SAP to all laboratories and the Contractor's field sampling crew. The SAP shall address all levels of the investigation with enough detail to become a document which may be used

as an audit guide for field and laboratory work.

3.3.1 Field Sampling Plan

The FSP shall contain necessary technical detail and direction for the field personnel to understand sampling and field measurement requirements. The FSP shall provide a comprehensive description and full detail for personnel to perform all onsite activities required to attain project DQO, including: locations of samples, sampling procedures for onsite and offsite chemical analysis, summaries of analyses to be performed on samples, shipment of samples for offsite analyses, performance of onsite and offsite instrumental parameter measurements, data documentation and reporting requirements.

3.3.2 Quality Assurance Project Plan

The QAPP shall contain necessary technical detail and direction for field and laboratory personnel to understand project sample analysis, quality control and data reporting requirements, analytical methods, required detection limits, QC requirements, and data validation and reporting requirements.

3.4 CONTROL OF CHEMICAL DATA QUALITY

Contractor chemical data quality control shall ensure that a quality control program is in place that assures sampling and analytical activities and the resulting chemical parameter measurement data comply with the DQO and the requirements of the SAP. Utilize the three-phase control system that includes a preparatory, initial and follow-up phase for each definable feature of work. The Contractor's three-phase chemical data control process shall ensure that data reporting requirements are achieved and shall be implemented according to Section 01 45 00.00 10 QUALITY CONTROL. The three-phase chemical data control process shall be combined with that under Section 01 45 00.00 10 QUALITY CONTROL.

3.5 ANALYTICAL TESTING LABORATORIES

The Contractor shall propose the analytical laboratories to be used for the primary samples analyses. Laboratory validation requirements shall be in accordance with paragraph Laboratory Validation Requirements. The Contractor may utilize its own laboratory or utilize subcontract laboratories to achieve the primary required sample analyses.

3.5.1 Laboratory Analytical Requirements

The Contractor shall provide the specified chemical analyses by the Contractor's laboratory. The Contractor shall provide chemical analyses to achieve the project DQO for all parameters specified by the methods. To give the USACE programs the greatest flexibility in the execution of its projects, the EPA SW-846.3-3 methods are generally the methods employed for the analytical testing of environmental samples. These methods are flexible and shall be adapted to individual project-specific requirements.

3.5.2 Laboratory Performance

The Contractor shall provide continued acceptable analytical performance and shall establish a procedure to address data deficiencies noted by review and/or quality assurance sample results. The Contractor shall provide and implement a mechanism for monitoring the lab's performance and

for performing corrective action procedures.

3.6 LABORATORY REPORT

Laboratory Reports shall be produced including a summary of quality control practices employed and all chemical parameter measurement activities.

3.7 DOCUMENTATION

Documentation records shall be provided as factual evidence that required chemical data has been produced and chemical data quality has been achieved.

3.8 NOTIFICATION OF NON-COMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice.

-- End of Section --

SECTION 01 42 00

SOURCES FOR REFERENCE PUBLICATIONS
03/13

PART 1 GENERAL

1.1 REFERENCES

Various publications are referenced in other sections of the specifications to establish requirements for the work. These references are identified in each section by document number, date and title. The document number used in the citation is the number assigned by the standards producing organization, (e.g. ASTM B564 Nickel Alloy Forgings). However, when the standards producing organization has not assigned a number to a document, an identifying number has been assigned for reference purposes.

1.2 ORDERING INFORMATION

The addresses of the standards publishing organizations whose documents are referenced in other sections of these specifications are listed below, and if the source of the publications is different from the address of the sponsoring organization, that information is also provided. Documents listed in the specifications with numbers which were not assigned by the standards producing organization should be ordered from the source by title rather than by number.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Ph: 513-742-2020 or 513-742-6163
Fax: 513-742-3355
E-mail: mail@acgih.org
Internet: http://www.acgih.org

AMERICAN GAS ASSOCIATION (AGA)
400 North Capitol Street N.W.
Suite 450
Washington, D.C. 20001
Ph: 202-824-7000
Fax: 202-824-7115
E-mail: website@aga.org
Internet: http://www.aga.org

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
1819 L Street, NW, 6th Floor
Washington, DC 20036
Ph: 202-293-8020
Fax: 202-293-9287
E-mail: info@ansi.org
Internet: http://www.ansi.org/

AMERICAN PETROLEUM INSTITUTE (API)
1220 L Street, NW
Washington, DC 20005-4070
Ph: 303-397-7993
Fax: 303-397-2740

E-mail: greg.kallio@ihs.com
Internet: http://www.api.org

AMERICAN WATER WORKS ASSOCIATION (AWWA)
6666 West Quincy Avenue
Denver, CO 80235
Ph: 800-926-7337
Fax: 303-347-0804
E-mail: smorrison@awwa.org
Internet: http://www.awwa.org

ASME INTERNATIONAL (ASME)
Three Park Avenue, M/S 10E
New York, NY 10016-5990
Ph: 800-854-7179 or 800-843-2763
Fax: 212-591-7674
E-mail: infocentral@asme.org
Internet: http://www.asme.org

ASTM INTERNATIONAL (ASTM)
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959
Ph: 610-832-9585
Fax: 610-832-9555
E-mail: service@astm.org
Internet: http://www.astm.org

BAY AREA AIR QUALITY MANAGEMENT DISTRICT (Bay Area AQMD)
939 Ellis Street
San Francisco, CA 94109
Ph: 415-771-6000
Fax: 415-928-8560
E-Mail: publicrecords@baaqmd.gov
Internet: http://www.baaqmd.gov/

FORESTRY SUPPLIERS INC. (FSUP)
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39284-8397
Ph: 800-752-8460
Fax: 601-292-0165
E-mail: cs@forestry-suppliers.com
Internet: http://www.forestry-suppliers.com

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)
University of South California
Kaprielian Hall 200
Los Angeles, CA 90089-2531
Ph: 213-740-2032 or 866-545-6340
Fax: 213-740-8399
E-mail: fccchr@usc.edu
Internet: http://www.usc.edu/dept/fccchr

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)
P.O. Box 9140
Boulder, CO 80301-9140
Ph: 303-447-2020
Fax: 303-357-1070

E-mail: gsaservice@geosociety.org
Internet: http://www.geosociety.org
Publication available from: http://www.munsellstore.com/

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA)
1901 North Moore Street
Arlington, VA 22209-1762
Ph: 703-525-1695
Fax: 703-528-2148
E-mail: isea@safety equipment.org
Internet: http://www.safetyequipment.org/

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)
127 Park Street, NE
Vienna, VA 22180
Ph: 703-281-6613
Fax: 703-281-6671
E-mail: info@mss-hq.com
Internet: http://www.mss-hq.com

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Burnaby, BC CANADA V5C 6G7
Ph: 604-298-7578
Fax: 604-298-7571
E-mail: info@paintinfo.com,jody@mpi.net,bgl@mpi.net
Internet: http://www.paintinfo.com/mpi

NACE INTERNATIONAL (NACE)
1440 South Creek Drive
Houston, TX 77084-4906
Ph: 281-228-6200
Fax: 281-228-6300
E-mail: firstservice@nace.org
Internet: http://www.nace.org

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1 Batterymarch Park
Quincy, MA 02169-7471
Ph: 617-770-3000 or 800-344-3555
Fax: 617-770-0700
E-mail: webmaster@nfpa.org
Internet: http://www.nfpa.org

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)
Mail Stop C-34
4676 Columbia Parkway
Cincinnati, OH 45226
Ph: 513-533-8611
Fax: 513-533-8285
E-mail: nioshdocket@cdc.gov
Internet: http://www.cdc.gov/nchs/products.htm

NSF INTERNATIONAL (NSF)
789 North Dixboro Road
P.O. Box 130140
Ann Arbor, MI 48113-0140
Ph: 734-769-8010 or 800-NSF-MARK

Fax: 734-769-0109
E-mail: info@nsf.org
Internet: http://www.nsf.org

PLASTICS PIPE INSTITUTE (PPI)
105 Decker Court, Suite 825
Irving, TX 75062
Ph: 469-499-1044
Fax: 469-499-1063
E-Mail: sboros@plasticpipe.org
Internet: http://www.plasticpipe.org

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)
2200 Powell Street, Suite 725
Emeryville, CA 94608
Ph: 510-452-8000
Fax: 510-452-8001
Internet: http://www.scs1.com

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)
40 24th Street, 6th Floor
Pittsburgh, PA 15222-4656
Ph: 412-281-2331
Fax: 412-281-9992
E-mail: info@sspc.org
Internet: http://www.sspc.org

UNDERWRITERS LABORATORIES (UL)
2600 N.W. Lake Road
Camas, WA 98607-8542
Ph: 877-854-3577
Fax: 360-817-6278
E-mail: CEC.us@us.ul.com
Internet: http://www.ul.com/
UL Directories available through IHS at http://www.ihs.com

U.S. AIR FORCE (USAF)
Air Force Publishing Distribution Center
E-mail: afdpo-ppl@pentagon.af.mil
Internet: http://www.e-publishing.af.mil/

U.S. ARMY (DA)
U.S. Army Publishing Directorate
Ph: 314-592-0910
Fax: 314-592-0923
Internet: http://www.apd.army.mil

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE (USACHPPM)
5158 Blackhawk Road
Aberdeen Proving Ground, MD 21010-5403
Ph: 800-222-9698
Fax: 1 (410) 436-7142
E-mail: chppmhhc@AMEDD.ARMY.MIL
Internet: http://chppm-www.apgea.army.mil

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Obtain Military Specifications, Standards and Related Publications from:
Acquisition Streamlining and Standardization Information System (ASSIST)
Department of Defense Single Stock Point (DODSSP)
Document Automation and Production Service (DAPS)
Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094
Ph: 215-697-6396 - for account/password issues
Internet: http://assist.daps.dla.mil/online/start/; account registration required
Obtain Unified Facilities Criteria (UFC) from:
Whole Building Design Guide (WBDG)

National Institute of Building Sciences (NIBS)
1090 Vermont Avenue NW, Suite 700
Washington, CD 20005
Ph: 202-289-7800
Fax: 202-289-1092
Internet: http://www.wbdg.org/references/docs_refs.php

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20004
Ph: 202-272-0167
for Fax and E-mail see below
Internet: http://www.epa.gov
--- Some EPA documents are available only from:
National Technical Information Service (NTIS)
5301 Shawnee Road
Alexandria, VA 22312
Ph: 703-605-6050 or 1-688-584-8332
Fax: 703-605-6900
E-mail: info@ntis.gov
Internet: http://www.ntis.gov

U.S. GENERAL SERVICES ADMINISTRATION (GSA)
General Services Administration
1800 F Street, NW
Washington, DC 20405
Ph: 202-501-0800
Internet: www.GSA.gov
Obtain documents from:
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Document Automation and Production Service (DAPS)
Building 4/D
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Philadelphia, PA 19111-5094
Ph: 215-697-6396 - for account/password issues
Internet: http://assist.daps.dla.mil/online/start/; account registration required

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
8601 Adelphi Road
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Internet: http://www.gpoaccess.gov

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

-- End of Section --

SECTION 01 45 00.00 20

QUALITY CONTROL
03/13

PART 1 GENERAL

1.1 SUMMARY OF WORK

Excavate and dispose of contaminated soil, sediment, and debris impacted by metals, radionuclides, pesticides, polychlorinated biphenyls, semivolatile organic compounds, total petroleum hydrocarbons, and dioxins in selected areas. Consolidate and contain remaining contamination, including installing a soil cover over all of Parcel E-2 with a protective liner. Install below-ground barriers to limit groundwater flow from the landfill to San Francisco Bay. Remove and treat landfill gas to prevent it from moving beyond the Parcel E-2 boundary. Build a shoreline revetment. Monitor, maintain, and use institutional controls to protect human health and the environment to ensure the integrity of the remedial action.

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Contracting Officer. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES

SD-01 Preconstruction Submittals

Quality Control (QC) Plan; G

1.3 INFORMATION FOR THE CONTRACTING OFFICER

Deliver the following to the Contracting Officer:

a. Combined Contractor Production Report/Contractor Quality Control Report (1 sheet): Original and 1 copy by 10:00 am the next working day after each day that work is performed;

b. QC Specialist Reports: Submit the report (original and one copy) by 10:00 AM the next working day after each day that work is performed;

f. Field Test Reports: 2 copies, within 2 working days after the test is performed, attached to the Contractor Quality Control Report;

g. Monthly Summary Report of Tests: 2 copies attached to the Contractor Quality Control Report;

h. Testing Plan and Log: 2 copies, at the end of each month;

i. Rework Items List: 2 copies, by the last working day of the month;

j. CQC Meeting Minutes: 2 copies, within 2 working days after the meeting and;

k. QC Certifications: As required by the paragraph titled “QC

Certifications."

1.4 QC PROGRAM REQUIREMENTS

The QC program requirements are contained in the Remedial Action Contract (RAC).

1.4.1 Acceptance of the Construction Quality Control (QC) Plan

Acceptance of the QC Plan is required prior to the start of construction. The Contracting Officer reserves the right to require changes in the QC Plan and operations as necessary, including removal of personnel, to ensure the specified quality of work. The Contracting Officer reserves the right to interview any member of the QC organization at any time in order to verify the submitted qualifications. All QC organization personnel are subject to acceptance by the Contracting Officer. The Contracting Officer may require the removal of any individual for non-compliance with quality requirements specified in the Contract.

1.5 QC Manager

1.5.1 Duties

Provide a QC Manager at the work site to implement and manage the QC program. In addition to implementing and managing the QC program, the QC Manager may perform the duties of project superintendent.

The QC Manager is required to attend the Coordination and Mutual Understanding Meeting, conduct the QC meetings, perform the three phases of control, perform submittal review, perform submittal approval, ensure testing is performed, and provide QC certifications and documentation required in this Contract. The QC Manager is responsible for managing and coordinating the three phases of control and documentation performed by Testing Laboratory personnel and any other inspection and testing personnel required by this contract.

1.5.2 Qualifications

An individual with a minimum of 5 years combined experience in the following positions: Project Superintendent, QC Manager, Project Manager, Project Engineer or Construction Manager on similar size and type construction contracts which included the major trades that are part of this Contract.

1.6 COORDINATION AND MUTUAL UNDERSTANDING MEETING

After submission of the QC Plan, and prior to the start of construction, the QC Manager will meet with the Contracting Officer to present the QC program required by this Contract. When a new QC Manager is appointed, the coordination and mutual understanding meeting shall be repeated.

1.7 QC MEETINGS

After the start of construction, conduct weekly QC meetings at the work site with the Project Superintendent. The QC Manager is to prepare the minutes of the meeting and provide a copy to the Contracting Officer within two working days after the meeting. The Contracting Officer may attend these meetings. As a minimum, accomplish the following at each meeting:

a. Review the minutes of the previous meeting.

b. Review the schedule and the status of work and rework.

c. Review the status of submittals.

d. Review the work to be accomplished in the next two weeks and documentation required.

e. Resolve QC and production problems.

f. Address items that may require revising the QC Plan.

1.8 THREE PHASES OF CONTROL

Adequately cover both on-site and off-site work with the Three Phases of Control and include the following for each DFOW.

1.8.1 Preparatory Phase

Notify the Contracting Officer at least two work days in advance of each preparatory phase meeting. The meeting will be conducted by the QC Manager and attended by the Project Superintendent. Document the results of the preparatory phase actions in the daily Contractor Quality Control Report and in the Quality Control Checklist. Perform the following prior to beginning work on each DFOW:

a. Review each paragraph of the applicable specification sections.

b. Review the Contract drawings.

c. Verify that appropriate shop drawings and submittals for materials and equipment have been submitted and approved. Verify receipt of approved factory test results, when required.

d.. Review the testing plan and ensure that provisions have been made to provide the required QC testing.

e. Examine the work area to ensure that the required preliminary work has been completed.

f. Examine the required materials, equipment and sample work to ensure that they are on hand and conform to the approved shop drawings and submitted data.

g. Review the APP and appropriate Activity Hazard Analysis (AHA) to ensure that applicable safety requirements are met, and that required Material Safety Data Sheets (MSDS) are submitted.

h. Discuss construction methods and the approach that will be used to provide quality construction for each definable feature of work.

1.8.2 Initial Phase

Notify the Contracting Officer at least one work day in advance of each initial phase. When construction crews are ready to start work on a DFOW,

conduct the initial phase with the Project Superintendent and the foreman responsible for that DFOW. Observe the initial segment of the DFOW to ensure that the work complies with Contract requirements. Document the results of the initial phase in the daily CQC Report and in the Quality Control Checklist. Repeat the initial phase for each new crew to work on-site, or when acceptable levels of specified quality are not being met. Perform the following for each DFOW:

a. Establish the quality of workmanship required.

b. Resolve conflicts.

c. Review the Safety Plan and the appropriate activity hazard analysis to ensure that
applicable safety requirements are met; and.

d. Ensure that testing is performed.

1.8.3 Follow-Up Phase

Perform the following for on-going work daily, or more frequently as necessary, until the completion of each DFOW and document in the daily CQC Report:

a. Ensure the work is in compliance with Contract requirements.

b. Maintain the quality of workmanship required.

c. Ensure that testing is performed by the approved laboratory.

d. Ensure that rework items are being corrected.

1.9 SUBMITTAL REVIEW AND APPROVAL

Procedures for submission, review and approval of submittals are described in Section 01 33 00 SUBMITTAL PROCEDURES.

1.10 TESTING

Except as stated otherwise in the specification sections, perform sampling and testing required under this Contract.

1.10.1 Accreditation Requirements

Construction materials testing laboratories must be accredited by a laboratory accreditation authority and will be required to submit a copy of the Certificate of Accreditation and Scope of Accreditation. The laboratory's scope of accreditation must include the appropriate ASTM standards (E 329 and D 3740) listed in the technical sections of the specifications. Laboratories engaged in Hazardous Materials Testing shall meet the requirements of OSHA and EPA. The policy applies to the specific laboratory performing the actual testing, not just the Corporate Office.

1.10.2 Laboratory Accreditation Authorities

In addition to applicable U.S. Navy approval through the Naval Facilities Engineering Service Center (NFESC), acceptable accreditation programs are the National Institute of Standards and Technology (NIST)/National Voluntary Laboratory Accreditation Program (NVLAP) administered by the

National Institute of Standards and Technology at http://ts.nist.gov/ts/htdocs/210/214/214.htm , the American Association of State Highway and Transportation Officials (AASHTO) program at http://www.transportation.org/aashto/home.nsf/frontpage and the American Association for Laboratory Accreditation (A2LA) program at http://www.a2la.org/. Furnish to the Contracting Officer a copy of the Certificate of Accreditation and Scope of Accreditation and latest directory of the accrediting organization for accredited laboratories. The scope of the laboratory's accreditation shall include the test methods required by the Contract.

1.10.3 Inspection of Testing Laboratories

Prior to approval of non-accredited laboratories, the proposed testing laboratory facilities and records may be subject to inspection by the Contracting Officer. Records subject to inspection include equipment inventory, equipment calibration dates and procedures, library of test procedures, audit and inspection reports by agencies conducting laboratory evaluations and certifications, testing and management personnel qualifications, test report forms, and the internal QC procedures.

1.10.4 Capability Check

The Contracting Officer retains the right to check laboratory equipment in the proposed laboratory and the laboratory technician's testing procedures, techniques, and other items pertinent to testing, for compliance with the standards set forth in this Contract.

1.10.5 Test Results

Cite applicable Contract requirements, tests or analytical procedures used. Provide actual results and include a statement that the item tested or analyzed conforms or fails to conform to specified requirements. If the item fails to conform, notify the Contracting Officer immediately. Conspicuously stamp the cover sheet for each report in large red letters "CONFORMS" or "DOES NOT CONFORM" to the specification requirements, whichever is applicable. Test results must be signed by a testing laboratory representative authorized to sign certified test reports. Furnish the signed reports, certifications, and other documentation to the Contracting Officer via the QC Manager. Furnish a summary report of field tests at the end of each month, per the paragraph entitled "INFORMATION FOR THE CONTRACTING OFFICER".

1.10.6 Test Reports and Monthly Summary Report of Tests

The QC Manager shall furnish the signed reports, certifications, and a summary report of field tests at the end of each month to the Contracting Officer. Attach a copy of the summary report to the last daily Contractor Quality Control Report of each month.

1.11 QC CERTIFICATIONS

1.11.1 CQC Report Certification

Contain the following statement within the CQC Report: "On behalf of the Contractor, I certify that this report is complete and correct and equipment and material used and work performed during this reporting period is in compliance with the contract drawings and specifications to the best of my knowledge, except as noted in this report."

1.11.2 Invoice Certification

Furnish a certificate to the Contracting Officer with each payment request, signed by the QC Manager, attesting that as-built drawings are current, coordinated and attesting that the work for which payment is requested, including stored material, is in compliance with Contract requirements.

1.11.3 Completion Certification

Upon completion of work under this Contract, the QC Manager shall furnish a certificate to the Contracting Officer attesting that "the work has been completed, inspected, tested and is in compliance with the Contract." Provide a copy of this final QC Certification for completion to the OMSI preparer for inclusion into the OMSI documentation.

1.12 DOCUMENTATION

Maintain current and complete records of on-site and off-site QC program operations and activities.

1.12.1 Contractor Production Report

Reports are required for each day that work is performed and shall be attached to the Contractor Quality Control Report prepared for the same day. Account for each calendar day throughout the life of the Contract. The reporting of work shall be identified by terminology consistent with the construction schedule. Contractor Production Reports are to be prepared, signed, and dated by the project superintendent and shall contain the following information:

a. Date of report, report number, name of contractor, Contract number, title and location of Contract, and superintendent present.

b. Weather conditions in the morning and in the afternoon including maximum and minimum temperatures.

c. A list of Contractor and subcontractor personnel on the work site, their trades, employer, work location, description of work performed, and hours worked.

d. A list of job safety actions taken and safety inspections conducted. Indicate that safety requirements have been met including the results on the following:
- Attach a copy of the meeting minutes from the daily job safety meeting.
- Were there any lost time accidents? (If YES, attach a copy of the completed Occupational Safety and Health Administration report.)
- Was crane/trenching/scaffold/high voltage electrical/high work done? (If YES, attach a statement or checklist showing inspection performed.)
- Was hazardous material/waste released into the environment? (If YES, attach a description of meetings held and accidents that happened.)

e. A list of equipment/material received each day that is incorporated into the job.

f. A list of construction and plant equipment on the work site including the number of hours used, idle, and down for repair.

g. Include a "remarks" section in this report which will contain pertinent information including directions received, problems encountered during construction, work progress and delays, conflicts or errors in the Drawings or specifications, field changes, safety hazards encountered, instructions given and corrective actions taken, delays encountered, and a record of visitors to the work site.

1.12.2 Contractor Quality Control Report

Reports are required for each day that work is performed and for every 7 consecutive calendar days of no work and on the last day of a no-work period. Account for each calendar day throughout the life of the Contract. The reporting of work shall be identified by terminology consistent with the construction schedule. Contractor Quality Control Reports are to be prepared, signed, and dated by the QC Manager, and shall contain the following information:

a. Identify the control phase and the definable feature of work

b. Results of the Preparatory Phase meetings held including the location of the definable feature of work and a list of personnel present at the meeting. Indicate in the report that, for this definable feature of work, the Drawings and specifications have been reviewed, submittals have been approved, materials comply with approved submittals, materials are stored properly, preliminary work was done correctly, the testing plan has been reviewed, and work methods and schedule have been discussed.

c. Results of the Initial Phase meetings held including the location of the definable feature of work and a list of personnel present at the meeting. Indicate in the report that for this definable feature of work the preliminary work was done correctly, samples have been prepared and approved, the workmanship is satisfactory, test results are acceptable, work is in compliance with the Contract, and the required testing has been performed, and include a list of who performed the tests.

d. Results of the Follow-up Phase inspections held including the location of the definable feature of work. Indicate in the report for this definable feature of work that the work complies with the Contract as approved in the Initial Phase, and that required testing has been performed, and include a list of who performed the tests.

e. Results of the three phases of control for off-site work, if applicable, including actions taken.

f. List the rework items identified, but not corrected, by close of business.

g. List the rework items corrected from the rework items list along with the corrective action taken.

h. Include a "remarks" section in this report that will contain pertinent information including directions received, quality control problem areas, deviations from the QC plan, construction deficiencies encountered, QC meetings held, acknowledgment that as-built Drawings have been updated, corrective direction given by the QC Organization, and corrective action taken by the Contractor.

i. Contractor Quality Control Report certification.

1.12.3 Testing Plan and Log

As tests are performed, the QC Manager will record on the "Testing Plan and Log" the date the test was performed and the date the test results were forwarded to the Contracting Officer. Attach a copy of the updated "Testing Plan and Log" to the last daily CQC Report of each month.

1.12.4 Rework Items List

The QC Manager shall maintain a list of work that does not comply with the Contract, identifying what items need to be reworked, the date the item was originally discovered, and the date the item was corrected. There is no requirement to report a rework item that is corrected the same day it is discovered. Attach a copy of the “Contractor Rework Items List” to the last daily Contractor Quality Control Report of each month. The Contractor shall be responsible for including on this list items needing rework, including those identified by the Contracting Officer.

1.12.5 As-Built Drawings

The QC Manager is required to ensure the as-built drawings are kept current on a daily basis and marked to show deviations which have been made from the Contract drawings. The QC Manager shall initial each deviation and each revision. Upon completion of work, the QC Manager shall furnish a certificate attesting to the accuracy of the as-built Drawings prior to submission to the Contracting Officer.

1.12.6 Report Forms

The following forms, which are attached at the end of this section, are acceptable for providing the information required by the paragraph titled “Documentation.” While use of these specific formats is not required, any other format used shall contain the same information:

a. Combined Contractor Production Report and Contractor Quality Control Report (1 sheet), with separate continuation sheet

b. Testing Plan and Log

c. Rework Items List

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 01 50 00

TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS
03/13

PART 1 GENERAL

1.1 SUMMARY

Requirements of this Section apply to, and are a component of, each section of the specifications.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Construction site plan; G

Traffic control plan; G

SD-06 Test Reports

Backflow Preventer Test; G

SD-07 Certificates

Backflow Tester Certification; G

Backflow Preventers Certificate of Full Approval

1.4 CONSTRUCTION SITE PLAN

Prior to the start of work, submit a site plan showing the locations and dimensions of temporary facilities (including layouts and details, equipment and material storage area (onsite and offsite), and access and haul routes, avenues of ingress/egress to the fenced area and details of the fence installation. Identify any areas which may have to be graveled to prevent the tracking of mud. Indicate if the use of a supplemental or other staging area is desired. Show locations of safety and construction fences, site trailers, construction entrances, trash dumpsters, temporary

sanitary facilities, and worker parking areas.

1.5 BACKFLOW PREVENTERS CERTIFICATE

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance backflow preventer tests and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

1.5.1 Backflow Tester Certificate

Prior to testing, submit to the Contracting Officer certification issued by the State or local regulatory agency attesting that the backflow tester has successfully completed a certification course sponsored by the regulatory agency. Tester must not be affiliated with any company participating in any other phase of this Contract.

1.5.2 Backflow Prevention Training Certificate

Submit a certificate recognized by the State or local authority that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.

1.6 IDENTIFICATION OF CONTRACTOR VEHICLES

Each Contractor-provided vehicle and towed trailer shall show the Contractor’s name so that it is clearly visible from at least 100 feet on both front doors of the vehicle and both sides of a towed trailer. Removable company identification is acceptable. Contractor-provided vehicle shall at all times display a valid state license plate and safety inspection sticker. Contractor vehicles operated on Government property shall be maintained in a good state of repair.

1.7 PROJECT SIGN

Within 15 days after the commencement of work, provide one project identification sign at a location indicated by the Contracting Officer. Construct the sign in accordance with project sign detail attached at the end of this section. Verify the content of the sign with the Contracting Officer using shop drawings. Maintain sign throughout the life of the project. Upon completion of the project, remove the sign from the site.

1.7.1 Project Identificaiton Signboard

The signboard shall be provided at a conspicuous location on or near the job site where directed by the Contracting Officer.

a. The field of the sign shall consist of a 4- by 8- foot sheet of grade B-B, medium-density overlaid exterior plywood.

b. Lumber shall be B or better Southern pine, pressure-preservative treated with pentachlorophenol. Nails shall be aluminum or galvanized steel.

c. The entire signboard and supports shall be given one coat of exterior alkyd primer and two coats of exterior alkyd enamel paint. The lettering and sign work shall be performed by a skilled sign painter using paint known in the trade as bulletin colors. The colors,

lettering sizes, and lettering styles shall be as indicated. Where preservative-treated lumber is required, use only cured pressure-treated wood that has had the chemicals leached from the surface of the wood prior to painting.

d. The high-gloss acrylic gold enamel paint used as background for the Department of the Navy-applied sticker shall be spray applied automotive quality paint. The 18-inch diameter applied sticker shall be a silkscreened image in the design indicated, painted on a 2 millimeter transparent polyester film. The weather resistant, self-adhering film shall be rated for a minimum of 2 years of exterior vertical exposure and be mounted to the sign with pressure-sensitive, permanent acrylic adhesive. Shop cut sticker to round shape and provide pull-off backing sheet on adhesive side of design sticker for shipping. Provide applied design sticker in accordance with attached detail.

e. Sign paint colors (numbers listed below for color identification only)
(1) Blue = Benjamin Moore Paints No. 826.
(2) White = Benjamin Moore Paints No. 873.
(3) Gold = Dupont No. B8014, Metallic gold.

1.8 STATION OPERATION AFFECT ON CONTRACTOR OPERATIONS

1.8.1 Interruption of Vehicular Traffic

If, during the performance of work, it becomes necessary to modify vehicular traffic patterns at any locations, notify the Contracting Officer at least 15 calendar days prior to the proposed modification date, and provide a Traffic Control Plan detailing the proposed controls to traffic movement for approval. The plan shall be in accordance with State and local regulations and the FHWA MUTCD, Part VI. Provide cones, signs, barricades, lights, and other traffic control devices and personnel required to control traffic.

1.9 UNAUTHORIZED ACCESS

Ensure that the public and other unauthorized personnel do not have access to the area during the construction period.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 01 57 19.00 20

TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Unless otherwise noted, the latest version of each publication is to be used.

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 263	Standards Applicable to Transporters of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 300	National Oil and Hazardous Substances Pollution Contingency Plan
49 CFR 171	General Information, Regulations, and Definitions
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

2009-0009-DWQ	onstruction General Permit Order 2009-0009-DWQ National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction Activity (CAS000002)

BAY AREA AIR QUALITY MANAGEMENT DISTRICT (Bay Area AQMD)

Regulation 8, Rule 40	Aeration of Contaminated Soil and Removal of Underground Storage Tanks

1.2 CONTRACTOR LIABILITIES FOR ENVIRONMENTAL PROTECTION

Contractors shall complete and provide documentation of environmental training for training required by Federal, State, and local regulations.

1.3 DEFINITIONS

1.3.1 Sediment

Soil and other debris that have eroded and have been transported by runoff water or wind.

1.3.2 Solid Waste

Rubbish, debris, garbage, and other discarded solid materials, except hazardous waste as defined in Paragraph 1.3.7 Hazardous Waste, resulting from industrial, commercial, and agricultural operations and from community activities.

1.3.3 Sanitary Wastes

Wastes characterized as domestic sanitary sewage.

1.3.4 Rubbish

Combustible and noncombustible wastes such as paper, boxes, glass, crockery, metal, lumber, cans, and bones.

1.3.5 Debris

Combustible and noncombustible wastes such as ashes and waste materials resulting from construction or maintenance and repair work, leaves, and tree trimmings.

1.3.6 Garbage

Refuse and scraps resulting from preparation, cooking, dispensing, and consumption of food.

1.3.7 Hazardous Waste

Hazardous substances as defined by 40 CFR 261 or as defined by applicable State and local regulations.

1.3.8 Hazardous Materials

Hazardous materials as defined in 49 CFR 171 and listed in 49 CFR 172.

1.3.9 Oily Waste

Petroleum products and bituminous materials.

1.3.10 Dust

Any particulate matter emitted as liquid or solid particles.

1.3.11 Storm Water

Water discharged with possible sheeting action and subsequent soil erosion;

that may terminate in drainage ditches, storm sewers, creeks, and/or "waters of the United States."

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 Submittal P rocedures:

1.4.1 SD-01, Preconstruction Submittals

a. Environmental Protection Plan; G
b. Preconstruction Survey Report; G

1.4.2 SD-07, Certificates

Submit to the Contracting Officer once every 7 calendar days and within 24 hours of a storm event that produces 0.5 inch of rain or greater.

1.5 ENVIRONMENTAL PROTECTION REGULATORY REQUIREMENTS

Provide and maintain, during the life of the contract, environmental protection as defined in this Section. Plan for and provide environmental protective measures to control pollution that develops during normal construction practice. Plan for and provide environmental protective measures required to correct conditions that develop during the construction of permanent or temporary environmental features associated with the project. Comply with Federal, State, and local regulations pertaining to the environment, including but not limited to water, air, solid waste, and noise pollution.

1.6 ENVIRONMENTAL PROTECTION PLAN

1.6.1 Contents of Environmental Protection Plan

a. Any hazardous materials (HM) planned for use on the station shall be included in the station HM Tracking Program maintained by the Safety Department. To assist this effort, the Contractor shall submit a list (including quantities) of HM to be brought to the station and copies of the corresponding Material Safety Data Sheets (MSDS). Submit this list to the Contracting Officer. At project completion, remove any hazardous material brought onto the station. Account for the quantity of HM brought to the station, the quantity used or expended during the job, and the leftover quantity that (1) may have additional useful life as a HM and shall be removed by the Contractor, or (2) may be a hazardous waste, which shall then be removed as specified herein.

b. The Environmental Protection Plan shall list and quantify any Hazardous Waste (HW) to be generated during the project.

c. In accordance with station regulations, store HW near the point of generation up to a total quantity of one quart of toxic waste or 55 gallons of hazardous waste. Move any volume that exceeds these quantities to a HW-permitted area within 3 days. Prior to generation of HW, contact the Contracting Officer for labeling requirements for storage of hazardous wastes.

d. In accordance with station regulations, substitute materials as necessary to reduce the generation of HW and include a statement to that effect in the Environmental Protection Plan.

e. Contact Contracting Officer for conditions in the area of the project that may be subject to special environmental procedures. Include this information in the Preconstruction Survey Report. Describe in the Environmental Protection Plan any permits required prior to working in the area, and contingency plans in case an unexpected environmental condition is discovered.

f. Obtain permits for handling HW, and deliver completed documents to Contracting Officer for review. File the documents with the appropriate agency, and complete disposal with the approval of the Contracting Officer. Deliver correspondence with the State concerning the environmental permits and completed permits to Contracting Officer.

1.6.2 Preconstruction Site Inspection

Perform a preconstruction inspection of the project site with the Contracting Officer, and take photographs showing existing environmental conditions in and adjacent to the site.

PART 2 PRODUCTS

The contractor shall provide appropriate spill response materials including, but not limited to the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times when contaminated or potentially contaminated materials are being handled or transported. Spill response materials shall be compatible with the type of materials and contaminants being handled.

PART 3 EXECUTION

3.1 PROTECTION OF NATURAL RESOURCES

Preserve the natural resources within the project boundaries and outside the limits of permanent work. Restore to an equivalent or improved condition upon completion of work. Confine construction activities to within the limits of the work indicated or specified.

3.1.1 Water Resources

Prevent oily or other hazardous substances from entering the ground, drainage areas, wetlands or local bodies of water. Surround all temporary fuel oil or petroleum storage tanks with a temporary earthen berm of sufficient size and strength to contain the contents of the tanks in the event of leakage or spillage.

3.1.2 Fish and Wildlife Resources

Do not unnecessarily disturb fish and wildlife. Do not alter water flows or otherwise significantly disturb the native habitat adjacent to the project, except as indicated or specified.

3.2 HISTORICAL AND ARCHAEOLOGICAL RESOURCES

Carefully protect in-place and report immediately to the Contracting Officer historical and archaeological items or human skeletal remains discovered in the course of work. Stop work in the immediate area of the discovery until directed by the Contracting Officer to resume work. The Government retains ownership and control over historical and archaeological

resources.

3.3 NOISE

Make the maximum use of low-noise emission products, as certified by the U.S. Environmental Protection Agency (EPA). Blasting or use of explosives will not be permitted without written permission from the Contracting Officer, and then only during designated times.

3.4 EROSION AND SEDIMENT CONTROL MEASURES

3.4.1 Burnoff

Burnoff of the ground cover is not permitted.

3.4.2 Protection of Erodible Soils

Immediately finish the earthwork brought to a final grade, as indicated or specified. Protect side and back slopes upon completion of rough grading. Plan and conduct earthwork to minimize the duration of exposure of unprotected soils.

3.4.3 Temporary Protection of Erodible Soils

Use the following methods to prevent erosion and control sedimentation:

3.4.3.1 Sub Title

Mechanically retard and control the rate of runoff from the construction site. This includes construction of diversion ditches, benches, berms, and use of silt fences and straw bales to retard and divert runoff to protected drainage courses.

3.4.4 Construction Stormwater Permit

Follow procedures in the storm water pollution prevention plan as required under the Construction General Permit Order 99-08-DWQ. Submit the plan as a preconstruction submittal according to 01 30 00 Administrative Requirements.

3.5 CONTROL AND DISPOSAL OF CONTRACTOR-GENERATED SOLID WASTES

Pick up solid wastes and place them in covered containers that are regularly emptied. Do not prepare or cook food on the project site. Prevent contamination of the site or other areas when handling and disposing of wastes. At project completion, leave the areas clean.

3.5.1 Disposal of Rubbish and Debris

Dispose of rubbish and debris in accordance with the requirements specified below:

3.5.1.1 Removal from Government Property

Remove and dispose of rubbish and debris from Government property.

3.5.2 Garbage Disposal

Place garbage in approved containers, and move to a pickup point or

disposal area, where directed.

3.6 CONTROL AND DISPOSAL OF HAZARDOUS WASTE

3.6.1 Hazardous Waste Generation

Handle generated hazardous waste in accordance with 40 CFR 262.

3.6.2 Hazardous Waste Disposal

Dispose of hazardous waste in accordance with Federal, State, and local regulations, especially 40 CFR 263, 40 CFR 264, and 40 CFR 265. Removal of hazardous waste from Government property shall not occur without prior notification and coordination with the Contracting Officer. Transport hazardous waste by a permitted, licensed, or registered hazardous waste transporter to a treatment, storage, and disposal (TSD) facility. Hazardous waste shall be properly identified, packaged, and labeled in accordance with 49 CFR 172. Provide completed manifests for hazardous waste disposed of off-site to the Contracting Officer within 7 days of disposal. Hazardous waste shall not be brought onto the base.

3.6.3 Hazardous Waste Storage

Store hazardous waste in containers in accordance with 49 CFR 178. Identify hazardous waste in accordance with 40 CFR 261 and 40 CFR 262. Identify hazardous waste generated within the confines of the station by the station's EPA generator identification number.

3.6.4 Spills of Oil and Hazardous Materials

Take precautions to prevent spills of oil and hazardous material. In the event of a spill, immediately notify the Contracting Officer. Spill response shall be in accordance with 40 CFR 300 and applicable State regulations.

3.6.5 Spills of Petroleum Products

Protect against spills and evaporation during fueling and lubrication of equipment and motor vehicles. Properly dispose of lubricants and excess oil.

3.6.6 Spills of Polylactate

Protect against spills and evaporation during injection of the polylactate. Properly dispose of excess material.

3.7 DUST CONTROL

Control dust at all times, including during nonworking periods. Sprinkle or treat, with approved dust suppressants, the soil at the site, haul roads, and other areas disturbed by operations. Dry power brooming will not be permitted. Instead, use vacuuming, wet mopping, wet sweeping, or wet power brooming. If street sweepers are used, brooms shall now be wire. Comply with BAAQMD Regulation 6, Rule 1, Particulate Matter General Requirements for opacity and visible particles; and Regulation 8, Rule 40, for storage piles of contaminated soils, if applicable.

3.8 DEWATERING

Dewater site and control stormwater in accordance with the Construction General Permit Order 2009-0009-DWQ.

3.9 DECONTAMINATION OF EQUIPMENT

Potentially contaminated soil and water must be removed from earthwork equipment in accordance with Section 01 35 29.13 Health, Safety, and Emergency Response paragraph 1.17 Personal Hygiene and Decontamination and subparagraphs.

For decontamination related to drilling and well installation refer to Section 33 24 13 Monitoring Wells paragraph 3.5 Decontamination.

-- End of Section --

SECTION 01 57 20.00 10

ENVIRONMENTAL PROTECTION
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

U.S. AIR FORCE (USAF)

AFI 32-1053	(2009) Integrated Pest Management Program

U.S. ARMY (DA)

DA AR 200-1	(2007) Environmental Protection and Enhancement

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual
WETLANDS DELINEATION MANUAL	(1987) Corps of Engineers Wetlands Delineation Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

33 CFR 328	Definitions of Waters of the United States
40 CFR 260	Hazardous Waste Management System: General
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 279	Standards for the Management of Used Oil
40 CFR 302	Designation, Reportable Quantities, and Notification
40 CFR 355	Emergency Planning and Notification
40 CFR 68	Chemical Accident Prevention Provisions
49 CFR 171 - 178	Hazardous Materials Regulations

1.2 DEFINITIONS

1.2.1 Environmental Pollution and Damage

Environmental pollution and damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the environment aesthetically, culturally and/or historically.

1.2.2 Environmental Protection

Environmental protection is the prevention/control of pollution and habitat disruption that may occur to the environment during construction. The control of environmental pollution and damage requires consideration of land, water, and air; biological and cultural resources; and includes management of visual aesthetics; noise; solid, chemical, gaseous, and liquid waste; radiant energy and radioactive material as well as other pollutants.

1.2.3 Contractor Generated Hazardous Waste

Contractor generated hazardous waste means materials that, if abandoned or disposed of, may meet the definition of a hazardous waste. These waste streams would typically consist of material brought on site by the Contractor to execute work, but are not fully consumed during the course of construction. Examples include, but are not limited to, excess paint thinners (i.e. methyl ethyl ketone, toluene etc.), waste thinners,excess paints, excess solvents, waste solvents, and excess pesticides, and contaminated pesticide equipment rinse water.

1.2.4 Installation Pest Management Coordinator

Installation Pest Management Coordinator (IPMC) is the individual officially designated by the Installation Commander to oversee the Installation Pest Management Program and the Installation Pest Management Plan.

1.2.5 Project Pesticide Coordinator

The Project Pesticide Coordinator (PPC) is an individual that resides at a Civil Works Project office and that is responsible for oversight of pesticide application on Project grounds.

1.2.6 Land Application for Discharge Water

The term "Land Application" for discharge water implies that the Contractor must discharge water at a rate which allows the water to percolate into the soil. No sheeting action, soil erosion, discharge into storm sewers, discharge into defined drainage areas, or discharge into the "waters of the United States" must occur. Land Application must be in compliance with all applicable Federal, State, and local laws and regulations.

1.2.7 Pesticide

Pesticide is defined as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, or intended for use as a plant regulator, defoliant or desiccant.

1.2.8 Pests

The term "pests" means arthropods, birds, rodents, nematodes, fungi, bacteria, viruses, algae, snails, marine borers, snakes, weeds and other organisms (except for human or animal disease-causing organisms) that adversely affect readiness, military operations, or the well-being of personnel and animals; attack or damage real property, supplies, equipment, or vegetation; or are otherwise undesirable.

1.2.9 Surface Discharge

The term "Surface Discharge" implies that the water is discharged with possible sheeting action and subsequent soil erosion may occur. Waters that are surface discharged may terminate in drainage ditches, storm sewers,creeks, and/or "waters of the United States" and would require a permit to discharge water from the governing agency.

1.2.10 Waters of the United States

All waters which are under the jurisdiction of the Clean Water Act, as defined in 33 CFR 328.

1.2.11 Wetlands

Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, and bogs. Official determination of whether or not an area is classified as a wetland must be done in accordance with WETLANDS DELINEATION MANUAL.

1.3 GENERAL REQUIREMENTS

Minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work must be protected during the entire duration of this contract. Comply with all applicable environmental Federal, State, and local laws and regulations. Any delays resulting from failure to comply with environmental laws and regulations will be the Contractor's responsibility.

1.4 SUBCONTRACTORS

Ensure compliance with this section by subcontractors.

1.5 PAYMENT

No separate payment will be made for work covered under this section. Payment of fees associated with environmental permits, application, and/or notices obtained by the Contractor, and payment of all fines/fees for violation or non-compliance with Federal, State, Regional and local laws and regulations are the Contractor's responsibility. All costs associated with this section must be included in the contract price.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control

approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Environmental Protection Plan; G

1.7 ENVIRONMENTAL PROTECTION PLAN

Prior to commencing construction activities or delivery of materials to the site, submit an Environmental Protection Plan for review and approval by the Contracting Officer. The purpose of the Environmental Protection Plan is to present a comprehensive overview of known or potential environmental issues which the Contractor must address during construction. Issues of concern must be defined within the Environmental Protection Plan as outlined in this section. Address each topic at a level of detail commensurate with the environmental issue and required construction task(s). Topics or issues which are not identified in this section, but are considered necessary, must be identified and discussed after those items formally identified in this section. Prior to submittal of the Environmental Protection Plan, meet with the Contracting Officer for the purpose of discussing the implementation of the initial Environmental Protection Plan; possible subsequent additions and revisions to the plan including any reporting requirements; and methods for administration of the Contractor's Environmental Plans. The Environmental Protection Plan must be current and maintained onsite by the Contractor.

1.7.1 Compliance

No requirement in this Section will relieve the Contractor of any applicable Federal, State, and local environmental protection laws and regulations. During Construction, the Contractor will be responsible for identifying, implementing, and submitting for approval any additional requirements to be included in the Environmental Protection Plan.

1.7.2 Contents

Include in the environmental protection plan, but not limit it to, the following:

a. Name(s) of person(s) within the Contractor's organization who is(are) responsible for ensuring adherence to the Environmental Protection Plan.

b. Name(s) and qualifications of person(s) responsible for manifesting hazardous waste to be removed from the site, if applicable.

c. Name(s) and qualifications of person(s) responsible for training the Contractor's environmental protection personnel.

d. Description of the Contractor's environmental protection personnel training program.

e. An erosion and sediment control plan which identifies the type and location of the erosion and sediment controls to be provided. The plan must include monitoring and reporting requirements to assure that the control measures are in compliance with the erosion and sediment control plan, Federal, State, and local laws and regulations. A Storm

Water Pollution Prevention Plan (SWPPP) may be substituted for this plan.

f. Drawings showing locations of proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on the site.

g. Traffic control plans including measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather. Plan shall include measures to minimize the amount of mud transported onto paved public roads by vehicles or runoff.

h. Work area plan showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas including methods for protection of features to be preserved within authorized work areas.

i. Drawing showing the location of borrow areas.

j. Include in the Spill Control plan the procedures, instructions, and reports to be used in the event of an unforeseen spill of a substance regulated by 40 CFR 68, 40 CFR 302, 40 CFR 355, and/or regulated under State or Local laws and regulations. The Spill Control Plan supplements the requirements of EM 385-1-1. Include in this plan, as a minimum:

(1) The name of the individual who will report any spills or hazardous substance releases and who will follow up with complete documentation. This individual will immediately notify the Contracting Officer in addition to the legally required Federal, State, and local reporting channels (including the National Response Center 1-800-424-8802) if a reportable quantity is released to the environment. Include in the plan a list of the required reporting channels and telephone numbers.

(2) The name and qualifications of the individual who will be responsible for implementing and supervising the containment and cleanup.

(3) Training requirements for Contractor's personnel and methods of accomplishing the training.

(4) A list of materials and equipment to be immediately available at the job site, tailored to cleanup work of the potential hazard(s) identified.

(5) The names and locations of suppliers of containment materials and locations of additional fuel oil recovery, cleanup, restoration, and material-placement equipment available in case of an unforeseen spill emergency.

(6) The methods and procedures to be used for expeditious contaminant cleanup.

k. A non-hazardous solid waste disposal plan identifying methods and locations for solid waste disposal including clearing debris and schedules for disposal.

(1) Identify any subcontractors responsible for the transportation and disposal of solid waste. Submit licenses or permits for solid waste disposal sites that are not a commercial operating facility.

(2) Evidence of the disposal facility's acceptance of the solid waste must be attached to this plan during the construction. Attach a copy of each of the Non-hazardous Solid Waste Diversion Reports to the disposal plan. Submit the report for the previous quarter on the first working day after the first quarter that non-hazardous solid waste has been disposed and/or diverted (e.g. the first working day of January, April, July, and October).

(3) Indicate in the report the total amount of waste generated and total amount of waste diverted in cubic yards or tons along with the percent that was diverted.

(4) A recycling and solid waste minimization plan with a list of measures to reduce consumption of energy and natural resources. Detail in the plan the Contractor's actions to comply with and to participate in Federal, State, Regional, and local government sponsored recycling programs to reduce the volume of solid waste at the source.

l. An air pollution control plan detailing provisions to assure that dust, debris, materials, trash, etc., do not become air borne and travel off the project site.

m. A contaminant prevention plan that: identifies potentially hazardous substances to be used on the job site; identifies the intended actions to prevent introduction of such materials into the air, water, or ground; and details provisions for compliance with Federal, State, and local laws and regulations for storage and handling of these materials. In accordance with EM 385-1-1, a copy of the Material Safety Data Sheets (MSDS) and the maximum quantity of each hazardous material to be onsite at any given time must be included in the contaminant prevention plan. Update the plan as new hazardous materials are brought onsite or removed from the site.

n. A waste water management plan that identifies the methods and procedures for management and/or discharge of waste waters which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, disinfection water, hydrostatic test water, and water used in flushing of lines. If a settling/retention pond is required, the plan must include the design of the pond including drawings, removal plan, and testing requirements for possible pollutants. If land application will be the method of disposal for the waste water, the plan must include a sketch showing the location for land application along with a description of the pretreatment methods to be implemented. If surface discharge will be the method of disposal, include a copy of the permit and associated documents as an attachment prior to discharging the waste water. If disposal is to a sanitary sewer, the plan must include documentation that the Waste Water Treatment Plant Operator has approved the flow rate, volume, and type of discharge.

o. A historical, archaeological, cultural resources biological resources and wetlands plan that defines procedures for identifying and protecting historical, archaeological, cultural resources, biological

resources and wetlands known to be on the project site: and/or identifies procedures to be followed if historical archaeological, cultural resources, biological resources and wetlands not previously known to be onsite or in the area are discovered during construction. Include in the plan methods to assure the protection of known or discovered resources, identifying lines of communication between Contractor personnel and the Contracting Officer.

p. Include and update a pesticide treatment plan, as information becomes available. Include in the plan: sequence of treatment, dates, times, locations, pesticide trade name, EPA registration numbers, authorized uses, chemical composition, formulation, original and applied concentration, application rates of active ingredient (i.e. pounds of active ingredient applied), equipment used for application and calibration of equipment. Federal, State, Regional and Local pest management record keeping and reporting requirements as well as any additional Installation Project Office specific requirements are the Contractor's responsibility in conformance with DA AR 200-1 Chapter 5--Pest Management, Section 5-4 "Program requirements" and AFI 32-1053 Sections 3.4.13 and 3.4.14 for data required to be reported to the Installation.

1.7.3 Appendix

Attach to the Environmental Protection Plan, as an appendix, copies of all environmental permits, permit application packages, approvals to construct, notifications, certifications, reports, and termination documents.

1.8 PROTECTION FEATURES

This paragraph supplements the Contract Clause PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES, AND IMPROVEMENTS. Prior to start of any onsite construction activities, the Contractor and the Contracting Officer will make a joint condition survey. Immediately following the survey, the Contractor will prepare a brief report including a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the Contractor's assigned storage area and access route(s), as applicable. This survey report will be signed by both the the Contractor and the Contracting Officer upon mutual agreement as to its accuracy and completeness. The Contractor must protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference which their preservation may cause to the work under the contract.

1.9 SPECIAL ENVIRONMENTAL REQUIREMENTS

Comply with the special environmental requirements attached at the end of this section.

1.10 ENVIRONMENTAL ASSESSMENT OF CONTRACT DEVIATIONS

Any deviations from the drawings,plans and specifications, requested by the Contractor and which may have an environmental impact, will be subject to approval by the Contracting Officer and may require an extended review, processing, and approval time. The Contracting Officer reserves the right to disapprove alternate methods, even if they are more cost effective, if

the Contracting Officer determines that the proposed alternate method will have an adverse environmental impact.

1.11 NOTIFICATION

The Contracting Officer will notify the Contractor in writing of any observed noncompliance with Federal, State or local environmental laws or regulations, permits, and other elements of the Contractor's Environmental Protection plan. After receipt of such notice, the Contractor will inform the Contracting Officer of the proposed corrective action and take such action when approved by the Contracting Officer. The Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions will be granted or equitable adjustments allowed for any such suspensions. This is in addition to any other actions the Contracting Officer may take under the contract, or in accordance with the Federal Acquisition Regulation or Federal Law.

1.12 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE (HTRW) PERIMETER AIR MONITORING

For the protection of public health, monitor and control contaminant emissions to the air from HTRW remedial action area sources to minimize short term risks that might be posed to the community during implementation of the remedial alternative in accordance with the following.

1.12.1 Perimeter Air Contaminant of Concern

Not used..

1.12.2 Time Averaged Perimeter Action Levels

Not used.

a. Concentration .
b. Time .

1.12.3 Perimeter Sampling/Monitoring Location(s)

Not used.

1.12.4 Monitoring Instruments/Sampling and Analysis Methods

Not used.

1.12.5 Staffing

Not used.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.1 ENVIRONMENTAL PERMITS AND COMMITMENTS

Obtaining and complying with all environmental permits and commitments required by Federal, State, Regional, and local environmental laws and regulations is the Contractor's responsibility.

3.2 LAND RESOURCES

Confine all activities to areas defined by the drawings and specifications. Identify any land resources to be preserved within the work area prior to the beginning of any construction. Do not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without approval, except in areas indicated on the drawings or specified to be cleared. Ropes, cables, or guys will not be fastened to or attached to any trees for anchorage unless specifically authorized. Provide effective protection for land and vegetation resources at all times, as defined in the following subparagraphs. Remove stone, soil, or other materials displaced into uncleared areas.

3.2.1 Work Area Limits

Mark the areas that need not be disturbed under this contract prior to commencing construction activities. Mark or fence isolated areas within the general work area which are not to be disturbed. Protect monuments and markers before construction operations commence. Where construction operations are to be conducted during darkness, any markers must be visible in the dark. The Contractor's personnel must be knowledgeable of the purpose for marking and/or protecting particular objects.

3.2.2 Landscape

Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved must be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques. Restore landscape features damaged or destroyed during construction operations outside the limits of the approved work area.

3.2.3 Erosion and Sediment Controls

Providing erosion and sediment control measures in accordance with Federal, State, and local laws and regulations is the Contractor's responsibility. Select and maintain the erosion and sediment controls such that water quality standards are not violated as a result of construction activities. The area of bare soil exposed at any one time by construction operations should be kept to a minimum. Construct or install temporary and permanent erosion and sediment control best management practices (BMPs) as indicated on the drawings. BMPs may include, but not be limited to, vegetation cover, stream bank stabilization, slope stabilization, silt fences, construction of terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. The Contractor's best management practices must also be in accordance with the National Pollutant Discharge Elimination System (NPDES) Storm Water Pollution Prevention Plan (SWPPP) which may be reviewed at the Environmental Office. Remove any temporary measures after the area has been stabilized.

3.2.4 Contractor Facilities and Work Areas

Place field offices, staging areas, stockpile storage, and temporary buildings in areas designated on the drawings or as directed by the Contracting Officer. Temporary movement or relocation of Contractor facilities will be made only when approved. Erosion and sediment controls must be provided for onsite borrow and spoil areas to prevent sediment from

entering nearby waters. Temporary excavation and embankments for plant and/or work areas must be controlled to protect adjacent areas.

3.3 WATER RESOURCES

Monitor all water areas affected by construction activities to prevent pollution of surface and ground waters. Do not apply toxic or hazardous chemicals to soil or vegetation unless otherwise indicated. For construction activities immediately adjacent to impaired surface waters, the Contractor must be capable of quantifying sediment or pollutant loading to that surface water when required by State or Federally issued Clean Water Act permits.

3.3.1 Cofferdams, Diversions, and Dewatering Operations

Construction operations for dewatering, removal of cofferdams, tailrace excavation, and tunnel closure will be controlled at all times to maintain compliance with existing State water quality standards and designated uses of the surface water body. Comply with the State of CA water quality standards and anti-degradation provisions.

3.3.2 Stream Crossings

Stream crossings must allow movement of materials or equipment without violating water pollution control standards of the Federal, State, and local governments.

3.3.3 Wetlands

Do not enter, disturb, destroy, or allow discharge of contaminants into any wetlandsexcept as authorized herein. The protection of wetlands shown on the drawings in accordance with paragraph ENVIRONMENTAL PERMITS AND COMMITMENTS is the Contractor's responsibility. Authorization to enter specific wetlands identified will not relieve the Contractor from any obligation to protect other wetlands within, adjacent to, or in the vicinity of the construction site and associated boundaries.

3.4 AIR RESOURCES

Equipment operation, activities, or processes will be in accordance with all Federal and State air emission and performance laws and standards.

3.4.1 Particulates

Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials, such as from asphaltic batch plants; must be controlled at all times, including weekends, holidays and hours when work is not in progress. Maintain excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and other work areas within or outside the project boundaries free from particulates which would cause the Federal, State, and local air pollution standards to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, baghouse, scrubbers, electrostatic precipitators or other methods will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. Provide sufficient, competent equipment available to accomplish these tasks. Perform particulate control as the work proceeds and whenever a particulate nuisance or hazard occurs. Comply with all

State and local visibility regulations.

3.4.2 Odors

Odors from construction activities must be controlled at all times. The odors must be in compliance with State regulations and/or local ordinances and may not constitute a health hazard.

3.4.3 Sound Intrusions

Keep construction activities under surveillance and control to minimize environment damage by noise. Comply with the provisions of the State of CA rules.

3.4.4 Burning

Burning is prohibited.

3.5 CHEMICAL MATERIALS MANAGEMENT AND WASTE DISPOSAL

Disposal of wastes will be as directed below, unless otherwise specified in other sections and/or shown on the drawings.

3.5.1 Solid Wastes

Place solid wastes (excluding clearing debris) in containers which are emptied on a regular schedule. Handling, storage, and disposal must be conducted to prevent contamination. Employ segregation measures so that no hazardous or toxic waste will become co-mingled with solid waste. Transport solid waste off Government property and dispose of it in compliance with Federal, State, and local requirements for solid waste disposal. A Subtitle D RCRA permitted landfill will be the minimum acceptable offsite solid waste disposal option. Verify that the selected transporters and disposal facilities have the necessary permits and licenses to operate.Waste materials will be hauled to the Government landfill site designated by the Contracting Officer. Comply with Federal, State, and local laws and regulations pertaining to the use of landfill areas.

3.5.2 Chemicals and Chemical Wastes

Dispense chemicals ensuring no spillage to the ground or water. Perform and document periodic inspections of dispensing areas to identify leakage and initiate corrective action. This documentation will be periodically reviewed by the Government. Collect chemical waste in corrosion resistant, compatible containers. Collection drums must be monitored and removed to a staging or storage area when contents are within 6 inches of the top. Wastes will be classified, managed, stored, and disposed of in accordance with Federal, State, and local laws and regulations.

3.5.3 Contractor Generated Hazardous Wastes/Excess Hazardous Materials

Hazardous wastes are defined in 40 CFR 261, or are as defined by applicable State and local regulations. Hazardous materials are defined in 49 CFR 171 - 178. At a minimum, manage and store hazardous waste in compliance with 40 CFR 262 hazardous waste management plan. Take sufficient measures to prevent spillage of hazardous and toxic materials during dispensing. Segregate hazardous waste from other materials and wastes, protect it from the weather by placing it in a safe covered

location, and take precautionary measures such as berming or other appropriate measures against accidental spillage. Storage, describing, packaging, labeling, marking, and placarding of hazardous waste and hazardous material in accordance with 49 CFR 171 - 178, State, and local laws and regulations is the Contractor's responsibility. Transport Contractor generated hazardous waste off Government property in accordance with the Environmental Protection Agency and the Department of Transportation laws and regulations. Dispose of hazardous waste in compliance with Federal, State and local laws and regulations. Spills of hazardous or toxic materials must be immediately reported to the Contracting Officer. Cleanup and cleanup costs due to spills are the Contractor's responsibility. Coordinate the disposition of hazardous waste with the HPNS Hazardous Waste Manager and the Contracting Officer.

3.5.4 Fuel and Lubricants

Storage, fueling and lubrication of equipment and motor vehicles must be conducted in a manner that affords the maximum protection against spill and evaporation. Manage and store fuel, lubricants and oil in accordance with all Federal, State, Regional, and local laws and regulations. Used lubricants and used oil to be discarded must be stored in marked corrosion-resistant containers and recycled or disposed in accordance with 40 CFR 279, State, and local laws and regulations. Storage of fuel on the project site will be in accordance with all Federal, State, and local laws and regulations.

3.5.5 Waste Water

Disposal of waste water will be as specified below.

a. Waste water from construction activities, such as onsite material processing, concrete curing, foundation and concrete clean-up, water used in concrete trucks, forms, etc. will not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants. Dispose of the construction related waste water off-Government property in accordance with all Federal, State, Regional and Local laws and regulations.

3.6 RECYCLING AND WASTE MINIMIZATION

Participate in State and local government sponsored recycling programs. The Contractor is further encouraged to minimize solid waste generation throughout the duration of the project.

3.7 NON-HAZARDOUS SOLID WASTE DIVERSION REPORT

Maintain an inventory of non-hazardous solid waste diversion and disposal of construction and demolition debris. Submit a report through the Contracting Officer on the first working day after each fiscal year quarter, starting the first quarter that non-hazardous solid waste has been generated. Include the following in the report:

a. Construction and Demolition (C&D) Debris Disposed = _____ in cubic yards or tons, as appropriate.

b. Construction and Demolition (C&D) Debris Recycled = _____ in cubic yards or tons, as appropriate.

c. Total C&D Debris Generated = _____ in cubic yards or tons, as appropriate.

d. Waste Sent to Waste-To-Energy Incineration Plant (This amount should not be included in the recycled amount) = _____ in cubic yards or tons, as appropriate.

3.8 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

Carefully protect in-place and report immediately to the Contracting Officer historical and archaeological items or human skeletal remains discovered in the course of work. Stop work in the immediate area of the discovery until directed by the Contracting Officer to resume work. The Government retains ownership and control over historical and archaeological resources.

3.9 BIOLOGICAL RESOURCES

Minimize interference with, disturbance to, and damage to fish, wildlife, and plants including their habitat. The protection of threatened and endangered animal and plant species, including their habitat, is the Contractor's responsibility in accordance with Federal, State, Regional, and local laws and regulations.

3.10 INTEGRATED PEST MANAGEMENT

Not used.

3.10.1 Pesticide Delivery and Storage

Not used.

3.10.2 Qualifications

Not used.

3.10.3 Pesticide Handling Requirements

Not used.

3.10.4 Application

Not used.

3.11 PREVIOUSLY USED EQUIPMENT

Not used.

3.12 MAINTENANCE OF POLLUTION FACILITIES

Not used.

3.13 MILITARY MUNITIONS

In the event military munitions, as defined in 40 CFR 260, are discovered or uncovered, the Contractor will immediately stop work in that area and immediately inform the Contracting Officer.

3.14 TRAINING OF CONTRACTOR PERSONNEL

The Contractor's personnel must be trained in all phases of environmental protection and pollution control. Conduct environmental protection/pollution control meetings for all personnel prior to commencing construction activities. Additional meetings must be conducted for new personnel and when site conditions change. Include in the training and meeting agenda: methods of detecting and avoiding pollution; familiarization with statutory and contractual pollution standards; installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental protection/pollution control; anticipated hazardous or toxic chemicals or wastes, and other regulated contaminants; recognition and protection of archaeological sites, artifacts, wetlands, and endangered species and their habitat that are known to be in the area.

3.15 CONTAMINATED MEDIA MANAGEMENT

Manage contaminated environmental media consisting of, but not limited to, ground water, soils, and sediments.

3.16 POST CONSTRUCTION CLEANUP

The Contractor will clean up all areas used for construction in accordance with Contract Clause: "Cleaning Up". Unless otherwise instructed in writing by the Contracting Officer, obliterate all signs of temporary construction facilities such as haul roads, work area, structures, foundations of temporary structures, stockpiles of excess or waste materials, and other vestiges of construction prior to final acceptance of the work. The disturbed area must be graded, filled and the entire area seeded unless otherwise indicated.

-- End of Section --

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA
03/13

PART 1 GENERAL

Items/values in this section have not been finalized. Bracketed items/values below will be selected in the draft final design.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM E1971	(2005; R 2011) Stewardship for the Cleaning of Commercial and Institutional Buildings

1.2 SUBMISSION OF OPERATION AND MAINTENANCE DATA

Submit Operation and Maintenance (O&M) Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system, stressing and enhancing the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation. The subcontractors must compile and prepare data and deliver to the Contractor prior to the training of Government personnel. The Contractor must compile and prepare aggregate O&M data including clarifying and updating the original sequences of operation to as-built conditions. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal. Submit in accordance with this section and Section 01 33 00 SUBMITTAL PROCEDURES.

1.2.1 Package Quality

Documents must be fully legible. Poor quality copies and material with hole punches obliterating the text or drawings will not be accepted.

1.2.2 Package Content

Data package content shall be as shown in the paragraph titled "Schedule of Operation and Maintenance Data Packages." Comply with the data package requirements specified in the individual technical sections, including the content of the packages and addressing each product, component, and system designated for data package submission, except as follows. Commissioned items without a specified data package requirement in the individual technical sections must use Data Package [3][4][5]. Commissioned items with a Data Package 1 or 2 requirement must use instead Data Package [3][4][5].

1.2.3 Changes to Submittals

Manufacturer-originated changes or revisions to submitted data must be furnished by the Contractor if a component of an item is so affected subsequent to acceptance of the O&M Data. Submit changes, additions, or revisions required by the Contracting Officer for final acceptance of submitted data within 30 calendar days of the notification of this change requirement.

1.2.4 Review and Approval

The [Contractor's Commissioning Authority (CA)][Government's Commissioning Authority (CA)] must review the commissioned systems and equipment submittals for completeness and applicability. The [CA][Government] must verify that the systems and equipment provided meet the requirements of the Contract documents and design intent, particularly as they relate to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts. [The CA must communicate deficiencies to the Contracting Officer. Upon a successful review of the corrections, the CA must recommend approval and acceptance of these O&M manuals to the Contracting Officer.] This work is in addition to the normal review procedures for O&M data.

[1.2.5 O&M Database

Develop a database from the O&M manuals that contains the information required to start a preventative maintenance program.

]1.3 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES

1.3.1 Operating Instructions

Include specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:

1.3.1.1 Safety Precautions

List personnel hazards and equipment or product safety precautions for all operating conditions.

1.3.1.2 Operator Prestart

Include procedures required to install, set up, and prepare each system for use.

1.3.1.3 Startup, Shutdown, and Post-Shutdown Procedures

Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.

1.3.1.4 Normal Operations

Provide narrative description of Normal Operating Procedures. Include Control Diagrams with data to explain operation and control of systems and specific equipment.

1.3.1.5 Emergency Operations

Include Emergency Procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include Emergency Shutdown Instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance and procedures for emergency operation of all utility systems including required valve positions, valve locations and zones or portions of systems controlled.

1.3.1.6 Operator Service Requirements

Include instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and recording gage readings.

1.3.1.7 Environmental Conditions

Include a list of Environmental Conditions (temperature, humidity, and other relevant data) that are best suited for the operation of each product, component or system. Describe conditions under which the item equipment should not be allowed to run.

1.3.2 Preventive Maintenance

Include the following information for preventive and scheduled maintenance to minimize corrective maintenance and repair for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.3.2.1 Lubrication Data

Include preventative maintenance lubrication data, in addition to instructions for lubrication provided under paragraph titled "Operator Service Requirements":

a. A table showing recommended lubricants for specific temperature ranges and applications.

b. Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities.

c. A Lubrication Schedule showing service interval frequency.

1.3.2.2 Preventive Maintenance Plan and Schedule

Include manufacturer's schedule for routine preventive maintenance, inspections, tests and adjustments required to ensure proper and economical operation and to minimize corrective maintenance. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.

1.3.2.3 Cleaning Recommendations

Provide environmentally preferable cleaning recommendations in accordance with ASTM E1971.

1.3.3 Corrective Maintenance (Repair)

Include manufacturer's recommended procedures and instructions for correcting problems and making repairs for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

1.3.3.1 Troubleshooting Guides and Diagnostic Techniques

Include step-by-step procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the checkout is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or require replacement.

1.3.3.2 Wiring Diagrams and Control Diagrams

Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type, identically to actual installation configuration and numbering.

1.3.3.3 Maintenance and Repair Procedures

Include instructions and a list of tools required to repair or restore the product or equipment to proper condition or operating standards.

1.3.3.4 Removal and Replacement Instructions

Include step-by-step procedures and a list of required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings and adjustments required. Instructions shall include a combination of text and illustrations.

1.3.3.5 Spare Parts and Supply Lists

Include lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonable delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead-time to obtain.

1.3.4 Corrective Maintenance Work-Hours

Include manufacturer's projection of corrective maintenance work-hours including requirements by type of craft. Corrective maintenance that requires completion or participation of the equipment manufacturer shall be identified and tabulated separately.

1.3.5 Appendices

Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

1.3.5.1 Product Submittal Data

Provide a copy of all SD-03 Product Data submittals required in the applicable technical sections.

1.3.5.2 Manufacturer's Instructions

Provide a copy of all SD-08 Manufacturer's Instructions submittals required in the applicable technical sections.

1.3.5.3 O&M Submittal Data

Provide a copy of all SD-10 Operation and Maintenance Data submittals required in the applicable technical sections.

1.3.5.4 Parts Identification

Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number that will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies in accordance with the manufacturer's standard practice. Parts data may cover more than one model or series of equipment, components, assemblies, subassemblies, attachments, or accessories, such as typically shown in a master parts catalog

1.3.5.5 Warranty Information

List and explain the various warranties and clearly identify the servicing and technical precautions prescribed by the manufacturers or contract documents in order to keep warranties in force. Include warranty information for primary components such as the compressor of air conditioning system.

1.3.5.6 Personnel Training Requirements

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems.

1.3.5.7 Testing Equipment and Special Tool Information

Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.3.5.8 Testing and Performance Data

Include completed prefunctional checklists, functional performance test forms, and monitoring reports. Include recommended schedule for retesting and blank test forms.

1.3.5.9 Contractor Information

Provide a list that includes the name, address, and telephone number of the General Contractor and each Subcontractor who installed the product or equipment, or system. For each item, also provide the name address and telephone number of the manufacturer's representative and service organization that can provide replacements most convenient to the project site. Provide the name, address, and telephone number of the product, equipment, and system manufacturers.

1.4 TYPES OF INFORMATION REQUIRED IN CONTROLS O&M DATA PACKAGES

Include Data Package 5 and the following for control systems:

a. Narrative description on how to perform and apply all functions, features, modes, and other operations, including unoccupied operation, seasonal changeover, manual operation, and alarms. Include detailed technical manual for programming and customizing control loops and algorithms.

b. Full as-built sequence of operations.

c. Copies of all checkout tests and calibrations performed by the Contractor (not Cx tests).

[d. Full points list, I/O list, and control logic diagram.

[e. Full print out of all schedules and set points after testing and acceptance of the system.]

[f. Full as-built print out of software program.]

[g. Electronic File:

(1) Assemble each manual into a composite electronically indexed file in PDF format. Provide HDD’s, DVD's or CD's as appropriate, so that each one contains all maintenance and record files, and also the Project Record Documents and Training Videos, of the entire program for this facility.

(2) Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.

(3) Link the index to separate files within the composite of files. Book mark maintenance and record files, that have a Table of Contents, according to the Table of Contents]

[h. Marking of all system sensors and instrumentation on the as-built equipment plan, P&ID and mechanical drawings with their control system designations.]

1.5 SCHEDULE OF OPERATION AND MAINTENANCE DATA PACKAGES

Furnish the O&M data packages specified in individual technical sections. The required information for each O&M data package is as follows:

1.5.1 Data Package 1

a. Safety precautions

b. Cleaning recommendations

c. Maintenance and repair procedures

d. Warranty information

e. Contractor information

f. Spare parts and supply list

1.5.2 Data Package 2

a. Safety precautions

b. Normal operations

c. Environmental conditions

d. Lubrication data

e. Preventive maintenance plan and schedule

f. Cleaning recommendations

g. Maintenance and repair procedures

h. Removal and replacement instructions

i. Spare parts and supply list

j. Parts identification

k. Warranty information

l. Contractor information

1.5.3 Data Package 3

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Environmental conditions

g. Lubrication data

h. Preventive maintenance plan and schedule

i. Cleaning recommendations

j. Troubleshooting guides and diagnostic techniques

k. Wiring diagrams and control diagrams

l. Maintenance and repair procedures

m. Removal and replacement instructions

n. Spare parts and supply list

o. Product submittal data

p. O&M submittal data

q. Parts identification

r. Warranty information

s. Testing equipment and special tool information

t. Testing and performance data

u. Contractor information

1.5.4 Data Package 4

a. Safety precautions

b. Operator prestart

c. Startup, shutdown, and post-shutdown procedures

d. Normal operations

e. Emergency operations

f. Operator service requirements

g. Environmental conditions

h. Lubrication data

i. Preventive maintenance plan and schedule

j. Cleaning recommendations

k. Troubleshooting guides and diagnostic techniques

l. Wiring diagrams and control diagrams

m. Maintenance and repair procedures

n. Removal and replacement instructions

o. Spare parts and supply list

p. Corrective maintenance man-hours

q. Product submittal data

r. O&M submittal data

s. Parts identification

t. Warranty information

u. Personnel training requirements

v. Testing equipment and special tool information

w. Testing and performance data

x. Contractor information

1.5.5 Data Package 5

a. Safety precautions

b. Operator prestart

c. Start-up, shutdown, and post-shutdown procedures

d. Normal operations

e. Environmental conditions

f. Preventive maintenance plan and schedule

g. Troubleshooting guides and diagnostic techniques

h. Wiring and control diagrams

i. Maintenance and repair procedures

j. Removal and replacement instructions

k. Spare parts and supply list

l. Product submittal data

m. Manufacturer's instructions

n. O&M submittal data

o. Parts identification

p. Testing equipment and special tool information

q. Warranty information

r. Testing and performance data

s. Contractor information

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 02 32 00

SUBSURFACE DRILLING, SAMPLING, AND TESTING
03/13

PART 1 GENERAL

This section is being deferred to the Draft Final version of the RD.

-- End of Section --

SECTION 02 35 27

SOIL-BENTONITE (S-B) SLURRY TRENCH
03/13

PART 1 GENERAL

1.1 DEFFINITIONS

The terms used in this Section are defined as follows:

1.1.1 Slurry Trench

The slurry trench is a 2 foot minimum width trench excavated through the existing ground or prepared working surface using the slurry method of excavation and
backfilled with S-B backfill material, to form a low permeability cutoff wall.

1.1.2 Slurry Method of Excavation

The slurry method of excavation consists of excavating a vertical walled trench and at the same time keeping the trench filled with a bentonite slurry mixture. The purpose of the slurry is to support the walls of the trench and prevent movement of ground water.

1.1.3 Bentonite/Clay

Bentonite is an ultra-fine natural clay whose principal mineral constituent is sodium cation montmorillonite. However, the nearshore slurry wall may also require cement in order to achieve the (30psi) strength requirement. Furthermore, the down gradient surface of the near shore slurry wall will be exposed to saline tidal water. For the near shore slurry wall, calcium cation bentonite, or other clay alternatives such as sepiolite or attapulgite, will need to be considered in the mix design in order to demonstrate the long term durability of the slurry wall. See Section 1.4 e - Compatibility Testing.

1.1.4 Slurry

Slurry is a colloidal mixture of bentonite/clay and water.

1.1.5 Soil Bentonite (S-B) Backfill

S-B backfill is a homogeneous mixture of material produced by mixing soil with bentonite (or equivalent clay) slurry, and possibly additional cement, or bentonite (or equivalent clay), which is placed into the excavated trench to complete the soil-bentonite slurry trench. Though a final S-B mix design and associated successful compatibility testing (See SD-06, and Sections 1.4e) may result in a final mix design with an clay alternative other than bentonite. Also, the near shore slurry wall alignment will require cement (or equivalent additive) to meet the 30 psi strength requirement. The near shore slurry alignment will likely be (Soil-Cement-Bentonite (S-C-B) mix design, however, the backfill will be referred to within this specification as 'soil-bentonite (S-B) backfill, wall, mix design, etc'.

1.1.6 Ground Water Level

The ground water level is the piezometric level of the ground water as determined from piezometers and wells.

1.1.7 Working Surface

The working surface is the top of the stripped and/or prepared natural ground or the surface of previously compacted fill from which the slurry trench shall be constructed See Design Drawings: Slurry Wall and Subsurface Drain Plan, and Slurry Wall and Subsurface Drain Details I and II.

1.1.8 Confining Stratum

The confining stratum is the soil stratum or rock unit to or into which the bottom of the slurry trench is excavated. The confining stratum for the near shore slurry wall will be the Bay Mud; however there will not be a confining stratum for the western boundary slurry wall ((See DBR Appendix - Design Drawings: Slurry Wall and Subsurface Drain Details I).

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API RP 13B-1	(2009; 4th Ed) Recommended Practice for Field Testing Water-Based Drilling Fluids
API Spec 13A	(2010) Specification for Drilling-Fluid Materials

ASTM INTERNATIONAL (ASTM)

ASTM C143/C143M	(2010a) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM D1140	(2000; R 2006) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D2216	(2010) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D4318	(2010) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5084	(2010) Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Contracting Officer.

SD-01 Preconstruction Submittals

Preconstruction Testing Plan; GBTC regulatory agencies
Slurry Trench Implementation Plan; GBTC regulatory agencies

SD-02 Shop Drawings

As-Built Profile

SD-04 Samples

Bentonite; specifically sodium bentonite, calcium bentonite, attapulgite, sepiolite clay, or equivalent alternative clay; and cement (including cement retarters and additives); G
Backfill Material (borrow source materialG

SD-06 Test Reports

S-B Backfill Test Report; G, and the BTC regulatory agencies
Quality Control Testing; G
Soundings; G
Water; G
Bentonite Slurry Mixes design; G, and the BTC regulatory agencies
Slurry Properties
Compatibility Test Report; G, and the BTC regulatory agencies

SD-07 Certificates

Bentonite, or equivalent alternative clay

1.4 OTHER SUBMITTAL REQUIREMENTS

Submit the following:

a. Plan describing the general work sequence and layout of operations. The layout of operations shall include scale drawings, which depict slurry and S-B backfill preparation and storage areas. The plan shall describe Contractor qualifications, equipment, method of trench excavation, use or disposal of excavated material, bottom cleaning,

slurry preparation and maintenance, S-B backfill preparation and placement, and site clean-up.

Plan can also describe the general work sequence of the associated slurry wall drainage features, leachate monitoring/extraction wells, and piezometer wells. Construction of the two slurry wall alignments includes a subsurface drainage (i.e. French drain) for the western boundary slurry wall alignment, and leachate monitoring/extraction wells along the near shore slurry wall alignment. The western boundary slurry wall alignment subsurface drain will be used to divert mounded groundwater from offsite to the constructed freshwater wetland (See design drawing X-X, Appendix C of the DBR). The near shore slurry wall alignment includes a subsurface drain, monitoring wells, and leachate monitoring risers. The Government recommends construction of the subsurface drains and leachate monitoring riser adjacent to the slurry wall alignment be installed prior to the installation of the slurry walls (See construction specifications Sections 31 00 00 - Earthwork, and Sections 33 24 00.00 20 Extraction Monitoring Wells for submittal requirements). The government also recommends that monitoring wells associated with the slurry wall alignments be installed following the installation of the slurry walls (See construction specification Sections 33 24 13 Groundwater Monitoring Wells for submittal requirement)

b. Plan describing quality control equipment and test procedures, sample test forms for reporting test results, and the offsite laboratory proposed for use.

c. Data on the equipment to be used in the construction of the slurry trench; equipment to be used to obtain Bay Mud samples; equipment to be used to obtain record control samples of the completed slurry trench and equipment to be used in the Contractor's quality control testing.

d. A copy of the test results from the bentonite/clay manufacturer for each lot shipped to the site and a certificate of compliance stating that the bentonite (or other clay equivalent) complies with applicable standards, and the mix designs selected and used in a successful Compatibility Test Report.

indent=0.33>e. A copy of a data package containing a S-B mix design with an associated successful Compatibility Testing program will contain, but not limited to, the following information:

1. Free swell (ASTM D5890) and filter cake permeability tests of several bentonites/clays using:
a. Groundwater at the western boundary slurry wall interface, and site mixing water (i.e. from a HPNS fire hydrant)
b. Contaminated groundwater form up gradient, down gradient tidal water, and site mixing water that will be used during construction to determine acceptable bentonites for use on the project.

2. Mix design optimization tests to determine the most economical mix of soils, dry bentonite, and bentonite slurry to produce the required permeability. This consists of short-duration (48-72 hours) permeability tests varying the amount of dry bentonite added (0, 2, and 4 percent) and if necessary the amount of additional fines added (0, 10, 20 percent) using site mixing water as the permeant.

3. Long-term flexible wall perimeter testing of at least 3 S-B

backfill samples: the optimum mix design with site mixing water only as the permeants (control); the optimum mix design with up gradient groundwater near the western boundary slurry wall as permeants, and with up gradient contaminated groundwater and tidal waters as permeants along the near shore slurry wall alignment. These 3 groundwater examples shall be used as the permeants. It is recommended that 3 pore volumes of each groundwater permeant pass through the S-B backfill samples. This typically takes at least 2 months.

4. Contractor should be aware that compatibility testing can take between 3-6 months to complete, and costs are typically in the $10,000 range. Geo-Logic Associates in Grass Valley is California based firm with significant experience in performing successful compatibility test programs for slurry wall applications. Kenneth Criley, Manager of Laboratory Services for Geo-Logic, can be reached at (530) 272-2448. A proposal and quote from Geo-Logic to perform this service is provided as Attachment X3 for the informational purposes.

To approximate field conditions in the lab, it is important to obtain contaminated ground water and mixing water from the site. The site mixing water used during compatibility testing shall be the water used to make the bentonite slurry during construction.

For laboratory testing, consider requiring a permeability of one-half an order of magnitude less than the required field permeability (for example, 5x10-8 cm/sec in the lab for 1x10-7 cm/sec in the field).

1.5 QUALITY ASSURANCE

The Government may perform quality assurance testing on representative samples obtained by the Contractor of the bentonite slurry and S-B backfill using the laboratory and equipment furnished by the Contractor. The Government testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the Construction Quality Control (CQC) requirements. Provide the equipment and laboratory space to government personnel on demand and these services will be considered a subsidiary obligation of the soil bentonite slurry trench construction. Make all routine testing procedures available for inspection by the Contracting Officer at any time.

1.5.1 Qualifications

1.5.1.1 Contractor

Successfully installed a minimum area of 1,000,000 square feet of slurry wall, including experience with near shore slury wall installations. The qualifications and experience of personnel who shall be responsible for conducting the operations shall include references (name and telephone number) of the owners of the Contractor's previous slurry trench construction projects.

1.5.1.2 Slurry Trench Specialist

The slurry trench specialist shall be an individual who has had experience with at least 5 projects in all aspects of slurry trench construction which includes, but is not limited to:

a. The use, testing, and control of bentonite slurries,

b. The mixing methods required to properly mix the slurry and backfill materials as required,

c. Trench excavation and backfilling procedures, and

d. A thorough knowledge of construction equipment and material testing required for slurry trench construction.

1.5.1.3 Slurry Trench Excavation Equipment Operator

The slurry trench excavation equipment operator shall have experience using similar slurry trench excavation equipment to be used for this contract in a minimum of 5 projects of similar or greater magnitude (depth).

1.6 DELIVERY, STORAGE, AND HANDLING

Protect materials delivered and placed in storage from the weather, dirt, dust or other contaminants.

1.7 GEOTECHNICAL SITE CONDITIONS

1.7.1 Exploratory Borings

Subsurface borings have been compiled to determine the character of materials to be excavated along the slurry wall alignments. Locations of the borings are shown in design drawing C-5 and C-6. The logs of those borings are included as Attachment TBD. Soil borings included are: GMP11, GMP 11A, IR01MWLF2A, IR01B015, TPBWE20B, GMP21, IR01MW403B, IR01MW31A, GMP20A, and IR01BO32 for the western boundary slurry wall, and soil borings: IR01B035, IR01CPT65, IR01B039, IR01CPT61, SO3, SO2, IR01MW43A, IR01MW64A, IR01MW47B, IR01B382, IR01CPT57, IR01CPT55, IR01B393, IR01B392, IR02B470, IR01MW44A, and IR01B500 along the near shore slurry wall locations. See DBR Section Subsurface Conditions further details regarding the subsurface in the vicinity of the two slurry wall alignments.

The Government assumes no responsibility for interpretation or deductions made from the logs and borings. Local variations exist in the subsurface materials between boring locations and, when encountered, will be considered as being materially different, but within the purview of this contract (N68711-05-C-6011). Soils classifications shown on the logs and profiles (Design drawing C-6, Appendix D or the DBR) are the result of field visual classifications, and laboratory classifications, in accordance with the Unified Soil Classifications System. The results of all laboratory testing, including rock and soil, are available for review by the Contractor as Attachment TBD of the DBR.

Additional exploratory borings should be necessary to determine or verify the characteristics of the subsurface along the exact slurry wall alignments and to verify depth of the key stratum (Bay Mud) along the near shore slurry wall alignment. This work will be specified with the Slurry Trench Implementation Plan and performed well in advance of slurry trench installation to prevent delays. Confirmation of subsurface conditions and exacted depth of the Bay Mud "key-in" stratum by drilling will be performed in accordance with project specifications 02 32 00 Subsurface Drilling, Sampling, and Testing, and an appropriate work plan for drilling will be prepared and submitted for approval by the Navy Contracting Officer, and the BTC regulatory agencies.

1.7.2 Subsurface Conditions

A description of subsurface conditions is presented in Section 2.4 of the Design Basis Report (DBR).

Cross sections of the subsurface strums along the western boundary slurry wall and the near shore slurry wall are provide in the geologic cross sections are provided in the DBR Section 2.4 Figures 3-6; and DBR Appendix D: Slurry wall design drawings C-5 through C-7. Design Drawing C-6 indicates the approximate location, elevations, and depths of the Bay Mud. The Bay Mud is the confining stratum that the near shore slurry wall will be keyed. See Section 3.3.1 of these project specifications for 'keying in' details and requirements.

The Government assumes no responsibility for interpretation or deductions made to create the geologic and subsurface cross sections and profiles. Local variations exist in the subsurface materials between boring locations and, when encountered, will be considered materially different, but within the purview of this contract (N68711-05-C-6011)..

1.7.2.1 Susurface Obstructions

Subsurface obstructions will be interpreted as large debris such as boulders, concrete blocks, and other man-made obstructions encountered in the subsurface along the near shore, and the western boundary slurry walls. If large debris is encountered at shallow depths and above the water table the debris should be dug out.

1.7.3 Ground Water

Groundwater and tidally influenced groundwater is expected to be encountered during installation of both the western boundary, and the near shore slurry wall alignments.

1.7.4 Embankment Conditions

Site grading to finish grade (design drawing C-5 and C-6- of the DBR) will allow for the slurry wall alignments to be prepared so that significant changes in grade along the slurry wall alignments are avoided during the installation of the slurry wall.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Bentonite

The bentonite shall be sodium cation base montmorillonite powder for the western boundary slurry wall, and calcium montmorillonite or other saline resistant clays (such as attipulgite, sepiolite or saponite) for the near shore slurry wall. Soda ash may also be considered in determination of the near shore backfill mix design to counteract the effects of saline groundwater on sodium bentonite. Both clays used for either the western boundary slurry wall or the near shore slurry wall shall conform to API Spec 13A, Section 4, and 5, and Table 1, located at the end of this section. Chemically treated bentonite will not be allowed. Other chemically treated bentonites may be considered provided the required

permeability values cannot be obtained with bentonites conforming with Section 4 or Section 5 of API Spec 13A. Use of these materials will depend upon the successful completion of a compatibility testing program and the concurrence of the Contracting Officer and BTC regulatory agencies. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the Contracting Officer. Bentonite not meeting specifications shall be promptly removed from the site at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage. Submit a minimum of 10 pounds of the proposed bentonite at least 1 month prior to use.

2.1.2 Water

The Government will supply water required for mixing with bentonite to produce slurry from a fire hydrant located at HPNS (see Design Drawing C-3). The water shall be clean, fresh, and potable water.

2.1.3 Backfill Material

The backfill material shall be obtained from an offsite borrow area. Thirty days prior to utilization of any off-site borrow, the site shall be identified and a minimum of 50 pounds of each type of proposed borrow soil, at least 3 months prior to use.of each type of material, shall be submitted to the Contracting Officer for QA testing. Backfill shall be free of contamination, roots, debris, brush, sod, organic, or frozen material and tested in accordance with the import fill specifications in the DBR. Material passing the No. 200 sieve shall have a liquid limit greater than 30 and a plasticity index greater than 10 . Materials shall be thoroughly blended prior to mixing with bentonite slurry and shall conform to the following gradation requirements:

Screen Size or Number (U.S. Standard)	Percent Passing by Dry Weight
3 inch	100
No. 4	40-80
No. 40	25-60
No. 200	20-40

2.2 EQUIPMENT

Furnish all necessary plant and equipment for use on this project.

2.2.1 Trench Excavation Equipment

Equipment for excavating the slurry trench shall be any type or combination of excavating equipment capable of performing the work as specified and shown on the drawings. The equipment shall be capable of excavating the required minimum width of trench in a single pass of the excavating equipment. The buckets utilized with such equipment may be perforated, tapered and equipped with bottom-side cutter teeth protruding no more than 6 inches. The bucket shall be designed to maintain the width of the trench and to minimize raveling of the trench sides during use. The equipment shall be able to reach at least 5 feet deeper than the maximum depth shown on the drawings.

2.2.2 Slurry Mixing and Cleaning Equipment

The slurry mixing plant shall be equipped with a high-speed/high-shear, colloidal mixer or a high-velocity/high pressure venturi jet mixer used in conjunction with a high-speed/high-shear centrifugal pump. The plant shall be equipped with a mechanically or hydraulically agitated sump and shall include pumps, valves, hoses, supply lines, tools, and other equipment and materials required to prepare the slurry and deliver it in a continuous supply from the tanks to the slurry trench. Mixers shall be capable of achieving complete dispersion of bentonite and additives, and shall be capable of continually mixing the slurry to provide and maintain a uniformly blended slurry. Provide sufficient tanks for storage of hydrated bentonite slurry. Slurry cleaning equipment shall be available to reduce sand, sediment, or other solids as necessary to maintain the sand content or density requirements of the slurry in the trench. Slurry cleaning equipment may include but not be limited to vibratory shaker screens, centrifugal sand separators, or stilling ponds. IF the freshwater water wetland pond or any temporary ponds is constructed for the purpose of slurry mixing, it will be constructed at or above the subgrade with clean import fill and lined.

2.2.3 Field Laboratory Equipment

The field laboratory shall contain as a minimum the following equipment:

1	Mold and rod for slump test
2	Marsh funnel sets
1	Standard filter press
2	Mud balances (direct reading of density)
1	Slurry sampler
2	Number 200 sieves
1	Set of standard sieves and sieve shaker
1	Oven for moisture content
1	Balance
1	pH meter
2	Sand content sets
1	4 inch Cylindrical mold

2.3 BENTONITE SLURRY MIXES

2.3.1 Initial Bentonite Slurry Mixture

The initial bentonite slurry mixture shall conform to the standards specified in Table 1.

2.3.2 Trench Bentonite Slurry Mixture

The trench bentonite slurry mixture shall conform to the standards specified in Table 1.

2.3.3 Additional Bentonite

If directed by the Contracting Officer, thicken the slurry to a more viscous condition than the limits specified above. Use additional bentonite, as directed.

2.3.4 Additives

Peptizing agents and bulking agents shall not be mixed with the slurry. Approved thinners or dispersants and flocculants of the types used in the control of oil field drilling muds, may be used to control standard properties of the slurry such as apparent viscosity, pH and filtration characteristics.

2.3.5 S-B Backfill

The Soil-Bentonite (S-B) backfill mix design consists of backfill material and bentonite slurry. A Soil Cement Bentontite (S-C-B) backfill design will also include a percentage of cement depending on the results of the Compatibility Test. Cement may also be supplemented with blast furnace slag or fly ash to achieve strength and permeability specifications, depending on the results of the Compatibility Test. Set time retarders and deflocculants can be added to improve the S-C-B backfill workability, with approval of the Contracting officer, and the BTC regulatory agencies. If preconstruction testing determines that dry bentonite is required, it shall be thoroughly mixed and shall conform to the standards specified in Table 1 just prior to placement in the trench.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

The slurry trench shall be constructed to the elevations, lines, grades, and cross-sections (See Design Drawings C-5 and C-6) shown and in accordance with these specifications, unless otherwise directed. The Government may modify the dimensions and quantities of the work as determined necessary. Submit a Slurry Trench Implementation Plan for approval, a minimum of 5 weeks prior to the start of construction.

3.2 WORKING SURFACE

Slurry trench construction shall be accomplished from the working surface, as shown on the drawings. If the Contractor's operations require a wider working surface, the reason for the change shall be submitted. If approved, a wider working surface may be constructed at no additional cost to the Government. Working surface material and compaction requirements are described in the DBR. In the event that the static ground water table is encountered at a depth of 3.0 feet or less below the designated working surface, at the direction of the Contracting Officer, raise the working surface to a height of 3 feet above the measured static ground water level with approved fill material.

3.3 SLURRY TRENCH EXCAVATION

The excavation shall begin from the working surface and shall provide a vertical (within 2 percent) continuous 2 foot minimum width trench to the required depth along the centerline of the excavation. The slurry trench shall key 2 feet into the Bay Mud stratum. The western boundary slurry trench shall not key into a stratum, but will however extend into the B-Zone Aquifer (See design drawings of the slurry wall profiles and cross sections C-6). The Contracting Officer may direct the Contractor to modify the trench depth based on examination of bucket cuttings or drive samples. The toe of the slope of the trench excavation shall not precede the toe of the S-B backfill slope by less than 30 feet or more than 100 feet. At the intersection of 2 straight line segments, the trench excavation shall extend a minimum of 5 feet beyond the outside of the intersection at all depths. If trench excavation overlaps into previously completed slurry trench, the excavation shall extend a minimum of 10 feet into the previously placed S-B backfill at all depths. Any removed section of completed slurry trench shall be refilled with S-B backfill at no additional expense to the Government.

3.3.1 Confining Stratum Excavation

Keying into a confining stratum is only required for the near shore slurry wall. The Bay Mud is the confining stratum and shall be excavated the full trench width at least 2-feet of depth into the Bay Mud. Approximate elevations and depths of the Bay Mud are shown in the slurry wall alignment profile. The Contractor will provide a methodology in Slurry Trench Implementation Plan to confirm excavation to the Bay Mud, the Bay Mud elevation, and how confirmation of the minimum excavation depth into the Bay Mud will be achieved. Any sandstone, boulders, or debris lenses encountered at the minimum excavation depth shall be removed for the full width of the trench and into the Bay Mud underlying confining stratum. The Bay Mud shall then be sampled in accordance with paragraph SAMPLES OF CONFINING STRATUM. Termination of excavation will be approved by the Contracting Officer.

3.4 SLURRY PLACEMENT AND TESTING

3.4.1 Slurry Placement

Introduce slurry into the trench at the time excavation begins. The level of the slurry in open trenches shall be maintained a minimum of 3 feet above ground water level and no more than 2 feet below the top of the working surface until the placement of S-B backfill is complete. If the density or sand content of the slurry in the trench does not conform to the standards specified in Table 1, the excess solids shall be removed from the slurry using approved methods or the slurry shall be replaced with fresh slurry. Slurry shall not be diluted by surface water. Conditioning of the slurry may require recirculation through a shaker screen or the addition of approved additives. Provide sufficient personnel, equipment, slurry storage areas, and prepared slurry materials ready to raise the slurry level at any time in the excavated trench, weekends and holidays included.

3.4.2 Slurry Testing

The bentonite slurry in the trench shall be sampled a minimum of 2 times each 8 hour shift (near the beginning and end of each shift), at two

depths; approximately 2 feet below the slurry surface and approximately 2 feet above the bottom of the trench. These samples shall be taken within 5 feet of the toe of the S-B backfill slope. Additional samples shall be obtained at the request of the Contracting Officer.

3.5 EXCAVATED MATERIAL

Material excavated from the trench shall not be used as backfill. Analytical testing and radiological screening of excavated materials would prohibit reuse of this material. Excavated trench material shall be stockpiled in a waste disposal area and will be detailed in the Contractor RAWP, waste management plan (WMP).

3.6 STABILITY

The Contractor is responsible for ensuring and maintaining the stability of the excavated trench at all times, for its full length and depth, and for maintaining slurry densities and levels within specified limits. Control surcharges from all excavation and backfilling equipment, waste, berm construction, backfill stockpiles, and any other loading situations that may affect trench stability. It is the Contractor's sole responsibility to ensure that the mixing of S-B backfill and any stockpiles do not affect the open trench stability. In the event of failure of the trench walls prior to completion of backfilling, re-excavate the trench, remove all material displaced into the trench, and take corrective action to prevent further deterioration, at the Contractor's expense.

3.7 TRENCH CLEANING

At a minimum, unless otherwise approved, the trench bottom shall be cleaned at the start of each day. If S-B backfill placement operations have ceased for longer than 24-hours, the face of the S-B backfill slope shall be cleaned prior to the placement of additional S-B backfill. The trench bottom shall be probed for any deposits or sloughed materials prior to cleaning. The trench bottom shall be cleaned by using an excavator bucket, or other approved equipment to ensure removal of sand, gravel, sediment, and other material left in the trench during excavation or which has settled out of the slurry. Cleaning equipment shall not remove material from the walls of the trench. The Contracting Officer may require more frequent cleaning. After the trench bottom has been cleaned, sample the trench bottom with an excavator bucket, or equivalent, as approved by the Contracting Officer. After examining the samples, the Contracting Officer will either approve the excavation at the points checked or require additional cleaning. If additional cleaning is required, then additional samples shall be furnished as specified above by the Contracting Officer.

3.8 S-B BACKFILL MIXING AND PLACEMENT

3.8.1 Mixing

The S-B backfill shall be thoroughly mixed via disking, harrowing, bulldozing, blading, or other approved methods into a homogeneous mass, free from large lumps or clods of soil or pockets of fines, sand, or gravel. Occasional lumps of up to 3 inches in their largest dimension will be permitted. All particles shall be coated with slurry. The S-B backfill may be sluiced with slurry during the mixing operations. Sluicing with water is not permitted. The S-B backfill shall be mixed in a separate mixing location as shown on the drawings. When mixing the S-B backfill along the side of the trench, heavy equipment such as bulldozers shall not

operate in a back and forth fashion, paralleling the open trench, closer than 15 feet from the lip of the trench. Excess slurry may be allowed to flow back into the trench.

3.8.2 Placement

Initial S-B backfill placement shall be by one of the following methods: (1) Placement by lowering S-B slurry to the bottom of the trench with crane and clamshell bucket, or tremie methods until the surface of the S-B backfill rises above the surface of the slurry trench at the end of the trench; (2) Construct a lead-in trench 1H:1V or flatter at a point outside of the limits of work to allow a S-B backfill face to form prior to reaching the full depth of the required slurry trench. No payments will be made for the portions of trenches which lie outside of the limits of work. Placement operations shall proceed in such a manner that the slope of the initially placed S-B backfill is maintained. Free dropping of S-B backfill through the slurry is not permitted. The S-B backfill shall be placed so that it will slide down the forward face of the S-B backfill slope. The S-B backfill shall be placed in the excavated trench so that no pockets of slurry are trapped and that a constant slope is maintained. Placement shall be continuous from the beginning of the trench in the direction of the excavation to the end of the trench.

3.8.3 Mixing and Placing During Cold Weather

No mixing or placing of the S-B backfill shall be performed when the air temperature is below 20 degrees F. Frozen S-B backfill shall not be placed in the trench and backfill material containing frozen lumps shall not be used to mix S-B backfill.

3.8.4 Testing

Samples for permeability testing shall be taken 1 sample per 500 cubic yards of backfill. If offsite laboratory test results do not meet the requirements listed in Table 1, corrective action, as determined by the Contracting Officer, shall be taken.

3.9 SOUNDINGS

Take excavation and S-B backfill soundings every 20 feet along the trench centerline using a weighted tape, cable, or other approved device. Submit a record of soundings and measurements taken during construction of the slurry trench. Soundings shall be measured to the nearest 0.1 ft. The soundings shall measure the following:

3.9.1 Elevation of Top of Confining Stratum

The top of the confining stratum shall be determined based on examination of samples taken as described under paragraph SAMPLES OF CONFINING STRATUM. This elevation shall be subject to approval.

3.9.2 Elevation of Trench Bottom Prior to Backfilling

Determine the elevation of the trench bottom after the trench has been cleaned and approved as described under paragraph Trench Cleaning. This sounding shall not precede the toe of the S-B backfill slope more than 50 feet. This elevation is subject to approval by the Contracting Officer.

3.9.3 Profile of S-B Backfill Slope and Trench Bottom

The S-B backfill slope and trench bottom shall be sounded at the beginning and end of each shift, and at additional times as directed, at intervals of 20 feet.

3.10 AS-BUILT PROFILE

An as-built profile of the trench bottom and S-B backfill slopes, including descriptions of materials encountered in the trench bottom, shall be continuously maintained. This profile shall indicate extent of excavation and the S-B backfill profile at the end of each work day and after each S-B backfill batch is placed in the trench as determined from soundings. The S-B backfill batch numbers shall appear on the profile with the limits of each batch of material delineated as placed. Submit a scale drawing providing a log of the subsurface materials excavated from the trench, and a profile of the completed slurry trench. The limits of each batch of S-B backfill shall be delineated as placed.

3.11 TREATMENT OF TOP OF SLURRY TRENCH

Prior to placement of the compacted trench cover, a temporary non-compacted soil or plastic sheeting cover shall be placed over the trench to prevent desiccation. The temporary cover material shall be placed within 2 days after S-B backfill placement is completed over each 100 foot reach. If any depression develops within the completed slurry trench area, it shall be repaired by placing and compacting additional trench cover soil. After a minimum two weeks, the temporary trench cover shall be removed and replaced by a final compacted trench cover. A final compacted trench cover minimum of 6 feet wide and 2 feet deep shall be placed as specified in the DBR to a dry density of 90 percent of maximum density at optimum moisture to plus 3 percent in accordance with ASTM D698. Heavy construction equipment and machinery shall only be driven over the slurry trench at approved heavy equipment crossing points until final grade is complete.
For heavy equipment crossings, it is recommended the upper portion of the S-B backfill be excavated and a clay plug be placed under the compacted trench cover. Additional support may be necessary to support the anticipated loads.

3.12 QUALITY CONTROL TESTING

Provide Quality Control Inspectors as necessary for bentonite slurry preparation and maintenance, trench excavation, and S-B backfill preparation and placement. Submit all test results.

3.12.1 Bentonite Tests

Manufacturer's test and certification data for each specified requirement shall be provided for each truck or rail car shipment delivered to the site.

3.12.2 Water Tests

Testing of potable water (i.e. from a fire hydrant)is not required. However, iF potable water from the City of San Francisco is not used, a minimum of 1 test for each specified requirement shall be performed for each water source used. Testing shall be performed as specified in Table 1.

3.12.3 Backfill Material Tests

One set of backfill material tests, as specified in Table 1, shall be performed for every 500 cubic yards used.

3.12.4 Slurry Properties

Slurry shall be required to hydrate a minimum of 8 hours prior to use. The initial bentonite slurry shall be tested prior to placing in the trench and a minimum of 2 times each 8 hour shift per mixing plant. Submit a record of bentonite slurry mix quantities, proportions of additives utilized, and adjustments for each batch.

3.12.5 S-B Backfill Tests

Sampling and testing shall be performed, in accordance with the approved Preconstruction Testing Plan, just prior to placing S-B backfill in the trench as shown in Table 1. The density of the S-B backfill shall be calculated using a 4 inch cylindrical mold as described in Paragraph 6 of ASTM D698. S-B backfill shall be placed in the mold and rodded 10 times. Additional S-B backfill shall then be added to fill the mold. The weight and volume of the molded S-B backfill shall then be used to determine the density or, the density of the S-B backfill shall be determined using a mud balance. Density shall be determined at a rate of 1 test for every 500 cubic yards. A sample of S-B backfill for permeability testing shall be taken just prior to placement in the trench for every 500 cubic yards. Submit a Plan providing a list of test equipment, procedures, and materials to be used to verify the mix design for the S-B backfill and an S-B Backfill Test Report containing the results of the tests performed, a report summarizing the procedures and results of the pre-construction S-B backfill mix tests, and associated successful compatibility tests. The report shall include a description of mix proportions, gradations, slumps, densities, permeabilities, and moisture contents of 3 samples of the final S-B backfill mix using the bentonite and backfill materials proposed for use. Submit a minimum of 50 pounds of each type of proposed borrow soil at least 3 month prior to use.

3.12.6 Samples of Confining Stratum

Samples of the Bay Mud (confining stratum) anong the shoreline only shall be taken at the completion pof each excavaion pass by the excavator bucket. Samples shall be obtained from the excavator bucket cuttings or equivalent method.. After examining these samples, the Contracting Officer will either approve the termination of excavation at the sample points or require additional excavation. If additional excavation is required, then additional samples shall be furnished as specified above. All samples shall be properly identified and labeled, placed in sealed plastic containers and stored in a location designated by the Contracting Officer.

3.13 CLEAN-UP

Excavation spoil, unused S-B backfill, and excess slurry shall be removed following completion of S-B backfill placement. These materials shall be disposed of in the waste disposal areathat will be designated in the Contractors RAWP ad WMP.

BENTONITE SLURRY TRENCH QUALITY		
Property	Requirement	Test Method
Bentonite Powder		
YP/PV Ratio	1.5 max.	API Spec 13A
Plastic Viscosity	> 10	API Spec 13A
Filtrate Loss	< 12.5 cubic cm	API Spec 13A
Moisture Content	< 10 percent	ASTM D2216
Chemical Analysis of Water		
pH	6 to 8	API RP 13B-1
Hardness	< 50 ppm	API RP 13B-1
Total Dissolved Solids	<500 ppm	EPA 600/4-79/020 Method 160.1
VOCs	See Table 4 of the DBR (groundwater remediation goals)	SW-846 Method 5030B/8260B
SVOCs	See Table 4 of the DBR (groundwater remediation goals)	SW-846 Method 3510C/8270C
TPH	See Table 4 of the DBR (groundwater remediation goals)	SW-846 Modified 8015
Metals	See Table 4 of the DBR (groundwater remediation goals)	SW-846 3005A/6010C
Pesticides	See Table 4 of the DBR (groundwater remediation goals)	SW-846 3510C/8081A/8141A
Initial Bentonite Slurry		
Viscosity	> 40 sec	API RP 13B-1
Density	> 64 pcf	API RP 13B-1

BENTONITE SLURRY TRENCH QUALITY		
Property	Requirement	Test Method
Filtrate Loss	< 20	API RP 13B-1
pH	6.5 to 10	API RP 13B-1
In-Trench Bentonite Slurry		
Density	1025-1360 and at least 240 less than S-B backfill density 64-85 pcf and at least 15 pcf less than S-B backfill density	API RP 13B-1
Viscosity	> 40 sec	API RP 13B-1
pH	6.5 to 10	API RP 13B-1
Sand Content	10 percent max.	API RP 13B-1
S-B Backfill (Western Boundary Slurry Wall)		
Grain Size	Para. 2.1.3	ASTM D422
Moisture content	For record	ASTM D2216
Fines Content	Para. 2.1.3	ASTM D1140
Atterberg limits	Para. 2.1.3	ASTM D4318
S-B Backfill (Near Shore Slurry Wall)		
Strength	3 PSI Minimum	Geotechnical Recommendation

BENTONITE SLURRY TRENCH QUALITY		
Property	Requirement	Test Method
Slump Cone	100-200 mm; 4-8 inches	ASTM C143/C143M
Density	For Record	ASTM D698 and Para. 2.4.5
Permeability	< 1 x 10-6 cm/sec in the field <5.0x10-7 during laboratory compatibility testing	ASTM D2434 ASTM D5084
1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.		

-- End of Section --

SECTION 02 41 00

SITE CLEARING AND DEMOLITION
3/13

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

Remove rubbish and debris from the project site; do not allow accumulations. Store materials that cannot be removed daily in areas specified by the Contracting Officer. Field verify topographical and survey information. Relocate and consolidate rubbish, debris, and surface soils, as indicated on the Drawings. Remove all debris, refuse, and other loose materials from the site from within the limits as shown in the Drawings. Inspect the interior of all buildings on the site and remove all debris, refuse and other loose materials from within the buildings. All existing groundwater monitoring wells within the site boundary are to be preserved. Refer to Section 33 24 13 MONITORING WELLS for additional information.

1.2 SUBMITTALS

1.2.1 SD-01, Presonstruciton Submittal

a. Demolition Plan; G

Submit proposed removal procedures to the Contracting Officer for approval before work is started.

1.3 DUST AND DEBRIS CONTROL

Prevent the spread of dust and debris and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution. Refer to paragraph 3.7 Dust Control of Section 01

1.4 PROTECTION

Protect existing work that is to remain in place, this includes but is not limited to all groundwater monitoring wells as shown in the drawings in addition to concrete pads or other areas that can be incorporated into the durable cover over the site. Repair items that are to remain and that are damaged during performance of the work to their original condition, or replace with new. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition or removal work. Repairs, reinforcement, or structural replacement must have Contracting Officer approval.

1.5 BURNING

Burning will not be permitted.

PART 2 EXECUTION

2.1 REFUSE DISPOSAL

All refuse generated by construction will be controlled such that it is not carried off site by wind or water and does not constitute a hazard to

worker safety or construction equipment. Refuse may be collected in construction dumpsters contracted through a local municipal waste hauler. Remove and transport refuse in a manner that will prevent spillage on pavements, streets, or adjacent areas. Clean up spillage from pavements, streets, and adjacent areas to prevent potential damage by foreign objects. Classify and handle all wastes in accordance with Section 01 57 19.00 20 Temporary

2.1.1 Utilities and Related Equipment

2.1.1.1 General Requirements

Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Contracting Officer. Do not interrupt existing utilities serving facilities occupied and used by the Government except when approved in writing and then only after temporary utility services have been approved and provided. Do not begin demolition or deconstruction work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

2.2 CLEARING AND GRUBBING

The boundaries for clearing and grubbing and removal of surface waste are provided on the Drawings. Cleared vegetation will be disposed of off-site. Existing asphaltic concrete, bollards, concrete, utility features, and other materials can be left in place and become the surface material of the cover with approval from the Contracting Officer. Existing site materials that will be used in the durable cover must be free from cracks and other damage or repaired as needed to meet such condition.

2.2.1 Organic Material (Green Waste)

Remove all trees and other woody debris that is practicable. All organic debris hauled off base shall be recycled at a local composting facility.

2.2.2 Surface Waste, Non-Organic Material

Monolithic inorganic trash or debris, such as waste concrete, pipe, abandoned equipment, orasphaltic pavement, located on the surface of the site within the boundary delineated on the Drawings may be contained under the cover if particle size does not exceed 3 inches in the largest dimension and will not negatively affect the constructed durable cover. Larger pieces may be broken down to achieve this requirement. All other pieces shall be characterized and disposed of or recycled off-site at the appropriate landfill or facility. Contractor shall minimize the generation of waste, inorganic trash, or debris whenever possible, recycle as much material as possible, and utilize the many waste recovery sites available in the area.

-- End of Section --

SECTION 02 81 00

TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS
03/13

PART 1 GENERAL

This section is being deferred to the Draft Final version of the Remedial Design.

-- End of Section --

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1. GENERAL

1.01 SUMMARY

A. This section covers all cast-in-place concrete, including reinforcing steel, finishing, curing, and other appurtenant work.

B. The Contractor shall furnish all labor, equipment, materials and incidentals necessary to complete all concrete work as shown on the Plans and specified herein.

C. All concrete foundation designs shall be based on 4,000 psi concrete. The minimum allowable concrete strength shall be 4,000 psi.

1.02 RELATED SECTIONS

TO BE ADDED

1.03 REFERENCE STANDARDS AND DOCUMENTS

A. Except as otherwise indicated on the Plans or stated in these Specifications, materials, equipment, details, and construction methods shall comply with the applicable provisions of the Standard Specifications for Public Works Construction (SSPWC).

B. All concrete work shall be in conformance with the recommended practices of American Concrete Institute (ACI-301). All concrete design and details shall conform to requirements of latest publication of ACI-318. All steel reinforcements shall comply with the Concrete Reinforcing Steel Institute (CRSI) “Manual of Standard Practices.”

TO BE EXPANDED

1.04 SUBMITTALS

A. The source and quality of concrete materials and the concrete proposed for the Work shall be submitted to the CQA Officer for review prior to any concrete placement.

B. Submit written reports to Project Manager of each proposed mix for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until proposed mix designs have been reviewed and approved by Project Manager.

C. Elevation Certificate: Surveyor to confirm elevation of finished foundations are above FEMA AE10.5 Flood Zone Elevation and to prepare and sign Elevation Certificate as described in the drawings.

D. Submittals shall be in accordance with Section 01300 of these Specifications.

1.05 QUALITY ASSURANCE AND CONTROL

A. The Contractor shall adhere to Section 01400 of these Specifications.

B. The Owner or CQA consultant shall inspect or monitor the placement of the reinforcing steel and concrete.

C. Contractor shall provide independent materials testing firm to verify subgrade soil compaction and strength-test concrete cylinders.

1. Subgrade soil compaction testing will be performed consistent with the requirements contained in Section 31 00 00 EARTHWORK.

2. Three (3) test cylinders shall be prepared and tested by the Contractor for every 50 cubic yards of concrete delivered to the site. One (1) test cylinder shall be tested at 7 days and two (2) test cylinders shall be tested at 28 days, in accordance with ASTM C39. The average of the 28-day results shall not be less than the specified strength.

PART 1. MATERIALS

1.01 MATERIALS

A. Cement - ASTM C150, Type II.

B. Fine Aggregate - Clean natural sand, ASTM C33.

C. Coarse Aggregate - Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33.

D. Water - Potable, clean and free from deleterious substances, ASTM C94

E. Reinforcing Steel - ASTM A615, deformed, Grade 60. Wire fabric shall conform to ASTM A185.

F. Membrane Curing Compound - Federal Specification TT-C-800, Type I, Class 1; minimum 18 percent solids; non-yellowing; unit moisture loss 0.039 gm/cm2 mas; Gifford-Hill "Sealco 800," ProSoCo "Kure and Seal," Protex "Acrychlor," or Sonneborn "Kure-N-Seal."

G. Polyethylene Film - PS17; 6 mil.

H. Fly Ash – ASTM C618, Type F.

I. Water Reducing Admixture: ASTM C494, Type A.

J. Tie Wire: Minimum 16 gauge, annealed type.

1.02 MIX DESIGN

A. Prepare and submit design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 310. For the trial batch method, use an independent testing agency acceptable to the Owner for preparing and reporting proposed mix designs.

B. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability, as approved by the Owner.

C. Unless otherwise specified, concrete mix shall be controlled within the following limiting requirements:

1. Cement Content - Not less than 550 pounds per cubic yard.

2. Water to Cement Ratio – Not to exceed 0.50.

3. Consistency - Workable, without segregation, with slump not more than 5 inches when concrete is placed.

4. Mixing - Thoroughly in a batch mixer for not less than 4 minutes at high speed.

5. Compressive Strength – 4,000 psi at 28 days in accordance with ASTM C39.

6. Maximum Aggregate Size – 1-inch.

1.03 CONTROLLED LOW STRENGTH MATERIAL

A. Controlled low strength material (CLSM) shall be a one-sack Portland cement / fine aggregate ad-mix with a maximum 28-day compressive strength of 300 psi.

1.04 CONCRETE FORMS

A. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the Plans or in the Specifications. Forms shall be substantial and sufficiently tight to prevent leakage and shall be maintained in proper position and accurate alignment. Forms shall be thoroughly cleaned and oiled before concrete is placed and shall not be removed until the concrete has hardened sufficiently to support all loads without damage.

B. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.

1. Use plywood complying with U. S. Product Standard PS-1 “B-B Concrete Form) Plywood,” Class I, Exterior Grade or

better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

C. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

D. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 mg/l volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

PART 2. EXECUTION

2.01 FORMS

A. Construct forms to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures.

B. Fabricate forms for easy removal without hammering or prying against concrete surfaces.

C. Chamfer exposed corners and edges as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

D. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before placing concrete. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

2.02 PLACING REINFORCEMENT

A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports and as specified.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as approved by Construction Manager.

D. Place reinforcement to maintain minimum coverage as indicated for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. All concrete slabs and foundations shall have a minimum steel

content of ½-inch diameter bar at 24-inches on center unless otherwise shown on the Drawings.

2.03 PLACEMENT OF CONCRETE

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete", and as specified.

C. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness.

D. Concrete shall be conveyed to the point of final deposit and placed by methods which will prevent the separation or loss of the ingredients.

E. Re-tempering of concrete or mortar which shows evidence of initial set shall not be permitted. Such concrete or mortar materials are unacceptable and shall be disposed away from the work site or as directed by the Project Manager.

F. Appropriate mechanical vibration shall be used in order to thoroughly work concrete around reinforcement and embedded fixtures and into corners of the forms during placing operations.

G. Unless otherwise authorized, compaction shall use immersion-type vibrators. Compaction shall result in concrete free of voids. Exercise care to compact concrete vigorously and thoroughly to obtain maximum density. Concrete shall be consolidated within 15 minutes after its placement in the forms.

H. Where depositing concrete by chute, provide equipment of such size and design as to ensure a continuous flow in the chute. Provide the discharge end of the chute with a baffle plate to prevent segregation. Position the chute so that the concrete will not need to flow more than 5 feet horizontally.

I. Do not drop concrete from the end of a chute a distance greater than 3 times the horizontal thickness of the layer being deposited, with a maximum distance of 5 feet. Where the distance from the end of the chute to the surface of the concrete exceeds these distances, use a spout (tremie) and maintain the lower end as near to the surface of deposits as practical. When the operation is intermittent, discharge the chute into a hopper.

J. Concrete shall be discharged at the job within 1.5 hours after the cement has been added to the water or the aggregates, except when the air temperature exceeds 85° F, the time shall

be reduced to 45 minutes.

K. Immediately after completion of trowel finish, surfaces shall be slightly roughened by brushing with a fiber-bristle brush in the directing of drainage.

L. Immediately following completion of finishing operations and after concrete has taken initial set, the floor shall be covered to prevent evaporation of water from the concrete, curing shall be accomplished by the following methods.

M. "Curing Compound" - When ponding or wetting method is not possible because of essential construction operations, the use of a colorless curing compound conforming to ASTM C309 will be acceptable. Application shall be in accordance with the manufacturer's instructions.

N. All footings shall be placed in undisturbed native soil or approved compacted fill.

2.04 FINISHING

A. Fins and other surface projections shall be removed from all formed surfaces except surfaces that will be in contact with earth backfill. Surface voids and recesses resulting from removal of form ties shall be filled with mortar. Forms shall not damage the concrete when removed.

2.05 CURING

A. Concrete shall be maintained in a moist condition and protected from loss of moisture for at least seven days by polyethylene film or curing compound. Curing compound shall be applied as recommended by the manufacturer. Concrete shall not be permitted to freeze for at least seven days following placement.

2.06 JOINTS

A. Construction Joints: Locate and install construction joints so they do not impair strength or appearance of the structure, as acceptable to Construction Manager.

B. Place construction joints perpendicular to main reinforcement.

2.07 INSTALLING EMBEDDED ITEMS

A. General: Set and build into formwork anchorage devices and other embedded items required for other work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.

B. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and secure units to

support screed strips using strike-off templates or compacting-type screeds.

PART 3. PRODUCTS

Not used.

END OF SECTION

SECTION 03 40 00.00 10

PLANT-PRECAST CONCRETE
03/13

PART 1 GENERAL

This section is being deferred to the Draft Final version of the Remedial Design.

-- End of Section --

SECTION 09 90 00

PAINTS AND COATINGS
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH 0100	(2001; Supplements 2002-2008) Documentation of the Threshold Limit Values and Biological Exposure Indices

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM D235	(2002; R 2012) Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D4214	(2007) Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D4263	(1983; R 2012) Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D523	(2008) Standard Test Method for Specular Gloss
ASTM D6386	(2010) Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM F1869	(2011) Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

MASTER PAINTERS INSTITUTE (MPI)

MPI 1	(Oct 2009) Aluminum Paint
MPI 101	(Oct 2009) Epoxy Anti-Corrosive Metal Primer
MPI 107	(Oct 2009) Rust Inhibitive Primer (Water-Based)

MPI 108	(Oct 2009) High Build Epoxy Coating, Low Gloss
MPI 11	(Oct 2009) Exterior Latex, Semi-Gloss, MPI Gloss Level 5
MPI 134	(Oct 2009) Galvanized Primer (Waterbased)
MPI 163	(Oct 2009) Exterior W.B. Light Industrial Coating, Semi-Gloss, MPI Gloss Level 5
MPI 19	(Oct 2009) Inorganic Zinc Rich Primer
MPI 2	(Oct 2009) Aluminum Heat Resistant Enamel (up to 427 C and 800 F
MPI 21	(Oct 2009) Heat Resistant Enamel, Gloss (up to 205 degrees C and 400 degrees F), MPI Gloss Level 6
MPI 23	(Oct 2009) Surface Tolerant Metal Primer
MPI 27	(Oct 2009) Exterior / Interior Alkyd Floor Enamel, Gloss
MPI 42	(Oct 2009) Latex Stucco and Masonry Textured Coating
MPI 72	(Oct 2009) Polyurethane, Two Component, Pigmented, Gloss
MPI 79	(Oct 2009) Alkyd Anti-Corrosive Metal Primer
MPI 94	(Oct 2009) Exterior Alkyd, Semi-Gloss, MPI Gloss Level 5
MPI 95	(Oct 2009) Quick Drying Primer for Aluminum

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS SP-01	(2000) Environmentally Preferable Product Specification for Architectural and Anti-Corrosive Paints

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC 7/NACE No.4	(2007; E 2004) Brush-Off Blast Cleaning
SSPC PA 1	(2000; E 2004) Shop, Field, and Maintenance Painting of Steel
SSPC PA Guide 3	(1982; E 1995) A Guide to Safety in Paint Application
SSPC QP 1	(1998; E 2004) Standard Procedure for Evaluating Painting Contractors (Field Application to Complex Industrial Structures)

SSPC SP 1	(1982; E 2004) Solvent Cleaning
SSPC SP 10/NACE No. 2	(2007) Near-White Blast Cleaning
SSPC SP 12/NACE No.5	(2002) Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating
SSPC SP 2	(1982; E 2000; E 2004) Hand Tool Cleaning
SSPC SP 3	(1982; E 2004) Power Tool Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning
SSPC VIS 1	(2002; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC VIS 3	(2004) Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning
SSPC VIS 4/NACE VIS 7	(1998; E 2000; E 2004) Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA Method 24	(2000) Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-313	(Rev D; Notice 1) Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1000	Air Contaminants

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

The current MPI, "Approved Product List" which lists paint by brand, label, product name and product code as of the date of contract award, will be used to determine compliance with the submittal requirements of this specification. The Contractor may choose to use a subsequent MPI "Approved Product List", however, only one list may be used for the entire contract and each coating system is to be from a single manufacturer. All coats on a particular substrate must be from a single manufacturer. No variation from the MPI Approved Products List is acceptable.

Samples of specified materials may be taken and tested for compliance with specification requirements.

In keeping with the intent of Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition", products certified by SCS as meeting SCS SP-01 shall be given preferential consideration over registered products. Products that are registered shall be given preferential consideration over products not carrying any EPP designation.

SD-02 Shop Drawings

Piping identification

Submit color stencil codes

SD-03 Product Data

Coating; G

Manufacturer's Technical Data Sheets

Indicate VOC content.

SD-04 Samples

Color; G

Submit manufacturer's samples of paint colors. Cross reference color samples to color scheme as indicated.

SD-07 Certificates

Applicator's qualifications

Qualification Testing laboratory for coatings; G

SD-08 Manufacturer's Instructions

Mixing

Detailed mixing instructions, minimum and maximum application temperature and humidity, potlife, and curing and drying times between coats.

Manufacturer's Material Safety Data Sheets

Submit manufacturer's Material Safety Data Sheets for coatings, solvents, and other potentially hazardous materials, as defined in FED-STD-313.

SD-10 Operation and Maintenance Data

Coatings:; G

Preprinted cleaning and maintenance instructions for all coating systems shall be provided.

1.3 APPLICATOR'S QUALIFICATIONS

1.3.1 Contractor Qualification

Submit the name, address, telephone number, FAX number, and e-mail address of the contractor that will be performing all surface preparation and coating application. Submit evidence that key personnel have successfully performed surface preparation and application of coatings on environmental remediation equipment on a minimum of three similar projects within the past three years. List information by individual and include the following:

a. Name of individual and proposed position for this work.

b. Information about each previous assignment including:

Position or responsibility

Employer (if other than the Contractor)

Name of facility owner

Mailing address, telephone number, and telex number (if non-US) of facility owner

Name of individual in facility owner's organization who can be contacted as a reference

Location, size and description of structure

Dates work was carried out

Description of work carried out on structure

1.3.2 SSPC QP 1 Certification

All contractors and subcontractors that perform surface preparation or coating application shall be certified by the Society for Protective Coatings (formerly Steel Structures Painting Council) (SSPC) to the requirements of SSPC QP 1 prior to contract award, and shall remain certified while accomplishing any surface preparation or coating application. The painting contractors and painting subcontractors must remain so certified for the duration of the project. If a contractor's or subcontractor's certification expires, the firm will not be allowed to perform any work until the certification is reissued. Requests for extension of time for any delay to the completion of the project due to an inactive certification will not be considered and liquidated damages will apply. Notify the Contracting Officer of any change in contractor certification status.

1.4 QUALITY ASSURANCE

1.4.1 Field Samples and Tests

The Contracting Officer may choose up to two coatings that have been delivered to the site to be tested at no cost to the Government. Take samples of each chosen product as specified in the paragraph "Sampling Procedures." Test each chosen product as specified in the paragraph "Testing Procedure." Products which do not conform, shall be removed from the job site and replaced with new products that conform to the referenced specification. Testing of replacement products that failed initial testing shall be at no cost to the Government.

1.4.1.1 Sampling Procedure

The Contracting Officer will select paint at random from the products that have been delivered to the job site for sample testing. The Contractor shall provide one quart samples of the selected paint materials. The samples shall be taken in the presence of the Contracting Officer, and labeled, identifying each sample. Provide labels in accordance with the paragraph "Packaging, Labeling, and Storage" of this specification.

1.4.1.2 Testing Procedure

Provide Batch Quality Conformance Testing for specified products, as defined by and performed by MPI. As an alternative to Batch Quality Conformance Testing, the Contractor may provide Qualification Testing for specified products above to the appropriate MPI product specification, using the third-party laboratory approved under the paragraph "Qualification Testing" laboratory for coatings. The qualification testing lab report shall include the backup data and summary of the test results. The summary shall list all of the reference specification requirements and the result of each test. The summary shall clearly indicate whether the tested paint meets each test requirement. Note that Qualification Testing may take 4 to 6 weeks to perform, due to the extent of testing required.

Submit name, address, telephone number, FAX number, and e-mail address of the independent third party laboratory selected to perform testing of coating samples for compliance with specification requirements. Submit documentation that laboratory is regularly engaged in testing of paint samples for conformance with specifications, and that employees performing testing are qualified. If the Contractor chooses MPI to perform the Batch Quality Conformance testing, the above submittal information is not required, only a letter is required from the Contractor stating that MPI will perform the testing.

1.5 REGULATORY REQUIREMENTS

1.5.1 Environmental Protection

In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the local Air Pollution Control District and regional jurisdiction. Notify Contracting Officer of any paint specified herein which fails to conform.

1.5.2 Lead Content

Do not use coatings having a lead content over 0.06 percent by weight of

nonvolatile content.

1.5.3 Chromate Content

Do not use coatings containing zinc-chromate or strontium-chromate.

1.5.4 Asbestos Content

Materials shall not contain asbestos.

1.5.5 Mercury Content

Materials shall not contain mercury or mercury compounds.

1.5.6 Silica

Abrasive blast media shall not contain free crystalline silica.

1.5.7 Human Carcinogens

Materials shall not contain ACGIH 0100 confirmed human carcinogens (A1) or suspected human carcinogens (A2).

1.6 PACKAGING, LABELING, AND STORAGE

Paints shall be in sealed containers that legibly show the contract specification number, designation name, formula or specification number, batch number, color, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name and address of manufacturer. Pigmented paints shall be furnished in containers not larger than 5 gallons. Paints and thinners shall be stored in accordance with the manufacturer's written directions, and as a minimum, stored off the ground, under cover, with sufficient ventilation to prevent the buildup of flammable vapors, and at temperatures between 40 to 95 degrees F. Do not store paint, polyurethane, varnish, or wood stain products with materials that have a high capacity to adsorb VOC emissions. Do not store paint, polyurethane, varnish, or wood stain products in occupied spaces.

1.7 SAFETY AND HEALTH

Apply coating materials using safety methods and equipment in accordance with the following:

Work shall comply with applicable Federal, State, and local laws and regulations, and with the ACCIDENT PREVENTION PLAN, including the Activity Hazard Analysis as specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES and in Appendix A of EM 385-1-1. The Activity Hazard Analysis shall include analyses of the potential impact of painting operations on painting personnel and on others involved in and adjacent to the work zone.

1.7.1 Safety Methods Used During Coating Application

Comply with the requirements of SSPC PA Guide 3.

1.7.2 Toxic Materials

To protect personnel from overexposure to toxic materials, conform to the

most stringent guidance of:

a. The applicable manufacturer's Material Safety Data Sheets (MSDS) or local regulation.

b. 29 CFR 1910.1000.

c. ACGIH 0100, threshold limit values.

1.8 ENVIRONMENTAL CONDITIONS

Comply, at minimum, with manufacturer recommendations for space ventilation during and after installation.

1.8.1 Coatings

Do not apply coating when air or substrate conditions are:

a. Less than 5 degrees F above dew point;

b. Below 50 degrees F or over 95 degrees F, unless specifically pre-approved by the Contracting Officer and the product manufacturer. Under no circumstances shall application conditions exceed manufacturer recommendations.

1.8.2 Post-Application

Vacate space for as long as possible after application. Wait a minimum of 48 hours before occupying freshly painted rooms. Maintain one of the following ventilation conditions during the curing period, or for 72 hours after application:

a. Supply 100 percent outside air 24 hours a day.

b. Supply airflow at a rate of 6 air changes per hour, when outside temperatures are between 55 degrees F and 85 degrees F and humidity is between 30 percent and 60 percent.

c. Supply airflow at a rate of 1.5 air changes per hour, when outside air conditions are not within the range stipulated above.

1.9 SCHEDULING

Allow paint, polyurethane, varnish, and wood stain installations to cure prior to the installation of materials that adsorb VOCs.

1.10 COLOR SELECTION

Colors of finish coats shall be as indicated or specified. Where not indicated or specified, colors shall be selected by the Contracting Officer. Manufacturers' names and color identification are used for the purpose of color identification only. Named products are acceptable for use only if they conform to specified requirements. Products of other manufacturers are acceptable if the colors approximate colors indicated and the product conforms to specified requirements.

Tint each coat progressively darker to enable confirmation of the number of coats.

Color, texture, and pattern of wall coating systems shall be as indicated.

1.11 LOCATION AND SURFACE TYPE TO BE PAINTED

1.11.1 Painting Included

Where a space or surface is indicated to be painted, include the following unless indicated otherwise.

a. Surfaces behind portable objects and surface mounted articles readily detachable by removal of fasteners, such as screws and bolts.

b. New factory finished surfaces that require identification or color coding and factory finished surfaces that are damaged during performance of the work.

c. Existing coated surfaces that are damaged during performance of the work.

1.11.1.1 Exterior Painting

Includes new surfacesandexisting uncoated surfaces of the equipment and appurtenances. Also included are existing coated surfaces made bare by cleaning operations.

1.11.1.2 Interior Painting

Includes new surfaces and existing uncoated surfaces of the equipment and appurtenances as indicated and existing coated surfaces made bare by cleaning operations. Where a space or surface is indicated to be painted, include the following items, unless indicated otherwise.

a. Exposed columns, girders, beams, joists, and metal deck; and

b. Other contiguous surfaces.

1.11.2 Painting Excluded

Do not paint the following unless indicated otherwise.

a. Surfaces concealed and made inaccessible by panelboards, fixed ductwork, machinery, and equipment fixed in place.

b. Surfaces in concealed spaces. Concealed spaces are defined as enclosed spaces above suspended ceilings, furred spaces, attic spaces, crawl spaces, elevator shafts and chases.

c. Steel to be embedded in concrete.

d. Copper, stainless steel, aluminum, brass, and lead except existing coated surfaces.

e. Hardware, fittings, and other factory finished items.

1.11.3 Mechanical and Electrical Painting

Includes field coating of new and existing uncoated surfaces.

a. Where a space or surface is indicated to be painted, include the

following items unless indicated otherwise.

(1) Exposed piping, conduit, and ductwork;

(2) Supports and hangers;

(3) Miscellaneous metalwork and insulation coverings.

b. Do not paint the following, unless indicated otherwise:

(1) New zinc or chromate-coated, aluminum, and copper surfaces under insulation

1.11.4 MISCELLANEOUS PAINTING

Lettering

Lettering shall be provided as scheduled on the drawings, shall be block type, and shall be black enamel . Samples shall be approved before application.

1.11.5 Definitions and Abbreviations

1.11.5.1 Qualification Testing

Qualification testing is the performance of all test requirements listed in the product specification. This testing is accomplished by MPI to qualify each product for the MPI Approved Product List, and may also be accomplished by Contractor's third party testing lab if an alternative to Batch Quality Conformance Testing by MPI is desired.

1.11.5.2 Batch Quality Conformance Testing

Batch quality conformance testing determines that the product provided is the same as the product qualified to the appropriate product specification. This testing shall only be accomplished by MPI testing lab.

1.11.5.3 Coating

A film or thin layer applied to a base material called a substrate. A coating may be a metal, alloy, paint, or solid/liquid suspensions on various substrates (metals, plastics, wood, paper, leather, cloth, etc.). They may be applied by electrolysis, vapor deposition, vacuum, or mechanical means such as brushing, spraying, calendaring, and roller coating. A coating may be applied for aesthetic or protective purposes or both. The term "coating" as used herein includes emulsions, enamels, stains, varnishes, sealers, epoxies, and other coatings, whether used as primer, intermediate, or finish coat. The terms paint and coating are used interchangeably.

1.11.5.4 DFT or dft

Dry film thickness, the film thickness of the fully cured, dry paint or coating.

1.11.5.5 DSD

Degree of Surface Degradation, the MPI system of defining degree of surface degradation. Five (5) levels are generically defined under the Assessment

sections in the MPI Maintenance Repainting Manual.

1.11.5.6 EPP

Environmentally Preferred Products, a standard for determining environmental preferability in support of Executive Order 13101.

1.11.5.7 EXT

MPI short term designation for an exterior coating system.

1.11.5.8 INT

MPI short term designation for an interior coating system.

1.11.5.9 micron / microns

The metric measurement for 0.001 mm or one/one-thousandth of a millimeter.

1.11.5.10 mil / mils

The English measurement for 0.001 in or one/one-thousandth of an inch, equal to 25.4 microns or 0.0254 mm.

1.11.5.11 mm

The metric measurement for millimeter, 0.001 meter or one/one-thousandth of a meter.

1.11.5.12 MPI Gloss Levels

MPI system of defining gloss. Seven (7) gloss levels (G1 to G7) are generically defined under the Evaluation sections of the MPI Manuals. Traditionally, Flat refers to G1/G2, Eggshell refers to G3, Semigloss refers to G5, and Gloss refers to G6.

Gloss levels are defined by MPI as follows:

Gloss Level	Description	Units at 60 degrees	Units at 85 degrees
G1	Matte or Flat	0 to 5	10 max
G2	Velvet	0 to 10	10 to 35
G3	Eggshell	10 to 25	10 to 35
G4	Satin	20 to 35	35 min
G5	Semi-Gloss	35 to 70	
G6	Gloss	70 to 85	
G7	High Gloss		

Gloss is tested in accordance with ASTM D523. Historically, the Government has used Flat (G1 / G2), Eggshell (G3), Semi-Gloss (G5), and Gloss (G6).

1.11.5.13 MPI System Number

The MPI coating system number in each Division found in either the MPI Architectural Painting Specification Manual or the Maintenance Repainting Manual and defined as an exterior (EXT/REX) or interior system (INT/RIN). The Division number follows the CSI Master Format.

1.11.5.14 Paint

See Coating definition.

1.11.5.15 REX

MPI short term designation for an exterior coating system used in repainting projects or over existing coating systems.

1.11.5.16 RIN

MPI short term designation for an interior coating system used in repainting projects or over existing coating systems.

PART 2 PRODUCTS

2.1 MATERIALS

Conform to the coating specifications and standards referenced in PART 3. Submit manufacturer's technical data sheets for specified coatings and solvents. Comply with applicable regulations regarding toxic and hazardous materials.

PART 3 EXECUTION

3.1 PROTECTION OF AREAS AND SPACES NOT TO BE PAINTED

Prior to surface preparation and coating applications, remove, mask, or otherwise protect, hardware, hardware accessories, machined surfaces, radiator covers, plates, lighting fixtures, public and private property, and other such items not to be coated that are in contact with surfaces to be coated. Following completion of painting, workmen skilled in the trades involved shall reinstall removed items. Restore surfaces contaminated by coating materials, to original condition and repair damaged items.

3.2 SURFACE PREPARATION

Remove dirt, splinters, loose particles, grease, oil, disintegrated coatings, and other foreign matter and substances deleterious to coating performance as specified for each substrate before application of paint or surface treatments. Oil and grease shall be removed prior to mechanical cleaning. Cleaning shall be programmed so that dust and other contaminants will not fall on wet, newly painted surfaces. Exposed ferrous metals such as nail heads on or in contact with surfaces to be painted with water-thinned paints, shall be spot-primed with a suitable corrosion-inhibitive primer capable of preventing flash rusting and compatible with the coating specified for the adjacent areas.

3.2.1 Existing Coated Surfaces with Minor Defects

Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings. Remove chalking by sanding so that when tested in accordance with ASTM D4214, the chalk rating is not less than 8.

3.3 PREPARATION OF METAL SURFACES

3.3.1 Existing and New Ferrous Surfaces

a. Ferrous Surfaces including Shop-coated Surfaces and Small Areas That Contain Rust, Mill Scale and Other Foreign Substances: Detergent wash in accordance with SSPC SP 1 to remove oil and grease. Where shop coat is missing or damaged, clean according to SSPC SP 2 or SSPC SP 3, as applicable. WJ-4 may be used to remove loose coating and other loose materials. Use inhibitor as recommended by coating manufacturer to prevent premature rusting. Shop-coated ferrous surfaces shall be protected from corrosion by treating and touching up corroded areas immediately upon detection.

b. Surfaces With More Than 20 Percent Rust, Mill Scale, and Other Foreign Substances: Clean entire surface in accordance with SSPC SP 6/NACE No.3.

c. Metal Floor Surfaces to Receive Nonslip Coating: Clean in accordance with SSPC SP 10/NACE No. 2.

3.3.2 Final Ferrous Surface Condition:

For tool cleaned surfaces, the requirements are stated in SSPC SP 2 and SSPC SP 3. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 3.

For abrasive blast cleaned surfaces, the requirements are stated in SSPC 7/NACE No.4, SSPC SP 6/NACE No.3, and SSPC SP 10/NACE No. 2. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 1.

For waterjet cleaned surfaces, the requirements are stated in SSPC SP 12/NACE No.5. As a visual reference, cleaned surfaces shall be similar to photographs in SSPC VIS 4/NACE VIS 7.

3.3.3 Galvanized Surfaces

a. New or Existing Galvanized Surfaces With Only Dirt and Zinc Oxidation Products: Clean with steam or non-alkaline detergent solution in accordance with SSPC SP 1. If the galvanized metal has been passivated or stabilized, the coating shall be completely removed by brush-off abrasive blast. New galvanized steel to be coated shall not be "passivated" or "stabilized" If the absence of hexavalent stain inhibitors is not documented, test as described in ASTM D6386, Appendix X2, and remove by one of the methods described therein.

b. Galvanized with Slight Coating Deterioration or with Little or No Rusting: Water jetting to SSPC SP 12/NACE No.5 WJ3 to remove loose coating from surfaces with less than 20 percent coating deterioration and no blistering, peeling, or cracking. Use inhibitor as recommended by the coating manufacturer to prevent rusting.

c. Galvanized With Severe Deteriorated Coating or Severe Rusting: Spot abrasive blast rusted areas as described for steel in SSPC SP 6/NACE No.3, and waterjet to SSPC SP 12/NACE No.5, WJ3 to remove existing coating.

3.3.4 Non-Ferrous Metallic Surfaces

Aluminum and aluminum-alloy, lead, copper, and other nonferrous metal surfaces.

Surface Cleaning: Solvent clean in accordance with SSPC SP 1 and wash with mild non-alkaline detergent to remove dirt and water soluble contaminants.

3.3.5 Terne-Coated Metal Surfaces

Solvent clean surfaces with mineral spirits, ASTM D235. Wipe dry with clean, dry cloths.

3.3.6 Existing Surfaces with a Bituminous or Mastic-Type Coating

Remove chalk, mildew, and other loose material by washing with a solution of 1/2 cup trisodium phosphate, 1/4 cup household detergent, one quart 5 percent sodium hypochlorite solution and 3 quarts of warm water.

3.4 PREPARATION OF CONCRETE AND CEMENTITIOUS SURFACE

3.4.1 Concrete and Masonry

a. Curing: Concrete, stucco and masonry surfaces shall be allowed to cure at least 30 days before painting, except concrete slab on grade, which shall be allowed to cure 90 days before painting.

b. Surface Cleaning: Remove the following deleterious substances.

(1) Dirt, Grease, and Oil: Wash new surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cuphousehold detergent, and 4 quarts of warm water. Then rinse thoroughly with fresh water. For large areas, water blasting may be used.

(2) Fungus and Mold: Wash surfaces with a solution composed of 1/2 cup trisodium phosphate, 1/4 cup household detergent, 1 quart 5 percent sodium hypochlorite solution and 3 quarts of warm water. Rinse thoroughly with fresh water.

(3) Paint and Loose Particles: Remove by wire brushing.

(4) Efflorescence: Remove by scraping or wire brushing followed by washing with a 5 to 10 percent by weight aqueous solution of hydrochloric (muriatic) acid. Do not allow acid to remain on the surface for more than five minutes before rinsing with fresh water. Do not acid clean more than 4 square feet of surface, per workman, at one time.

(5) Removal of Existing Coatings: For surfaces to receive textured coating MPI 42, remove existing coatings including soundly adhered coatings if recommended by textured coating manufacturer.

c. Cosmetic Repair of Minor Defects: Repair or fill mortar joints and minor defects, including but not limited to spalls, in accordance with manufacturer's recommendations and prior to coating application.

d. Allowable Moisture Content: Latex coatings may be applied to damp surfaces, but not to surfaces with droplets of water. Do not apply epoxies to damp vertical surfaces as determined by ASTM D4263 or

horizontal surfaces that exceed 3 lbs of moisture per 1000 square feet in 24 hours as determined by ASTM F1869. In all cases follow manufacturers recommendations. Allow surfaces to cure a minimum of 30 days before painting.

3.5 APPLICATION

3.5.1 Coating Application

Painting practices shall comply with applicable federal, state and local laws enacted to insure compliance with Federal Clean Air Standards. Apply coating materials in accordance with SSPC PA 1. SSPC PA 1 methods are applicable to all substrates, except as modified herein.

At the time of application, paint shall show no signs of deterioration. Uniform suspension of pigments shall be maintained during application.

Unless otherwise specified or recommended by the paint manufacturer, paint may be applied by brush, roller, or spray. Use trigger operated spray nozzles for water hoses. Rollers for applying paints and enamels shall be of a type designed for the coating to be applied and the surface to be coated. Wear protective clothing and respirators when applying oil-based paints or using spray equipment with any paints.

Paints, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.

Thoroughly work coating materials into joints, crevices, and open spaces. Special attention shall be given to insure that all edges, corners, crevices, welds, and rivets receive a film thickness equal to that of adjacent painted surfaces.

Each coat of paint shall be applied so dry film shall be of uniform thickness and free from runs, drops, ridges, waves, pinholes or other voids, laps, brush marks, and variations in color, texture, and finish. Hiding shall be complete.

Touch up damaged coatings before applying subsequent coats.

a. Drying Time: Allow time between coats, as recommended by the coating manufacturer, to permit thorough drying, but not to present topcoat adhesion problems. Provide each coat in specified condition to receive next coat.

b. Primers, and Intermediate Coats: Do not allow primers or intermediate coats to dry more than 30 days, or longer than recommended by manufacturer, before applying subsequent coats. Follow manufacturer's recommendations for surface preparation if primers or intermediate coats are allowed to dry longer than recommended by manufacturers of subsequent coatings. Each coat shall cover surface of preceding coat or surface completely, and there shall be a visually perceptible difference in shades of successive coats.

c. Finished Surfaces: Provide finished surfaces free from runs, drops, ridges, waves, laps, brush marks, and variations in colors.

d. Thermosetting Paints: Topcoats over thermosetting paints (epoxies and urethanes) should be applied within the overcoating window recommended by the manufacturer.

e. Floors: For nonslip surfacing on level floors, as the intermediate coat is applied, cover wet surface completely with almandite garnet, Grit No. 36, with maximum passing U.S. Standard Sieve No. 40 less than 0.5 percent. When the coating is dry, use a soft bristle broom to sweep up excess grit, which may be reused, and vacuum up remaining residue before application of the topcoat.

3.5.2 Mixing and Thinning of Paints

Reduce paints to proper consistency by adding fresh paint, except when thinning is mandatory to suit surface, temperature, weather conditions, application methods, or for the type of paint being used. Obtain written permission from the Contracting Officer to use thinners. The written permission shall include quantities and types of thinners to use.

When thinning is allowed, paints shall be thinned immediately prior to application with not more than 1 pint of suitable thinner per gallon. The use of thinner shall not relieve the Contractor from obtaining complete hiding, full film thickness, or required gloss. Thinning shall not cause the paint to exceed limits on volatile organic compounds. Paints of different manufacturers shall not be mixed.

3.5.3 Two-Component Systems

Two-component systems shall be mixed in accordance with manufacturer's instructions. Any thinning of the first coat to ensure proper penetration and sealing shall be as recommended by the manufacturer for each type of substrate.

3.5.4 Coating Systems

a. Systems by Substrates: Apply coatings that conform to the respective specifications listed in the following Tables:

Table

Division 3. Exterior Concrete Paint Table
Division 4. Exterior Concrete Masonry Units Paint Table
Division 5. Exterior Metal, Ferrous and Non-Ferrous Paint Table
Division 6. Exterior Wood; Dressed Lumber, Paneling, Decking, Shingles Paint Table
Division 9: Exterior Stucco Paint Table
Division 10. Exterior Cloth Coverings and Bituminous Coated Surfaces Paint Table

Division 3. Interior Concrete Paint Table
Division 4. Interior Concrete Masonry Units Paint Table
Division 5. Interior Metal, Ferrous and Non-Ferrous Paint Table
Division 6. Interior Wood Paint Table
Division 9: Interior Plaster, Gypsum Board, Textured Surfaces Paint Table

b. Minimum Dry Film Thickness (DFT): Apply paints, primers, varnishes, enamels, undercoats, and other coatings to a minimum dry film thickness of 1.5 mil each coat unless specified otherwise in the Tables. Coating thickness where specified, refers to the minimum dry film thickness.

c. Coatings for Surfaces Not Specified Otherwise: Coat surfaces which

have not been specified, the same as surfaces having similar conditions of exposure.

d. Existing Surfaces Damaged During Performance of the Work, Including New Patches In Existing Surfaces: Coat surfaces with the following:

(1) One coat of primer.

(2) One coat of undercoat or intermediate coat.

(3) One topcoat to match adjacent surfaces.

e. Existing Coated Surfaces To Be Painted: Apply coatings conforming to the respective specifications listed in the Tables herein, except that pretreatments, sealers and fillers need not be provided on surfaces where existing coatings are soundly adhered and in good condition. Do not omit undercoats or primers.

3.6 COATING SYSTEMS FOR METAL

Apply coatings of Tables in Division 5 for Exterior and Interior.

a. Apply specified ferrous metal primer on the same day that surface is cleaned, to surfaces that meet all specified surface preparation requirements at time of application.

b. Inaccessible Surfaces: Prior to erection, use one coat of specified primer on metal surfaces that will be inaccessible after erection.

c. Shop-primed Surfaces: Touch up exposed substrates and damaged coatings to protect from rusting prior to applying field primer.

d. Surface Previously Coated with Epoxy or Urethane: Apply MPI 101, 1.5 mils DFT immediately prior to application of epoxy or urethane coatings.

e. Pipes and Tubing: The semitransparent film applied to some pipes and tubing at the mill is not to be considered a shop coat, but shall be overcoated with the specified ferrous-metal primer prior to application of finish coats.

f. Exposed Nails, Screws, Fasteners, and Miscellaneous Ferrous Surfaces. On surfaces to be coated with water thinned coatings, spot prime exposed nails and other ferrous metal with latex primer MPI 107.

3.7 COATING SYSTEMS FOR CONCRETE AND CEMENTITIOUS SUBSTRATES

Apply coatings of Tables in Division 3, 4 and 9 for Exterior and Interior.

3.8 PIPING IDENTIFICATION

Piping Identification, Including Surfaces In Concealed Spaces: Provide in accordance with ASME A13.1. Place stenciling in clearly visible locations. On piping not covered by ASME A13.1, stencil approved names or code letters, in letters a minimum of 1/2 inch high for piping and a minimum of 2 inches high elsewhere. Stencil arrow-shaped markings on piping to indicate direction of flow using black stencil paint.

3.9 INSPECTION AND ACCEPTANCE

In addition to meeting previously specified requirements, demonstrate mobility of moving components, including swinging and sliding doors, cabinets, and windows with operable sash, for inspection by the Contracting Officer. Perform this demonstration after appropriate curing and drying times of coatings have elapsed and prior to invoicing for final payment.

3.10 WASTE MANAGEMENT

As specified in the Waste Management Plan and as follows. Do not use kerosene or any such organic solvents to clean up water based paints. Properly dispose of paints or solvents in designated containers. Close and seal partially used containers of paint to maintain quality as necessary for reuse. Store in protected, well-ventilated, fire-safe area at moderate temperature. Place materials defined as hazardous or toxic waste in designated containers. Set aside extra paint for future color matches or reuse by the Government.

3.11 PAINT TABLES

All DFT's are minimum values. Use only materials meeting BAAQMD requirements and having a minimum MPI "Environmentally Friendly" E1 rating based on VOC (EPA Method 24) content levels Acceptable products are listed in the MPI Green Approved Products List, available at http://www.specifygreen.com/APL/ProductIdxByMPInum.asp.

3.11.1 EXTERIOR PAINT TABLES

DIVISION 5: EXTERIOR METAL, FERROUS AND NON-FERROUS PAINT TABLE

STEEL / FERROUS SURFACES

A. New Steel that has been hand or power tool cleaned to SSPC SP 2 or SSPC SP 3
1. Alkyd
New; MPI EXT 5.1Q-G5 (Semigloss) / Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 23	MPI 94	MPI 94

System DFT: 5.25 mils

B. New Steel that has been blast-cleaned to SSPC SP 6/NACE No.3:
1. Alkyd
New; MPI EXT 5.1D-G5 (Semigloss) / Existing; MPI REX 5.1D-G5

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

System DFT: 5.25 mils

C. Existing steel that has been spot-blasted to SSPC SP 6/NACE No.3:
1. Surface previously coated with alkyd or latex:
Waterborne Light Industrial Coating
MPI REX 5.1C-G5 (Semigloss)

Spot Primer:	Intermediate:	Topcoat:
MPI 79	MPI 163	MPI 163

System DFT: 5 mils

2. Surface previously coated with epoxy:
Pigmented Polyurethane
b. MPI REX 5.1H-G6 (Gloss)

STEEL / FERROUS SURFACES

Spot Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 72

System DFT: 8.5 mils

D. Metal floors (non-shop-primed surfaces or non-slip deck surfaces) with non-skid additive (NSA), load at manufacturer's recommendations.:

1. Alkyd Floor Enamel
   MPI EXT 5.1S-G6 (Gloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 27	MPI 27 (plus NSA)

System DFT: 5.25 mils

EXTERIOR GALVANIZED SURFACES

E. New Galvanized surfaces:

1. Waterborne Primer / Latex
   MPI EXT 5.3H-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 134	MPI 11	MPI 11

System DFT: 4.5 mils

F. Galvanized surfaces with slight coating deterioration; little or no rusting:

1. Waterborne Light Industrial Coating
   MPI REX 5.3J-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 134	N/A	MPI 163

System DFT: 4.5 mils

G. Galvanized surfaces with severely deteriorated coating or rusting:

1. Pigmented Polyurethane
   MPI REX 5.3K-G6(Gloss)

Primer:	Intermediate:	Topcoat:
MPI 101	MPI 108	MPI 72

System DFT: 5 mils

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)

H. Aluminum, aluminum alloy and other miscellaneous non-ferrous metal items not otherwise specified except hot metal surfaces, roof surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd
   MPI EXT 5.4F-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 95	MPI 94	MPI 94

System DFT: 5 mils

I. Existing roof surfaces previously coated:

1. Aluminum Paint
   MPI REX 10.2D

Primer:	Intermediate:	Topcoat:
MPI 107	MPI 1	MPI 1

System DFT: 3.5 mils

J. Surfaces adjacent to painted surfacesand miscellaneous metal items not otherwise specified except floors, hot metal surfaces, and new prefinished equipment. Match surrounding finish:

1. Alkyd

EXTERIOR SURFACES, OTHER METALS (NON-FERROUS)
MPI EXT 5.1D-G5 (Semigloss)

Primer:	Intermediate:	Topcoat:
MPI 79	MPI 94	MPI 94

System DFT: 5.25 mils

K. Hot metal surfaces including smokestacks subject to temperatures up to 400 degrees F:

1. Heat Resistant Enamel
MPI EXT 5.2A

Primer:	Intermediate:	Topcoat:
MPI 21	Surface preparation and number of coats per manufacturer's instructions.	

System DFT: Per Manufacturer

L. Ferrous metal subject to high temperature, up to 750 degrees F:

1. Inorganic Zinc Rich Coating
MPI EXT 5.2C

Primer:	Intermediate:	Topcoat:
MPI 19	Surface preparation and number of coats per manufacturer's instructions.	

System DFT: Per Manufacturer

2. Heat Resistant Aluminum Enamel
MPI EXT 5.2B (Aluminum Finish)

Primer:	Intermediate:	Topcoat:
MPI 2	Surface preparation and number of coats per manufacturer's instructions.	

System DFT: Per Manufacturer

-- End of Section --

SECTION 10 14 01

EXTERIOR SIGNAGE
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A449	(2010) Standard Specification for Hex Cap Screws, Bolts, and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM B209	(2010) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

1.2 SUBMITTALS

Submit the following in accordance with Seciton 01330 Submittal Procedures.

1.2.1 SD-02, Drawings

a. Warning sign; G
One shop drawing of sign indicated on the Drawings for approval from the Contracting Officer.

PART 2 PRODUCTS

2.1 SIGNS

2.1.1 Substrate

Conform to ASTM B209 for aluminum sheet plate requirements. Provide caution of warning signs from aluminum plate witht eh thickness of at least 1.3 mm. Appropriate sign mounting hardware shall be fastened to back of substrate by rivets or welding to allow mounting of sign on post.

2.1.2 Paint

Use the opaque glossy sample colors as specified in Table 1 of Fundamental Specificaiton of Safety Colors for Commercial Item Description, Standard Source "C" ANS 253.1-1967. Unless directed by the Contracting Officer, standard color of the background shall be yellow with black letters.

2.1.3 Posts

Signposts shall be of the U-channel type, 3 lbs/ft nominal, fabricated of hot rolled carbon steel bars. Finish shall be galvanized according to ASTM A123/A123M. Posts shall have a uniform hole pattern.

The post shall consist of two parts, a signpost and a base post. The base post shall be identical to the signpost except having a pointed and sharpened-edge end for post driving. Holes between the base post and signpost shall be of identical pattern.

2.1.4 Anchors

Metal fasteners shall conform to ASTM A307. All other hardware shall be Society of Automotive Engineers (SAE) Grade 5 or ASTM A449 hardness minimum. Threaded components shall use either nyon inserts of a chemical thread lock compound to prevent self-looening. Where appropriate sign may be fastened to fencing based on approval from the Contracting Officer.

2.1.5 Signs

Provide signs around the boundary of the site according to the Drawings.

Sign shall be furnished with rounded or blunt corners and shall be free from sharp edges, burrs, splinters, or other sharp projections. The ends or heads of bolts or other fastening devices shall be located in such a way they do not constitute a hazard.

The wording of the sign should be easy to read, concise, and as indicated on the Drawings.

PART 3 EXECUTION

3.1 INSTALLATION

Embedded metals shall be given a primer coat of the required paint on all surfaces prior to installation. Install posts to dimensions as designated on the Drawings. Signs can be attached to fence at locations designated on the Drawings using appropriate anchors. Do not damage coating before or during installation. .

-- End of Section --

SECTION 11000

LANDFILL GAS CONTROL SYSTEM

PART 1. GENERAL

1.01 SUMMARY:

A. Provide and install all landfill gas (LFG) control system equipment as shown on the Contract Drawings, as specified herein, and as needed for a complete and properly operating LFG control system facility including, but not limited to, the following:

1. Enclosed LFG flare with automated ignition, flame safety and temperature controls and data recording;

2. LFG blower skid with two 100-percent capacity blowers, variable frequency motor drives, and automated flow and vacuum controls for diversion of LFG to either the flare or treatment system;

3. Condensate sump and pump system with automated pump, level controls and level alarms.

B. Each process unit shall include its own piping and controls, completely prefabricated in a self-contained package.

C. The Contractor shall furnish all required connections of mechanical and power to each process unit.

D. The Contractor shall furnish all required field piping and wiring connections between the units and utility services.

E. The LFG control system shall provide programmable logic controllers (PLCs) and all required programming for automated, unsupervised, fail-safe operation of the LFG blowers and flares.

F. The LFG control system shall provide local digital recorder for blower and flare parameters for operations and compliance reporting. The LFG control system shall provide telemetry equipment and service (cellular VPN) for remote viewing and downloading of operating and compliance data from the recorder.

1.02 QUALITY ASSURANCE

A. Specification Division 11 is intended to be performance-based. As such, the Contractor is responsible for providing a fully-integrated LFG conveyance, control and treatment system meeting the functional requirements described herein. The Contractor shall name in their bid the manufacturers of the major equipment packages and the system integrator who they will use. These suppliers must submit evidence of extensive training and experience in engineering, manufacturing and integrating automated LFG control packages, and be completely familiar with the specified requirements and the methods needed for proper completion of the Work. ACCEPTANCE CRITERIA TO BE ADDED

B. Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the Work.

C. If the flare and blower skid are not standard designs using proven automation control programs (DETERMINATION CRITERIA TO BE ADDED) by the same manufacturer, the Contractor shall provide: a third-party LFG controls integrator to coordinate between the equipment manufacturers for the successful final design, fabrication and operation of the complete LFG control system under the Owner's existing supervisory controls.

1. The system integrator shall confirm before and during start-up that the manufacturer's designs and the completed system meet all functional, safety and compliance requirements for the project.

2. Prefabricated panels, electromechanical equipment, wiring and electrical components shall be UL inspected and certified before delivery to site.

1.03 RELATED SECTIONS

A. Section 01010 - Summary of Work

B. Section 01300 – Contractor Submittals

C. Section 01630 - Product Options and Substitutions

D. Section 01720 - Project Record Documents

E. Section 01730 - Installation, Operation and Maintenance Manuals

F. Section 02200 – Earthwork

G. Section 03300 - Cast-In-Place Concrete

H. Section 09910 - Painting

I. Section 11100 – Enclosed LFG Flare

J. Section 11200 – LFG Blower Skid

K. Section 11300 – LFG Condensate Sump Pump System

L. Section 15480 – LFG Piping

M. Section 16010 - Basic Electrical Requirements

N. Section 16900 – Equipment Control Signals

1.04 REFERENCES

A. The equipment and installations provided in accordance with these Specifications shall comply with the requirements of all applicable regulations and permits including but not limited to:

1. Bay Area Air Quality Management District (BAAQMD) Regulation 8, Rule 34 - Solid Waste Disposal Sites

2. Code of California Regulations, Title 27, Subchapter 4, Article 6, Sections 20919 to 20939, Gas Monitoring and Control at Active and Closed Disposal Sites.

B. Applicable air quality compliance requirements are incorporated herein.

1.05 SYSTEM DESCRIPTION

A. The LFG control system to be provided shall extract LFG from the landfill waste by vacuum. The LFG shall be drawn from a network of LFG extraction wells and conveyed through collection piping by vacuum supplied by the LFG blower package specified herein. The blowers shall convey the LFG through adsorption pretreatment vessels to the enclosed flare package.

B. The LFG control system shall operate either continuously or intermittently, depending on the availability of LFG from the landfill. Raw LFG shall not be emitted to the atmosphere, except for very short periods during system start-up and shutdown.

C. The LFG flare package shall automatically receive and destroy all LFG (within the specified design capacity range) extracted by the LFG blower package. Flare and blower emissions shall meet all applicable regulatory requirements.

D. The flare and blower package controls shall be fully integrated within a single programmable logic controller (PLC). The control system shall provide automated system operation as the default and fail-safe manual override for back-up operation in the case of PLC malfunction.

E. The control system key operating parameter data shall be accessible for remote viewing and downloading.

1.06 LFG SYSTEM CONTROL LOGIC

A. The system control logic specified herein is conceptual only and performance-based. The equipment manufacturers shall provide integrated system controls and automation for the equipment provided to meet the design and operational intents of the Owner/Engineer and of these specifications. The Owner/Engineer understands that the selected equipment manufacturers will be the most qualified agents to perform detailed controls design for their proposed equipment. Thus final equipment fabrication, construction and operational integration will be based on detailed manufacturer shop drawings and control schemes to be submitted by the Contractor and reviewed and approved by the Navy. As such the Contractor and equipment manufacturers will ultimately be responsible for the proper control and operation of the integrated systems as installed.

B. The basic functions required of the LFG control system are as follows:

3. The LFG blower skid will operate continuously or intermittently to extract the available LFG from the landfill and convey it through the pretreatment vessels and to the flare.

4. Intermittent operation will be controlled by a user-programmable timer.

5. The LFG blower and flare shall start-up automatically for high LFG pressure at the treatment facility inlet.

6. The LFG throughput from the landfill will be maintained at a consistent operator set-point by modulating LFG blower speed by either controlling system inlet vacuum or flow rate.

7. The LFG flare shall be available for operation at all times and must be combusting the LFG whenever it is being extracted.

8. The flare operation shall continue so long as the following conditions are met:

   a. The LFG blower speed in consistently maintained within the manufacturer recommended operating range.

   b. The LFG flare heat loading is within the manufacturer specified flare turn-down range, as indicated by stack temperatures continuously within the allowable temperature set point range.

9. In the event of either site-wide or equipment power service outage:

   a. The flare inlet valve will close to prevent uncontrolled release of LFG.

   b. The blower and flare controls shall automatically re-set to standby conditions upon restoration of power.

   c. The blower and flare shall automatically restart after a user-settable time delay.

   d. The operator may manually initiate blower and flare at any time during the automatic re-start time delay.

C. Normal LFG Flare Operations

1. The normal equilibrium blower operating flow and pressure ranges shall be determined for the expected configuration of control devices (adsorption pretreatment vessels and flare) by the Contractor and vendor technicians during the initial system start-up operations.

2. A normal minimum blower discharge pressure shall be established for the equilibrium LFG flow using the manual

throttling valves.

D. LFG Blower Operations

1. Since the LFG blower is intended to operate continuously, the LFG blower start sequence shall be operator-initiated after remediating the cause of any non-routine shut-down.

2. The LFG blower shall shutdown automatically based on any one of the following conditions:

   a. Blower LFG discharge flow-rate cannot attain operating speed set-point within normal operating ranges;

   b. Blower motor overload;

   c. High LFG discharge temperature or blower bearing temperature;

   d. High blower vibration.

3. All non-routine blower shut-downs shall actuate both local and remote alarm notifications.

4. The blower speed setpoints shall be operator-adjustable and the actual operating parameters (LFG flows, vacuums, pressures and temperatures) shall be available in real time and continuously recorded for compliance monitoring and diagnostics.

E. Condensate generated by the cooling of the LFG in the collection piping, knock-out pot, adsorption pretreatment vessels and blower/flare piping will be gravity drained via piping to be provided with the blower skid into a below-ground condensate sump to be procured by the Contractor and installed at the treatment facility. The condensate sump(s) shall discharge to the condensate storage tank.

1. The LFG blower system shall shut-down and transmit a remote alarm signal on a high liquid level in the condensate knock-out pot or condensate storage tank.

2. A pump level control sensor and control system provided with the condensate sump and storage tank shall provide the following basic functions:

   a. Pump-off at normal low level;

   b. Pump-on at normal start level;

   c. Remote alarm on high level.

F. The LFG system control logic shall conform to all applicable safety, air quality, building and other regulatory requirements.

1.07 SUBMITTALS

C. Product Data: Within 15 calendar days after the Contractor has received the Owner's Notice to Proceed, submit five copies of:

1. Listing of materials proposed to be provided under this Section;

2. Final list of manufacturers/suppliers of the major equipment packages to be provided under this Section;

1. For major equipment packages by different manufacturers, provide statement of qualifications and experience for proposed system integrations consultant;

2. Manufacturers’ specifications and other data needed to prove compliance of materials with the specified requirements;

3. The flare manufacturer shall provide a written guarantee and supporting source test data for similar units to demonstrate that the emissions of the proposed combustion process design will meet all applicable air quality standards (methane and non-methane organic compound [NMOC] destruction efficiency and criteria pollutant emissions).

4. List of client references for similar equipment packages (with operators’ contact information) successfully installed and operated within the past three years. References may be contacted by the Owner to verify overall acceptable equipment and controls performance.

D. Shop Drawing: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:

1. Shop Drawings in sufficient detail showing the fabrication, installation, anchoring, and interfacing of the work of this Section with the work of other sections.

2. Detailed descriptions of all automated blower and flare control logic and communication programs.

3. Manufacturer's recommended installation instructions which, when approved by the Owner/Engineer, will become the basis for accepting or rejecting actual installation procedures used in the work.

E. Upon approval of the above submittals and all equipment provided, and as a condition of final project acceptance, deliver to the Owner three complete copies of O&M manuals and as-constructed Record Drawings.

1. The O&M manual shall contain a reference copy of the control logic program(s) and approved final operational settings, such that a controls engineer knowledgeable in the software and combustion applications can troubleshoot

and diagnose operational malfunctions without the assistance of the manufacturer.

2. Provide three CD/DVD copies of all user-software required to access, diagnose, maintain and repair all control programs.

3. Provide three sets of all communication cables required to access, diagnose, maintain and repair all microprocessor-based components.

F. Upon successful completion of start-up, prepare and submit flare source test plan, perform testing, and prepare and submit final report in accordance with Part 3.03 of this Specification Section and BAAQMD requirements.

1. The source emission testing lab shall be certified by the California Air Resources Board (CARB) for the standard test methods for the applicable emission parameters.

1.08 REGULATORY REQUIREMENTS

1. Without additional cost to the Owner, the Contractor is to provide such other labor and materials as are required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for in these Contract Documents.

a. Prefabricated panels, electromechanical equipment, wiring and electrical components shall be UL inspected and certified before delivery to site.

b. Contractor shall provide third-party source emission performance testing to demonstrate initial compliance of flare with applicable emission standards.

2. In addition to complying with the specified emission requirements, comply with applicable regulations of other governmental agencies having jurisdiction.

3. In the event of conflict between or among specified requirements and pertinent regulations, the more stringent requirements will govern unless otherwise approved by the Owner/Engineer.

1.09 DELIVERY, STORAGE AND HANDLING

A. Acceptance at Site

1. The Contractor will be responsible for coordination of delivery, unloading, placement, connection, and construction of all equipment and materials.

2. All materials and equipment provided shall be new.

3. Loading, transporting, unloading, and storage of all

materials and equipment shall be conducted such that they are kept clean and free from damage.

4. The Contractor shall submit certifications of compliance for materials and equipment delivered for the Work. Certificates shall be signed by an authorized representative of the producer or manufacturer and shall state that the equipment or material complies in all respects with the Specifications and accepted submittals. In the case of multiple shipments, each shipment shall be accompanied by a certificate of compliance.

5. Materials and equipment used may be sampled and tested at any time. The fact that material or equipment is used on the basis of a certificate of compliance shall not relieve the Contractor of responsibility for incorporating material or equipment in the work which conforms to the requirements of the contract and any such material or equipment not conforming to such requirements will be subject to rejection by the Owner/Engineer, whether in place or not.

6. The Owner/Engineer reserves the right to refuse permission to use certain materials or equipment.

B. Storage and Protection

1. Provide sheltered, weathertight, or heated weathertight storage as required for materials and equipment subject to weather damage.

2. Provide blocking, platforms, or skids for materials and equipment subject to damage by contact with the ground.

3. Store packaged materials and equipment in their original, unbroken packages or containers.

1.10 WARRANTY

A. Contractor will provide a minimum one-year warranty after the Owner’s final project acceptance on all materials, equipment, and labor furnished for all work performed.

B. The equipment (adsorption pretreatment system, flare and blower) manufacturers’ warranty periods will begin upon the flare passing the emissions source performance test, the Owner’s final project acceptance, or 6 months after the equipment is delivered complete to site, whichever occurs first.

1.11 SYSTEM STARTUP

A. The Contractor shall notify the Owner/Engineer a minimum of 15 days before the intended start-up of the equipment. Notify the BAAQMD in writing a minimum of 7 days before the initial operation of the equipment.

B. The Contractor shall include and coordinate each required LFG equipment manufacturers’ technician to be on site to verify that the

system is properly installed, to configure the control settings and to start the equipment, provide system shakedown operation, and provide a training session for the Navy/Engineer and operator. Technical assistance during start-up and source testing shall be provided at no additional cost to the Owner.

C. The Contractor and equipment manufacturer(s) shall establish and maintain 48 hours of continuous, ARAR-compliant, unsupervised operation before the scheduling the initial source emission performance tests.

D. The equipment manufacturer(s) will not be released from start-up responsibility until Owner-approved compliance set-point levels have been established for all operating parameters and the control system maintains compliant steady-state equipment operation for a minimum of five continuous days.

1.12 MAINTENANCE

A. Contractor shall provide the spare parts required for manufacturer recommended maintenance for the first two years of equipment operation.

B. Major equipment suppliers shall maintain available on-line or telephone technical service assistance to assist with system adjustments, repairs, or maintenance during the warranty period and for one additional year, at no additional cost to the Owner.

PART 1. PRODUCTS

1.01 LANDFILL GAS FLARE

A. Contractor shall provide an enclosed LFG flare that shall automatically receive and destroy all LFG extracted by the LFG blower package. Flare emissions shall meet all applicable regulatory requirements.

1.02 CENTRIFUGAL GAS BLOWERS

A. Contractor shall provide an LFG blower package to maintain a consistent operator-selected extraction flow rate from the LFG well field and to the adsorption pretreatment vessels and the new LFG flare.

B. Contractor and equipment packagers shall fully integrate the controls of the LFG blower package with the LFG flare.

1.03 EQUIPMENT CONTROL

A. The flare and blower equipment control designs manufactured by a single approved supplier shall be integrated and finalized by the supplier to provide comprehensive system monitoring, communication and control under both manual and automated operating modes.

B. If flare and blower equipment are provided by different suppliers, Contractor shall provide a system integrator to coordinate and integrate system controls.

1.04 AUTOMATED CONTROL PROGRAMS

A. In addition to basic operational and safety controls, the equipment manufacturer(s) shall incorporate proven control logic programs into the equipment package to provide and guarantee consistent, safe and reliable automated operation of the equipment under all anticipated LFG flow and pressure conditions.

B. In general, the primary control objectives are:

1. To maintain continuous operational and emissions compliance with all regulatory requirements.

2. To minimize operational disruption and downtime by providing smooth transitions during both scheduled and unplanned demand swings.

3. To minimize disruptive variations and related stresses on both the LFG wellfield and the gas conveyance and combustion equipment.

4. To facilitate ease of troubleshooting, diagnostics and repair for unanticipated operational deviations and shut-downs.

C. The following sections describe general control integration and performance requirements anticipated to be provided with the LFG control system, as a minimum. (The component identification numbers noted below refer to items in Contract Drawings M1 and M2).

D. Manual selection of operating mode for the flare:

1. Standard LFG flare control logic signals permissive for LFG blower package start-up and operation under constant speed or flow-control.

2. In the absence of any component alarms or shut-down conditions, the LFG blower package should continue operating at a pre-established flow rate so long as there is a permissive signal from the flare.

E. For the operating modes above provide automated blower speed control based on the normal LFG consumption of the control devices on-line:

1. The LFG blower control system is initially intended to operate continuously with stoppage only for maintenance or repairs.

a. Provide manual LFG blower start-up and time-delayed re-start attempts.

b. Controls shall allow operator selection of from zero to three automated restart attempts after a power supply transient, non-routine shutdown or unsuccessful start-up attempt.

c. Provide clock-timer program for scheduling intermittent flare start-up operation.

2. The LFG blowers shall operate independently, each with capacity for 100 percent of the maximum system design flow and pressure.

3. The LFG collection wellfield vacuum shall be monitored continuously by a vacuum indicating transmitter (VIT-100) which transmits the signal to the PLC.

a. If the LFG collection wellfield vacuum is sustained significantly lower or higher than the setpoint for an operator-specified interval, an alarm and/or blower shut-down signal shall be initiated, depending on the severity of the deviation.

4. The LFG flows to the flare shall be monitored continuously by a thermal mass flow meter which transmits signals to the PLC.

a. The variable speed blower drives shall be adjusted by the PLC to maintain a consistent total discharge flow to the combustion devices.

b. Alarms and shut-downs shall be activated for total LFG flow values outside the anticipated normal set-point range.

c. The opening and closing of automatic LFG process valves shall be coordinated with blower and treatment device time delays to minimize conflicts or flow transients during system start-ups, shutdowns or load switching.

5. The flare system shall automatically shut-down based on fatal alarm signal inputs to the PLC including: high stack temperature, sustained low stack temperature, high knock-out pot condensate level, high condensate storage tank level, start-up purge failure, auto-valve failure, blower flow stalling or surge, vibration or motor overload, and power failure.

a. Equipment shut-down alarm signals shall relay the appropriate common-failure alarms to operator:

i. Flare package failure

ii. Blower package failure

iii. Condensate system failure

A. Provide an automated flare start-up program on high inlet pressure set point:

1. The flare system is on stand-by ready to start (power on, no flame, controls operational).

2. The automatic LFG process valve (FCV-200) upstream of the flare is closed.

3. The LFG blower discharge line pressure is monitored continuously by a pressure indicating transmitter (PIT-200) upstream of FCV-200 which transmits the signal to the flare controls.

4. If the LFG line pressure is above the high pressure setpoint (HPS) then the flare shall receive a latching start-up signal.

5. The purge air fan (PMP-201) shall ramp up to purge the flare pre-mix chamber of any combustible gases.

6. For pilot ignition: The propane pilot gas valve is opened; the ignition rod shall spark; the pilot ignites; the pilot flame is established at 1,100°F (600°C).

7. Then the automatic LFG process valve is opened. The ignition phase continues until the flame/flue gas temperature has reached 1470°F (800°C). If this temperature is not reached within the preset ignition time period, an alarm signal shall be generated and shutdown shall follow.

8. Once the flame/flue gas temperature is above 1470°F (800°C), the stack temperature shall be controlled to the setpoint for optimal emissions by the temperature control loop (TIC-202). Depending on the flare design and process gas mixture this set point may vary, to minimize exhaust emissions. The final set point shall be determined during the source test emissions monitoring.

B. Automated flare shutdown program on low pressure set point:

1. If the LFG line pressure falls below the low pressure set-point (LPS), then the flare shall receive a latching signal to shutdown.

2. The automatic LFG process valve shall close.

3. Once the LFG main burner is off the purge air fan shall safely purge the stack of any combustible gases.

4. The unit shall then go into safe standby mode, reset the high pressure set point and be ready for a new start-up cycle.

C. Non-fatal alarm notification at the flare local PLC to be provided for detection of low pilot fuel pressure. Non-fatal alarm notification at the LFG blower package local PLC to be provided for high condensate sump level, low blower inlet vacuum.

D. Provide local monitoring and recording for flare operations:

1. Flare operating status (go/no go)

2. Flare inlet valve position (closed/not closed)

3. Flare inlet pressure monitoring and recording

4. Flare instantaneous and totalized flow rate recording.

PART 2. EXECUTION

2.01 EXAMINATION

A. Examine the areas and conditions under which work of this Section shall be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

B. Contractor to pothole, locate and protect all underground facilities potentially impacted by the work in this and other sections. Hand dig or hydrojet in areas of suspected existing pipes, cables or conduits.

2.02 INSTALLATION OF EQUIPMENT

A. Coordinate delivery schedules with Owner for all equipment to be provided by the Contractor.

B. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.

C. Install the work of this Section in strict accordance with the original design, the approved Shop Drawings, pertinent requirements of governmental agencies having jurisdiction, and the manufacturers' recommended installation procedures as approved by the Owner/Engineer, anchoring all components firmly into position for long life under hard use.

1. Crane rigging shall use manufacturer-specified lifting points and spreader bars as required to avoid stressing or damaging equipment components during transport and placement.

D. Upon completion of the installation, make all required arrangements, conduct all required tests, make all required changes, and secure all required inspections and approvals. Contractor to provide flare/blower skid manufacturer's technical representative for a minimum of 3 days of on-site testing, operation, and training, at completion of system installation. Up to five working days additional technician time shall be provided at unit cost to the Owner until all provided systems operate in accordance with the specifications and the manufacturer's submittals. Any additional technician time required for issues outside the control of the Owner shall be considered warranty work at no additional cost to the Owner.

E. When installation of equipment is complete, demonstrate to the

Owner's maintenance personnel that the contents of the operation and maintenance manuals are complete as required under Part 1 above.

2.03 ACCEPTANCE TESTING OF EQUIPMENT

A. Contractor shall retain an independent testing company certified to conduct compliance testing of the operating flare system for performance criteria of these Specifications and the BAAQMD rule requirements. The Owner/Engineer will not accept the flare facility until compliance with the performance standards is verified by this testing in writing. All work and materials (including re-testing) required to correct problems arising from noncompliance (except that due to high fuel sulfur content) shall be performed and provided at no additional expense to the Owner/Engineer.

B. The flare source test and test methods shall comply with the applicable requirements of BAAQMD and as a minimum, shall determine the following:

1. LFG flow rate to the flare;

2. Concentrations of carbon dioxide (CO_2), nitrogen (N_2), oxygen (O_2), total hydrocarbons (THC), methane (CH_4), and total non-methane organic compounds (NMOC) in the LFG;

3. Concentrations of specific listed volatile organic compounds (VOCs) in the LFG, per USEPA Method TO-14 or TO-15;

4. Stack gas flow rate from the flare;

5. NO_x, CO, CO_2, THC, CH_4, NMOC and O_2 in the flare stack gas;

6. The CH_4 and NMOC destruction efficiencies achieved by the flare;

7. The average combustion zone temperature during the test period.

C. Prepare and submit a flare source test plan to the BAAQMD for scheduling and pre-approval at least 14 days in advance of the test date. Prepare and submit the final source test report to the BAAQMD within 45 days of the test date.

END OF SECTION

SECTION 11 10 0

ENCLOSED LANDFILL GAS FLARE

PART 1. GENERAL

1.01 SUMMARY:

A. Provide and install a complete enclosed landfill gas (LFG) flare as shown on the Contract Drawings, as specified herein, and as needed for a complete and properly operating LFG control system including, but not limited to, the following:

1. Low-NOx LFG burner:

2. Enclosed flare stack, propane pilot system, automated ignition

3. User-programmable controls, integrated with blower controls, including combustion temperature controls, automated shutdown controls and safety alarms with local and remote signals.

1.02 RELATED SECTIONS

A. Section 01010 - Summary of Work

B. Section 01300 – Contractor Submittals

C. Section 01630 - Product Options and Substitutions

D. Section 01720 - Project Record Documents

E. Section 01730 - Installation, Operation and Maintenance Manuals

F. Section 02200 – Earthwork

G. Section 03300 - Cast-In-Place Concrete

H. Section 09910 - Painting

I. Section 11000 – LFG Control System

J. Section 11200 – LFG Blower Skid

K. Section 11300 – LFG Condensate Sump Pump System

L. Section 15480 – LFG Piping

M. Section 16010 - Basic Electrical Requirements

N. Section 16900 – Equipment Control Signals

1.03 REFERENCES

TO BE ADDED

1.04 GENERAL

A. Suppliers:

1. Provide one (1) enclosed LFG combusting flare. The flare system shall automatically receive and destroy all LFG extracted by the LFG blower package.

2. Pre-qualified suppliers for the LFG flare are Flare Industries, LLC (Austin, TX) for the model CEB 150 flare and LFG Specialties (Findlay, OH), Perennial Energy (West Plains, MO), and John Zink (Tulsa, OK) for the conventional enclosed flare.

a. The model CEB 150 flare is a low-profile flare.

b. A conventional enclosed LFG flare meeting the Contract Specifications shall be proposed in conjunction with a matching blower package.

1.05 REGULATORY REQUIREMENTS

A. Flare emissions shall meet all applicable regulatory requirements. Raw LFG not be emitted to the atmosphere, except for very short periods during system start-up and shutdown.

1. The LFG flare shall meet all applicable regulations of the USEPA, CARB and BAAQMD, and all applicable provisions of the BAAQMD Rule 8-34, including:

a. The flare shall operate continuously when the blower(s) are operating.

b. The heat input to the flare shall not exceed 41 million BTU per day.

c. The combustion zone temperature of the flare shall be maintained at a minimum of 1,450°F averaged over any 3-hour period.

d. The flare shall be equipped with both local and remote alarm systems.

e. Flare shall achieve a methane destruction efficiency of 99 percent by weight and a non-methane organic compound (NMOC) destruction efficiency of at least 98 percent by weight (or reduce the NMOC concentration to 30 ppmv or less measured as methane and corrected to 3 percent oxygen).

f. Flare shall simultaneously meet the NMOC standard, a NOx limit of 0.06 pounds per million Btu, and a CO limit of 0.20 pounds per million Btu, as demonstrated by independent, third-party source emissions testing.

g. Flare shall be equipped with a circular exhaust stack, and test ports and provisions for source emissions

testing as required by the BAAQMD.

h. Flare shall be equipped with all required automatic operations and safety monitoring and control systems, including flame detection, combustion temperature control, and low and high stack temperature alarms.

i. The landfill gas inlet pipe shall include an automatic shut off valve, flame arrestor and high temperature sensor and shutdown switch.

j. An automatic valve shall perform fail-safe line shut-down under all routine and non-routine shutdown conditions.

k. The flare shall include instrumentation to continuously measure, display and record the flare combustion and exhaust gas temperature (in °F).

l. The flare shall include instrumentation to continuously measure, display and record the LFG flare inlet flow rate (in scfm).

2. Flare manufacturer shall provide a guarantee for the flare emissions. Flare performance shall be in compliance with the applicable requirements, conditions and specifications of the BAAQMD and these Specifications. All work and materials (including that provided by third parties) required to correct problems arising from non-compliance with specifications or emission standards, shall be performed and provided by the flare manufacturer at no expense to the Navy.

1.06 SUBMITTALS

A. Submit documentation supporting successful compliance of the flare design with applicable emission standards for approval of the Navy/Engineer.

B. Final flare design and construction shall not commence until compliance with the specifications for the specific flare model is confirmed and shop drawings have been reviewed and approved by the Navy/Engineer.

C. Flare manufacturer shall provide the final flare anchor bolt design and location schedule to Contractor prior to flare foundation construction. Anchor bolt design and supporting calculations are to be certified by a Professional Engineer registered in the State of California and are to be sufficient to obtain a Building Permit.

D. Equipment manufacturers shall provide their recommended spare parts list and shall supply sufficient spare parts to facilitate all required routine and preventive maintenance for the first two years of operation.

PART 2. PRODUCTS

2.01 SHOP DRAWINGS

1. The flare shall be constructed and delivered to the site, ready for installation. All components shall be designed, fabricated, and assembled in accordance with best engineering and shop practices. Individual parts shall be manufactured in standard sizes. Equipment shall not have been in service except for shop tests prior to delivery.

2. All mechanisms and parts shall be amply proportioned for stresses which may occur during fabrication, delivery, erection, and operation. Individual parts which are alike in the unit shall be alike in workmanship and design and shall be interchangeable. All materials shall be suitable for the service conditions.

3. Materials and construction shall be in compliance with applicable requirements of the standards of ASME, AGA, NFPA, and the UL. Welding shall meet AWS standards. General fabrication shall be in compliance with the latest standard of AISC. All ratings shall be certified by the manufacturer and shall, at minimum, be equal to the requirements and conditions specified herein.

2.02 CONSTRUCTION

A. Specific construction requirements and features shall include the following:

1. Flare stack:

a. Flare stack, ¼-inch, steel (A-36 or better) welded construction, with self-supporting frame or base plate.

b. Sufficient number of thermocouples ports, with stack elevations to be determined by flare manufacturer, to establish and maintain permitted values of key operating parameters over the full design range of fuel heat loadings and LFG flow rates.

c. Minimum two (2) ports for sampling of stack gases, size and location as required by BAAQMD:

i. Minimum 3 stack diameters downstream of burner

ii. Minimum 1 stack diameter or 3.5 feet (whichever is larger) below top edge of stack

d. Combustion air-louvers

e. Heat shielding or other measures to maintain exterior skin temperature below 250°F at locations accessible from ground level and during stack test sampling.

f. Lifting lugs to facilitate proper handling during transport and installation.

g. Moisture and weather protection for top interior and stack refractory to prevent corrosion during both operating and non-operating periods.

h. Flare Maintenance Access: Provide easy removal of or access to flare components requiring maintenance.

2. Main and pilot fuel burner systems:

a. Burners or knit mesh of corrosion-resistant high temperature alloys suitable to burn the specified fuels over the specified inlet flow rate, temperature, and pressure ranges without exceeding specified stack emissions.

b. LFG burner inlet pipe connection, ASA flanged, terminating outside the flare.

c. All internal LFG and pilot fuel piping between gas inlet pipe flange and burners.

d. Pilot gas burner assembly, suitable for propane gas.

e. Flare stack purge air blower with controls.

3. Flare finish:

a. Finishes and colors will be selected and specified to comply with City of San Francisco requirements.

b. Site-applied finishes for all equipment surfaces shall be VOC compliant and approved by the equipment manufacturer for the specific application, e.g. high-temperature finish for the flare stack.

4. Provide OSHA-approved warning labels and signage for automatic starting equipment, hot surfaces, flammable gases, smoking prohibited areas, confined spaces and piping contents.

5. Ignition system, rack mounted:

a. Spark ignitor assembly, including corrosion-resistant conductor rod and electrode, insulated mounting support brackets for automatic ignition of pilot flame.

b. Ignition transformer.

c. High voltage conduit and wiring between ignition transformer and ignitor.

d. NEMA 4 cabinet to house the transformer and the temperature controller.

e. Thermocouple or UV sensor to confirm pilot and main flames.

f. User-settable timer program for ignition duration and repeat start-attempts.

6. Provide horizontal flame arrestor with aluminum housing and internals, Varec Model 5010 or approved equal.

7. Manual Butterfly Valves: Provide wafer type, butterfly valve with nitrile (Buna-N) seat and seals, gear-operated handle, Asahi-America or Engineer approved equal. Provide spacers as needed to ensure full sweep operation of the valve without interference with the LFG piping.

8. Combustion air louvers shall be provided with heat, dust and corrosion-resistant blades, bearings and actuator mechanisms. Louver blades shall be opposing-blade style for low-leakage when closed. Louver actuator motors, gears and housings shall be industrial quality for the conditions and classification at the installation location.

B. Criteria: Specific Flare Design Criteria and Performance Requirements shall be as follows:

1. Fuel to be burned — Landfill gas

2. Design heat rate range (HHV) — 0.17 to 1.7 MMBtu/hr

3. Fuel flow rate range — 50 scfm @ 50% CH4 to 150 scfm @ 15% CH4

4. Fuel composition range, percent

   a. CH_4 — 15 to 50

   b. CO_2 — 15 to 40

   c. O_2 — 0.5 to 5

   d. N_2 — Remainder

5. Max. Heating Value (HHV), Btu/SCF — 507

6. LFG temperature range — 50 to 140°F

7. Methane destruction efficiency — 99 percent

8. Overall total NMOC destruction efficiency measured at the outlet — 98 percent (or <30 ppmv)

9. Stack emissions guaranteed not to exceed:

   a. CO — 0.20 pounds/MM Btu

   b. NOx — 0.06 pounds/MM Btu

   c. NMOC — 30 ppmv

10.	Burner maximum temperature	2,200°F
11.	Burner design temperature range	1,500 to 2,200°F
12.	Minimum stack temperature	1,450°F
13.	Stack gas residence time meet	As required to emission standards at maximum design throughput.
14.	Noise not to exceed meters	65 db(A) @ 50
15.	Maximum flame-to-stack height ratio	<85 percent
16.	Flare structural design	
	a. Seismic load	**California Building Code latest edition
	b. Wind load	**California Building Code latest edition
17.	Pilot gas consumption not to exceed, at 5 psig	100,000 Btu/hr
18.	Flare dimensions (max.)	5 ft. dia.
	a. For low-profile flare:	11 ft. OAH
	b. For conventional flare:	18 ft. OAH
19.	Burner inlet pipe size	4-inch IPS, minimum
20.	Flame arrestor	
	a. Size	4-inch, flanged mount
	b. Pressure drop across clean element at maximum flow rate	2 in.w.c, maximum

2.03 EQUIPMENT CONTROL COMPONENTS

A. The flare and blower equipment control designs not by the same equipment suppliers shall be integrated and finalized by the approved system integrator to provide comprehensive system monitoring, communication and control under manual and automated operating modes.

B. The flare and controls should maintain a dynamic steady state operation with minimal non-routine shut-downs and start-ups.

C. Provide flame detection measures as needed to verify proper main burner and pilot burner operation: Provide ultraviolet-sensing (UV) scanner(s) for conventional burners or Type S thermocouples for mesh burners.

D. In addition to all required basic combustion and safety controls, the final flare and blower equipment control design shall provide

the following:

1. Motorized Fail-Close Valves:

   a. Provide motor-actuated positioning butterfly valves bubble-tight, wafer-style, carbon steel body, nickel plated disk, with nitrile (Buna-N) seat and seals.

   b. Provide spacers as needed to ensure full sweep operation of the valve disk without interference with adjacent fittings or piping.

   c. Valves shall be equipped with electric actuators and “fail safe” closure, in case of power failure.

   d. Provide “open” and “close” detection switches for confirming valve position for process control.

2. Provide thermal mass flow meter for monitoring LFG volume flow rates, appropriate for continuous use in corrosive and flammable atmospheres. Flow meters to be Fluid Components Inc. (FCI), or approved equal. Measurement range to be 0 to 200 scfm. The flow meters shall be calibrated at the factory for the flow ranges, pipe size, and LFG composition in these specifications or as provided in the approved submittals. Calibration parameters shall be approved by the Navy/Engineer before initial calibration.

3. Pressure transducer / transmitter to be Rosemount Type 3051 smart pressure transmitter or approved equal.

4. All components to be industrial grade, in NEMA 4 enclosures, except enclosures shall be NEMA 7 if required to be installed in NEC Class I areas.

5. Flame detection measures as needed to verify proper main burner and pilot burner operation: Provide ultraviolet-sensing (UV) scanner(s) for conventional burners or Type S thermocouples for mesh burners.

6. Stack gas temperature monitoring and control system, including:

   a. A flare control system consisting of both temperature and flame safety systems and a programmable logic controller (PLC) for monitoring and control of all flare operating parameters.

   b. The PLC shall be Allen-Bradley or Navy-approved equivalent that is fully compatible with other Navy facility SCADA systems. The PLC shall include a human machine interface (HMI) device mounted in the face of the control cabinet, for local operator interaction with the flare control system.

   c. The PLC shall be capable of automatically starting and shutting-down the flare system at operator-programmed intervals to allow periodic or timed operation of the flare. The allowable start and

shut-down times shall be in minimum increments of tenths of an hour and allow for at least two start and shut-down cycles per day. The flare system clock/timer shall be adjustable using the HMI.

d. Control systems shall be mounted in NEMA 4 cabinets, fully piped and wired. Cabinets shall be completely wired and provided with readily accessible terminal strips for external wiring connections. Cabinets shall be mounted to the electrical control rack on the LFG blower skid at eye level. Cabinets shall be provided with windows for viewing the HMI, digital recorder and any instrument displays. Cabinet windows shall be provided with exterior shields or sunlight/UV screening to reduce interior temperatures and prevent LCD screen burn out.

e. A flare stack gas temperature/combustion air flow control system consisting of an adjustable temperature control program, stack thermowells and thermocouples located as determined by the manufacturer for monitoring and recording operating temperature over the full design range of allowable heat rates, conduit and wiring between the thermocouple and the controller, combustion air louvers and air flow controls. The temperature control system shall automatically adjust the combustion air flow rate to maintain the flare stack gases at a constant optimal temperature for minimizing air emissions. The temperature control system shall automatically select the appropriate exhaust temperature thermocouple for the measured LFG flow range.

f. A digital video graphic data recorder, Yokogawa DXAdvanced 1000N or Engineer approved equal to record both blower and flare operating parameters. Recorder shall provide at least 8 configurable input channels (both digital and analog) and a minimum of 400Mbytes of data storage memory and 3 standard 1 Gbyte memory cards. Recorder shall perform and communicate flagging and alarm functions for outlier data. Recorder shall provide data output formats compatible with standard Navy SCADA software and database.

g. A high temperature sensor to detect and prevent pre-ignition or flashback at the flare inlet.

h. All monitoring sensors and transmitters shall be installed within weatherproof enclosures.

7. Remote monitoring and control:

a. The LFG blower package PLC shall communicate via Ethernet and a local network hub.

b. The LFG control system PLCs data outputs must be

compatible with Navy-standard SCADA software.

c. LFG control system shall be supplied with a local network hub with sufficient and appropriate communication ports for connection to the PLCs, the digital recorder, the local HMI, and the remote telemetry unit.

d. Contractor to provide all Ethernet cable connections and hard-wired common alarm and shut-down relay circuits.

e. Contractor to provide copies of PLC programs and all interface cables required for trained operators to access and adjust PLC.

f. Transferred and recorded data shall include:

i. Average, maximum, and minimum LFG flow rate to flare (one to two minute typical sampling frequency);

ii. Total cumulative LFG flow to flare;

iii. Flare stack operating temperature;

iv. LFG wellfield vacuum;

v. Total time LFG directed to flare .

g. Contractor shall provide the LFG control system with separate telemetry equipment and service (cellular) for remote viewing and downloading of flare operating and compliance data from the local flare data recorder.

2.04 PROPANE TANKS AND PILOT FUEL TRAIN

A. Provide two (2) DOT approved 10-gallon (40 pound) capacity propane gas tanks (filled with propane) complete with overfill safety valve.

B. Provide protective housing for propane gas tanks.

C. Provide pilot gas piping manifold piping including:

1. Flame and corrosion resistant piping between regulator and inlet to the pilot burner

2. Flexible stainless steel pressure tubing for equipment connection

3. 3-way tank selector valve or quarter-turn propane tank shut-off valves

4. Line pressure regulator with pressure gauge and relief valve

5. Pipe supports and tank safety hold-downs per code.

D. Pilot gas controls shall include:

1. Adjustable pilot flame duration timer

2. Solenoid valve, normally closed, explosion-proof

3. Pilot ignition failure indicator and alarm signal

SECTION 11 20 0

LANDFILL GAS BLOWER SKID

PART 1. GENERAL

1.01 SUMMARY:

A. Provide and install the landfill gas (LFG) blower skid as shown on the Contract Drawings, as specified herein, and as needed for a complete and properly operating LFG control system including, but not limited to, the following:

1. Two LFG blowers with variable frequency motor drives

1. Motor control center with programmable inlet vacuum and total discharge flow control

2. Condensate knockout pot

3. Monitoring instrumentation and regulating valves.

1.02 RELATED SECTIONS

A. Section 01010 - Summary of Work

1. Section 01300 – Contractor Submittals
2. Section 01630 - Product Options and Substitutions
3. Section 01720 - Project Record Documents
4. Section 01730 - Installation, Operation and Maintenance Manuals
5. Section 02200 – Earthwork
6. Section 03300 - Cast-In-Place Concrete
7. Section 09910 - Painting
8. Section 11100 – Enclosed LFG Flare
9. Section 15480 – LFG Piping
10. Section 16010 - Basic Electrical Requirements
11. Section 16900 – Equipment Control Signals

1.03 REFERENCES

TO BE ADDED

PART 2. PRODUCTS

2.01 SUPPLIERS

A. Pre-qualified suppliers for the LFG blower package are Flare Industries, LFG Specialties, Perennial Energy, or John Zink.

2.02 CENTRIFUGAL GAS BLOWERS

A. The centrifugal gas blower package shall be designed and pre-assembled as follows:

1. Provide two (2) identically sized centrifugal blowers, HSI Model 31, Lamson, or Engineer-approved equal. Each blower package shall be variable speed direct-drive, self-lubricating, complete with blower, motor, drive coupling, equipment base and vibration isolation pads.

2. All blower components shall be designed or selected and provided by the blower package manufacturer. Blower model selection shall be confirmed by the manufacturer for the performance requirements below, and approved by the Navy/Engineer.

3. All blower components shall be designed, assembled and aligned on a common steel equipment base to provide vibration-free operation.

4. All components of the equipment and base shall be coated with rust inhibiting primer and finished with a 3-mil thick coat of industrial enamel paint, of a neutral color to be specified by the Navy/Engineer.

5. Vibration isolation pads to be placed between the equipment base and the skid frame shall be designed or selected and provided by the blower manufacturer to minimize noise and vibration transfer to the skid and other appurtenances.

6. The blower assemblies shall be factory mounted and piped on the skid, factory-wired to the motor controls, tested and delivered to the site as a complete operational unit.

7. The motor and blower housings shall each be provided with a nameplate which states the manufacturer, model number, size, capacity, serial number, and the pertinent information regarding electrical requirements, etc.

8. Install the blower assembly in compliance with the manufacturer’s recommendations, the applicable codes, the Contract Drawings, and as specified herein.

B. Specific performance and construction requirements shall be as follows:

1. Gas pumped — Landfill gas

2. Gas composition:

   a. % methane (CH_4) range — 15 to 50

   b. carbon dioxide (CO_2) range — 10 to 40

   c. nitrogen (N_2) — 30 to 20

3. Gas density, average, lb/scf — 0.074

4. Gas relative humidity, % — 100

5. Elevation above MSL, ft 10

6. LFG max. operating flow rate, scfm 150
(at 4,200 rpm max.)

7. LFG min. operating flow rate, scfm 50

8. Inlet vacuum at condensate knock-out -50
at max. flow rate inlet, in.W.C.

9. Discharge pressure (in.W.C.) at max. flow at inlet to:
a. Initial adsorption vessel +110
c. CEB 150 flare: +80
b. Conventional burner flare: +13

10. Blower speed, rpm 2,400 to 4,200

11. Motor size, hp as per blower manufacturer

12. Maximum motor speed, rpm 4,200

13. Motor type Premium efficiency AC, variable frequency drive

14. Motor enclosure TEFC (TEXP if blowers are enclosed in housing)

15. NEMA design B

16. Insulation class B

17. Voltage, Phases, Cycles 480/3/60

18. Service factor 1.15

19. Provide inlet driven blower with outboard mounted bearings.

20. Inlet connection: vertical, flanged, ASA 125 pound drilled.

21. Outlet connection: vertical, flanged, ASA 125 pound drilled.

22. Noise limitation: <65 dbA at 50m (provide sound enclosure if higher)

23. Provide the number of impeller stages and impeller vane design (backward and/or straight bladed) as required for best efficiency performance across full design flows with minimum surge range.

24. Blower housing inlet head, outlet head and intermediate sections shall be cast iron.

25. Blower impeller shall be cast or fabricated aluminum alloy

of impeller vane design indicated above.

26. Provide labyrinth seals between impeller stages and low-emission gas seal at the outlet head.

27. Provide carbon ring gas seal on drive shaft ends.

28. Provide grease lubrication on bearings.

29. Shaft and impeller assembly shall be dynamically balanced to provide a vibration free operating blower.

30. Provide a certified report for the blower indicating the dynamic balancing results.

31. Provide a 3/8-inch NPT drain connection with plug at the bottom of the impeller housing.

32. Provide bearings selected for a minimum 10-year life under specified performance requirements.

33. Provide thermocouples for temperature monitoring of all blower bearings and shutdown above maximum temperature recommended by manufacturer.

34. Provide vibration switch on each inboard blower bearing with alarm output to PLC.

35. Provide premium industrial rated variable frequency drives with digital ammeter or wattmeter display.

C. Blower and motor monitoring controls shall shut down the blower (after adjustable time delays) for parameters above manufacturer recommended set points. Monitoring control components for the blowers shall be installed in the Motor Control Center (MCC) near the corresponding VFD.

D. Provide air conditioning and filtration for MCC and/or VFD enclosures as required to maintain temperatures for proper equipment functioning.

E. Miscellaneous:

1. Manual isolation butterfly valves shall be installed at the blower inlet and outlet for each blower. Configure blower piping to allow both parallel and series operation.

2. Configure blower piping to allow flow to either adsorption pretreatment system or to LFG flare.

3. Flexible expansion joints shall be provided at the inlet and outlet connections for each blower.

4. Aluminum body, dual flapper check valves shall be provided at the outlet of each blower.

5. Pressure gauges shall be provided for each blower outlet.

6. Vacuum/pressure sensor/transmitters shall be provided to monitor/regulate blower operation, applied wellfield vacuum, and LFG backpressure to flare.

F. CONDENSATE KNOCK-OUT POT (KOP)

LFG blower package to include demister / knock-out pot (KOP) ahead of blower inlets sized to remove free moisture and all particles over 10 microns from a LFG flow of 150 scfm at -50 in.w.c. inlet vacuum. Provide KOP with:

1. ASA 150 psi flanged connections, bottom inlet and top outlet.

2. User adjustable liquid level switch for high liquid level alarm and blower system shut-down.

3. 2-inch gravity drain connection with manual ball valve.

4. A heavy-duty liquid level sight gauge to indicate water level within KOP.

5. Deflector to reduce gas velocity and carry-over.

6. Corrosion-resistant demister pad with a 98% filtration efficiency of free liquid and solid particles of 10 micron or larger.

7. Internal coating of hi-build vinyl to resist acidic condensate.

8. External finish with rust resistant primer and industrial enamel color coat.

9. Removable lid to facilitate inspection, cleaning, and repair of internal components.

10. Vacuum gauge on the inlet header to the KOP.

11. Differential pressure gauge between inlet and outlet, complete with isolation valves.

2.03 EQUIPMENT SKID

A. LFG blower package to include heavy-duty structural steel base with non-skid floor over all walking areas. Skid shall be constructed of I-beams and other structural members sufficiently rigid to withstand all loading and transport forces. All necessary bracing, mounting pads, and piping supports shall be provided for safe transport and equipment installation.

B. Equipment to be mounted on skid includes: centrifugal LFG blowers, condensate knockout pot, propane tanks, rack mounted motor control center including all required power and control panels, and all

associated piping, valves, instrumentation and fittings.

C. Provide steel canopy/weather hood over electrical rack to minimize exposure of panels and displays to sun, heat and weather.

D. Provide OSHA-approved warning labels and signage for automatic starting equipment, hot surfaces, flammable gases, smoking prohibited areas, confined spaces and piping contents.

END OF SECTION

SECTION 11 30 0

CONDENSATE STORAGE TANK

PART 1. GENERAL

1.01 SUMMARY:

A. Provide and install SAFE-Tank® double wall high density cross-linked polyethylene tanks and accessories, complete and in place, in accordance with the Contract Documents.

1.02 RELATED SECTIONS

TO BE ADDED

1.03 REFERENCES, CODES AND STANDARDS

A. American Society of Testing Materials (ASTM):

1. D638 Tensile Properties of Plastics
2. D883 Standard Definitions of Terms Relating to Plastics
3. D1505 Density of Plastics by the Density-Gradient Technique
4. D1525 Test Method for Vicat Softening Temperature of Plastics
5. D1693 ESCR Specification Thickness 0.125" F50-10% Igepal
6. D1998 Standard Specification for Polyethylene Upright Storage Tanks
7. F412 Standard Terminology Relating to Plastic Piping Systems

B. ANSI Standards: B-16.5, Pipe Flanges and Flanged Fittings

C. Building Code: International Building Code, IBC 2009

1.04 SUBMITTALS

A. Shop Drawings: Shop drawings shall be approved by the Engineer prior to the manufacturing of the SAFE-Tank® double wall tank(s). Submit the following as a single complete initial submittal. Sufficient data shall be included to show that the product conforms to Specification requirements. Provide the following additional information:

1. SAFE-Tank® double wall tank and fitting material

   a. Resin Manufacturer Data Sheet

   b. Fitting Material

c. Gasket style and material

d. Bolt material

2. Dimensioned Tank Drawings

a. Location and orientation of openings, fittings, accessories, restraints and supports.

b. Details of manways, flexible connections, and vents.

3. Calculations shall be stamped and signed by a registered, third party engineer in the state of the installation.

a. Wall thickness. Hoop stress shall be calculated using 600 psi @ 100 degrees F.

b. Tank restraint system. Show seismic and wind criteria.

B. Manufacturer’s warranty

TO BE ADDED

C. Factory Test Report:

1. Material, specific gravity rating at 600 psi @ 100 degrees F. design hoop stress.

2. Wall thickness verification.

3. Fitting placement verification.

4. Visual inspection

5. Impact test

6. Gel test

7. Hydrostatic test

1.05 QUALITY ASSURANCE

A. Tanks furnished under this Section shall be supplied by Poly Processing Company or approved equal who has been regularly engaged in the design and manufacture of chemical storage tanks for over 10 years.

B. Tanks shall be manufactured from virgin materials.

C. Tanks shall be manufactured from materials certified to NSF/ANSI Standard 61 for chemical storage; submit form from NSF supporting chemical certification.

1.06 WARRANTY

A. Provide manufacturer’s 5 year full replacement warranty for the specific service application. For most chemical applications,

PART 2. PRODUCTS

2.01 GENERAL

A. Tanks shall be rotationally-molded, high density cross-linked polyethylene, double-wall, Safe-tank®, flat bottom tanks for above-ground, vertical installation with an oxidation resistant resin system (OR-1000™). The assembly consists of one cylindrical, closed top inner primary tank and one cylindrical, open top containment outer tank. Each tank is a rotationally molded one-piece seamless constructed tank.

B. The tank assembly shall be designed to prevent rainwater and debris from entering the containment tank. Tanks shall be adequately vented as prescribed by manufacturer. Tanks shall be provided with ancillary mechanical fittings and accessories where indicated in the Contract Drawings.

C. Tanks shall be marked to identify the manufacturer, date of manufacture and serial numbers. Markings must be permanently embossed into the tank.

D. Wall thickness for a given hoop stress is to be calculated in accordance with ASTM D 1998. Tanks shall be designed using a hoop stress no greater than 600 psi. In NO case shall the tank thickness be less than design requirements per ASTM D 1998..

2.02 TANK ACCESSORIES

A. Restraint System:

1. Metal components to be stainless steel edge softeners and tension ring with stainless steel, cables and clamps.

2. Tank restraint system shall be supplied and the design of same certified by a Structural Engineer registered in the State of California. Design shall conform to the most recent edition of the IBC code for seismic and wind load. Anchor bolts as required by the calculations shall be supplied by the tank manufacturer.

PART 3. EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. The tank shall be shipped upright or lying down on their sides with blocks and slings to keep them from moving. AVOID sharp objects on trailers.

B. All fittings shall be installed and, if necessary, removed for

shipping and shipped separately unless otherwise noted by the contractor.

C. Upon arrival at the destination, inspect the tank(s) and accessories for damage in transit. If damage has occurred, notified manufacturer immediately.

3.02 INSTALLATION

A. Install the tanks in strict accordance with manufacturer’s installation manual and shop drawings.

B. Installation will be inspected to verify flexible connections, venting and fittings are properly installed.

3.03 FIELD TESTING

A. Tank shall be hydrostatically tested by filling with clean water for minimum 24 hour hold time prior to commissioning.

B. Tank shall not leak during duration of test.

END OF SECTION

SECTION 11 40 0

PRETREATMENT VESSELS

PART 1. GENERAL

1.01 SUMMARY:

A. All adsorption pretreatment vessels shall be constructed in accordance with ASME Code Section 8, latest edition. Pressure vessels shall be ASME Code stamped except as noted otherwise in the vessel specification drawings.

A. Pretreatment vessels shall be rated for the maximum corrosion allowance possible at the rated design pressure for the steel thickness used.

1.02 RELATED SECTIONS

TO BE ADDED

1.03 REFERENCES

TO BE ADDED

PART 2. MATERIALS

2.01 EQUIPMENT REQUIREMENTS

A. Minimum vessel or head thickness not including corrosion allowance shall be 3/16". All bolting used inside the vessel shall be 304 S.S. minimum.

A. All vessels shall have lift lugs. Lift lugs shall be designed so that if vessel when new cold and empty is suspended and subjected to a vertical 2G load (3G total), the vessel stress will not exceed the ASME allowable stress.

B. Blind flanges and/or manways supplied with vessels shall be hinged or davited when they are in excess of 75 pounds. Blind flanges less than 75 pounds but more than 25 pounds shall have hand grips. All flanges shall be ANSI 150# RF unless otherwise noted on vessel drawings.

C. The minimum allowable grade stud and nut for flanges shall be SA-193 B7 and SA-194 2H, respectively.

D. Dimensions and Tolerances:

1. Overall dimensions shall be +/- 1/8" maximum from indicated dimensions, i.e. face to face, face to center, locations of attachments, etc.

1. Plumb and square tolerances. Vertical vessels shall be plumbed with 1/4" per 20 feet of height. Lateral translation of branches or connections shall be +/- 1/8" maximum.

2. Rotation of flanges from indicated position shall be +/- 1/16" maximum.

3. Flange alignment shall be 1/32" maximum from indicated

position measured across any diameter.

PART 3. EXECUTION

3.01 FABRICATION

A. Hydrotest pressure shall be the maximum allowable for the vessel new and cold. The maximum new and cold hydrotest pressure shall be shown on the vessel fabrication drawing based on the maximum possible vessel pressure rating using the corrosion allowance. Manways and nozzles or blind flanges shall not govern new and cold conditions.

B. Flange bolt holes are to straddle natural center lines.

C. Vessel shall be free standing without need of additional guy wires or braces.

D. Manways ID's shall not be less than the 15" ID.

E. All bolts and nuts shall be easily accessible for tightening.

F. Nozzles and couplings shall not pass the shell closer than 2" from the weld seam.

G. All reinforcing elements shall have a 1/4" NPT telltale hole and be pressure tested. If reinforcing pads must cross a weld, 100% x-ray inspection will be performed prior to installation of pad.

END OF SECTION

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS
03/13

PART 1 GENERAL

1.1 REFERENCES
The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2001; R 2007) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1 2012; INT 2 2012) National Electrical Safety Code
IEEE C57.12.28	(2005; INT 3 2011) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2005) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

1.2 RELATED REQUIREMENTS
This section applies to certain sections of Division 11, EQUIPMENT. This section applies to all sections of Division 26 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment

operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be kV primary, three phase, four wire, 60 Hz, and 480 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing utility service drop shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during

the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.9 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

1.11 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on a red and black field.

1.12 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.13 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. [When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications.]

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test[and the additional requirements specified in the technical sections].

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in [Section 09 90 00 PAINTS AND COATINGS] [the section specifying the associated electrical equipment].

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

-- End of Section --

SECTION 31 00 00

EARTHWORK
03/13

PART 1 GENERAL

The selected remedy includes the following components:

Excavation of soil, sediment, and debris that pose a significant risk to humans and wildlife, with disposal at off-site landfills and backfilling with clean soil. Screening for radiological release is to be performed in conjunction with excavation activities to screen soil for possible reuse.

Containment of remaining contamination with a minimum 2-foot thick soil cover placed over the site, and protective liner consisting of a geomembrane with overlying geocomposite drainage layer (except for wetlands areas).

Rock revetment structure consisting of large rocks placed on the shoreline slope to prevent erosion and protect the edge of the covered upland area.

Creation of wetlands to offset the loss of wetlands at Parcel E-2 and other areas at HPNS.

1.1 REFERENCES

ASTM INTERNATIONAL (ASTM)

ASTM D2103	(2010) Standard Specification for Polyethylene Film and Sheeting
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D792	(2008) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1556	(2007) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	(2012) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)

ASTM D1777	(1996; E 2011; R 2011) Thickness of Textile Materials
ASTM D2216	(2010) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2261	(2011) Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant Rate-of-Extension Tensile Testing Machine)
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D422	(1963; R 2007) Particle-Size Analysis of Soils
ASTM D4318	(2010) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4355	(2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D5035	(2011) Breaking Force and Elongation of Textile Fabrics (Strip Method)
ASTM D5199	(2012) Measuring Nominal Thickness of Geosynthetics
ASTM D5261	(2010) Measuring Mass Per Unit Area of Geotextiles
ASTM D6475	(2006) Standard Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets
ASTM D6525	(2009) Standard Test Method for Measuring Nominal Thickness of Permanent Rolled Erosion Control Products
ASTM D6938	(2010) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting

1.2 DEFINITIONS

1.2.1 Durable Cover

Sitewide cover comprosed of a 2-footerosion resistant layer underlain by a compacted foundation layer of variable thickness (2 feetminimum), and

protective layer (where applied).

1.2.2 Erosion Resistant Layer

The upper 2 feetof soil cover is the erosion resistant layer and consists of imported vegetative soil.

1.2.3 Compacted Foundation Layer

The compacted foundation layer consists of clean imported fill or excavation spoils (deemed suitable for reuse), and will be placed and compacted to the required degree of compaction beneth the erosion resistant layer. The compacted foundation layer is a minimum of 2 feet thick and varies in overall thickness across the site.

1.2.4 Clean Imported Fill

Clean imported fill is soil that is imported for use in the construction of the compacted foundation layer, and meets geotechnical and chemical assessment requirements in Paragraph 2.1.

1.2.5 Excavation Spoils

Excavated spoils consists of soil from site grading that has been radiologically released for reuse and meets geotechnical and chemical assessment requirement for imported fill (Paragraph 2.1).

1.2.6 Protective Liner

The protective liner consists of a geomembrane with overlying geocomposite drainage layer as discussed in Section 31 05 22 Geotextiles.

1.2.7 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum density.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval (i.e., submitted to the government for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Sampling and Analysis Plan; G
Materials Handling Plan
Materials Handling Plan describing placement and compaction procedures. The plan shall also describe equipment to be used (inclusing ground pressures).

Shoring and Sheeting Plan; G
Dewatering Work Plan; G

SD-03 Product Data

Erosion Control Blanket

Composite Turf Reinforcement Matting
Imported Fill Material

SD-04 Samples
Select Fill
A minimum of 50 pounds of fill from each proposed imported fill source to the Government's designated laboratory at least 15 days prior to placement.

SD-06 Test Reports

Select Fill Material Tests; G
See Paragraph 3.6.4 Construction Test for frequency and type. Submit raw data as available and summarize weekly.

Confirmation Screening Sampling Results; G
See Paragraph 2.2 Subgrade for testing requirements. Submit raw data as available and summarized weekly.

Imported Fill Material Assessment; G
See Paragraph 2.1.2 Imported Fill Source Assessment for testing requiremtns. Submit raw data as available and summarize weekly.

Moisture Content and Density Tests of In-Place Fill

See Paragraph 3.6.4.2 Moisture Content and Density Test of In-Place Fill for testing requirements. Submit raw data as available and summarize weekly.

Composite Turf Reinforced Matting MARV report(s)

SD-07 Certificates

California Registered Civil Engineer or Geologist

SD-11 Closeout Submittals

Final soil cover survey with As-Built Drawings
Survey information on permanent local site monuments
Testing

1.4 DELIVERY, STORAGE, and HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 Equipment

Equipment used to grade, compact, and place material shall be as described in the approved Materials Handling Plan. Equipment shall not accelerate of brake suddenly, turn sharply, or be operated at speeds exceeding 5.0 miles per hour.

PART 2 PRODUCTS

2.1 IMPORTED FILL

Imported material used as fill during hot spot removal and final grading of the landfill and wetlands shall conform to specifications 2.1.1 of this section. The soil shall be free of debris, roots, wood, scrap metal, vegetation, refuse, soft unsound particles, and deleterious or objectionable materials.

2.1.1 Soil Classification

Imported fill used as general fill for the soil cover below 2 feetdepth shall be ASTM D2487, classification SM, SC, CL, or ML with a maximum liquid limit of 45 percent and a maximum plasticity index of 25 percent per ASTM D4318. The maximum particle size shall be 3 inchesin its largest dimension with at least 90 percent passing a 3/4-inchsieve, and a least 60 percent passing the No. 4 sieve, and not more than 60% passing a No. 200 sieve.

Imported fill used as vegetative cover in the upper 2 feetof the soil cover shall be ASTM D2487, classification SM or SC, with a maximum liquid limit of 35 percent and a maximum plasticity index of 15 percent per ASTM D4318. The maximum particle size shall be 3 inches in its largest dimension with at least 90 percent pasing a 3/4-inch sieve, and at least 60 percent the No. 4 sieve, and not more than 60% passing a No. 200 sieve.

2.1.2 Imported Fill Material Assessment

2.1.2.1 Chemical Assessment of Imported Fill Source

Soil may be obtained from multiple fill sources; samples from fill sources should be analyzed for potential contaminants based on the DTSC Information Advisory. Each fill source should be characterized individually. The imported fill will be analyzed for site-specific chemicals of concern (COCs), former potential radionuclides of concern (ROCs), and other potential contaminants based on the nature of the fill source, as dictated by the DTSC Information Advisory.

The DTSC Information Advisory specifies laboratory analyses for potential contaminants based on the borrow source location, as follows:

- Fill sourced from land near a quarry will be analyzed for metals, total petroleum hydrocarbons (TPH), asbestos, and pH by the off-site laboratory.
- Fill sourced from residential and commercial land will be analyzed for metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), TPH, asbestos, and pH by the off-site laboratory.
- Fill sourced from near an existing freeway will be analyzed for lead and polycyclic aromatic hydrocarbons (PAHs) by the off-site laboratory.
- Fill sourced from agricultural land will be analyzed for organochlorine pesticides, organophosphorus pesticides, chlorinated herbicides, and metals.

Please note that fill will not be sourced from agricultural land during this remedial action.

All backfill sources will also be analyzed for site COCs and former potential ROCs. The Parcel E-2 ROD and DBR identified the following COCs

and ROCs at Parcel E-2:
- COCs: metals, PAHs, pesticides, TPH, dioxins, and PCBs.
- ROCs: Cesium-137, Cobalt-60, Radium-226, and Strontium-90.

Sample results will be screened against site-specific comparison criteria, which are provided below in Tables 1 through 10.

Table 1. Backfill Comparison Criteria for Metals

Analyte	**CAS No.**	**Comparison Criterion (mg/kg)**	**Comparison Criterion Reference**
Aluminum	7429-90-5	77,000	EPA RSL
Antimony	7440-36-0	25	Parcel E-2 ROD RG (RBC)
Arsenic	7440-38-2	11.1	Parcel E-2 ROD RG (RBC)
Barium	7440-39-3	314.4	HPAL
Beryllium	7440-41-7	0.71	HPAL
Cadmium	7440-43-9	4.2	Parcel E-2 ROD RG (RBC)
Chromium	7440-47-3	12,000	EPA RSL for Chromium (III), Insoluble Salts
Cobalt	7440-48-4		HPAL
Copper	7440-50-8	270	Parcel E-2 ROD RG (RBC)
Iron	7439-89-6	93,000	Parcel E-2 ROD RG (RBC)
Lead	7439-92-1	155	Parcel E-2 ROD RG (RBC)
Manganese	7439-96-5	2,433	Parcel E-2 ROD RG (RBC)
Mercury	7439-97-6	2.28	Parcel E-2 ROD RG (HPAL)
Molybdenum	7439-98-7	2.68	HPAL
Nickel	7440-02-0	112	Parcel E-2 ROD RG (RBC)
Selenium	7782-49-2	1.95	HPAL
Silver	7440-22-4	1.43	HPAL
Sodium	7758-19-2	2,300	EPA RSL for Sodium Salts
Thallium	7440-28-0	0.81	HPAL
Vanadium	7440-62-2	117.2	Parcel E-2 ROD RG (RBC)
Zinc	7440-66-6	410	Parcel E-2 ROD RG (RBC)

1. EPA Region 9 RSL for residential soil.
2. No RSL for total chromium has been published. The RSL for chromium III is used instead.
3. Sample-specific HPAL is calculated based on the approved HPNS cobalt/magnesium regression-based relationship (PRC Environmental Management, Inc., 1995). Average magnesium concentration in Parcel E-2 is based on soil sample taken within the East Adjacent and Panhandle areas (outside of the landfill and areas of excavation).

CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
HPAL = Hunters Point ambient level
HPNS = Hunters Point Naval Shipyard
mg/kg = milligrams per kilogram
RBC = risk-based criteria
RG = remediation goal
ROD = Record of Decision
RSL = regional screening level

Table 2. Backfill Comparison Criteria for VOCs

Analyte	**CAS No.**	**Comparison Criterion (ug/kg)**	Comparison Criterion Reference
1,1,1,2-Tetrachloroethane	630-20-6	1,900	EPA RSL

Analyte	**CAS No.**	**Comparison Criterion (ug/kg)**	Comparison Criterion Reference
1,1,1-Trichloroethane	71-55-6	8,700,000	EPA RSL
1,1,2,2-Tetrachloroethane	79-34-5	560	EPA RSL
1,1,2-Trichloroethane	79-00-5	1,100	EPA RSL
1,1-Dichloroethane	75-34-3	3,300	EPA RSL
1,1-Dichloroethene	75-35-4	240,000	EPA RSL
1,2,3-Trichlorobenzene	87-61-6	49,000	EPA RSL
1,2,3-Trichloropropane	96-18-4	5	EPA RSL
1,2,4-Trichlorobenzene	120-82-1	22,000	EPA RSL
1,2,4-Trimethylbenzene	95-63-6	62,000	EPA RSL
1,2-Dibromo-3-chloropropan (DBCP)	96-12-8	5.4	EPA RSL
1,2-Dibromoethane (EDB)	106-93-4	34	EPA RSL
1,2-Dichlorobenzene	95-50-1	1,900,000	EPA RSL
1,2-Dichloroethane	107-06-2	430	EPA RSL
1,2-Dichloropropane	78-87-5	940	EPA RSL
1,3,5-Trimethylbenzene	108-67-8	780,000	EPA RSL
1,3-Dichloropropane	142-28-9	1,600,000	EPA RSL
1,4-Dichlorobenzene	106-46-7	2,400	EPA RSL
2-Butanone (MEK)	78-93-3	28,000,000	EPA RSL
2-Chlorotoluene	95-49-8	1,600,000	EPA RSL
2-Hexanone	591-78-6	210,000	EPA RSL
4-Chlorotoluene	106-43-4	1,600,000	EPA RSL
4-Methyl-2-pentanone	108-10-1	5,300,000	EPA RSL
Acetone	67-64-1	61,000,000	EPA RSL
Benzene	71-43-2	1,100	EPA RSL
Bromobenzene	108-86-1	300,000	EPA RSL
Bromochloromethane	74-97-5	160,000	EPA RSL
Bromodichloromethane	75-27-4	270	EPA RSL
Bromoform	75-25-2	62,000	EPA RSL
Bromomethane	74-83-9	7,300	EPA RSL
Carbon disulfide	75-15-0	820,000	EPA RSL
Carbon tetrachloride	56-23-5	610	EPA RSL
Chlorobenzene	108-90-7	290,000	EPA RSL
Chloroform	67-66-3	290	EPA RSL
Chloromethane	74-87-3	120,000	EPA RSL
cis-1,2-Dichloroethene	156-59-2	160,000	EPA RSL
Dibromochloromethane	124-48-1	680	EPA RSL
Dibromomethane	74-95-3	25,000	EPA RSL
Dichlorodifluoromethane (Freon 12)	75-71-8	94,000	EPA RSL
Ethylbenzene	100-41-4	5,400	EPA RSL
Hexachlorobutadiene	87-68-3	6,200	
Methyl tert-butyl ether	1634-04-4	43,000	EPA RSL
Methylene chloride	75-09-2	56,000	EPA RSL
m-Xylene	108-38-3	590,000	EPA RSL
p-Xylene	106-42-3	600,000	EPA RSL
n-Butylbenzene	104-51-8	3,900,000	EPA RSL
Propyl benzene	103-65-1	3,400,000	EPA RSL
o-Xylene	95-47-6	690,000	EPA RSL
Styrene	100-42-5	6,300,000	EPA RSL
Tetrachloroethene	127-18-4	22,000	EPA RSL
Toluene	108-88-3	5,000,000	EPA RSL
trans-1,2-Dichloroethene	156-60-5	150,000	EPA RSL

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
1,3-Dichloropropene	10061-02-6	1,700	EPA RSL
Trichloroethene (trichloroethylene)	79-01-6	910	EPA RSL
Trichlorofluoromethane	75-69-4	790,000	EPA RSL
Vinyl chloride	75-01-4	60	EPA RSL

1. EPA Region 9 RSL for residential soil.
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
RSL = regional screening level
VOCs = volatile organic compounds
µg/kg = micrograms per kilogram

Table 3. Backfill Comparison Criteria for SVOCs

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
1,2-Dichlorobenzen	95-50-1	1,900,000	EPA RSL
1,4-Dichlorobenzen	106-46-7	2,400	EPA RSL
2,4,5-Trichlorophe	95-95-4	6,100,000	EPA RSL
2,4,6-Trichlorophe	88-06-2	44,000	EPA RSL
2,4-Dichlorophenol	120-83-2	180,000	EPA RSL
2,4-Dimethylphenol	105-67-9	1,200,000	EPA RSL
2,4-Dinitrophenol	51-28-5	120,000	EPA RSL
2,4-Dinitrotoluene	121-14-2	1,600	EPA RSL
2,6-Dinitrotoluene	606-20-2	61,000	EPA RSL
2-Chloronaphthalen	91-58-7	6,300,000	EPA RSL
2-Chlorophenol	95-57-8	390,000	EPA RSL
2-Nitroaniline	88-74-4	610,000	EPA RSL
3,3'-Dichlorobenzi	91-94-1	1,100	EPA RSL
4-Chloroaniline	106-47-8	2,400	EPA RSL
4-Nitroaniline	100-01-6	24,000	EPA RSL
Benzoic acid	65-85-0	240,000,000	EPA RSL

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Benzyl alcohol	100-51-6	6,100,000	EPA RSL
Bis(2-chloroethoxy	111-91-1	180,000	EPA RSL
Bis(2-chloroethyl)	111-44-4	210	EPA RSL
Bis(2-ethylhexyl)p	117-81-7	35,000	EPA RSL
Dibenzofuran	132-64-9	78,000	EPA RSL
Diethylphthalate	84-66-2	49,000,000	EPA RSL
Di-n-butylphthalat	84-74-2	6,100,000	EPA RSL
Hexachlorobenzene	118-74-1	300	EPA RSL
Hexachlorobutadien	87-68-3	6,200	EPA RSL
Hexachloroethane	67-72-1	12,000	EPA RSL
Isophorone	78-59-1	510,000	EPA RSL
Nitrobenzene	98-95-3	4,800	EPA RSL
n-Nitrosodiphenyla	86-30-6	99,000	EPA RSL
Pentachlorophenol	87-86-5	890	EPA RSL
Phenol	108-95-2	18,000,000	EPA RSL

1. EPA Region 9 RSL for residential soil.
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
RSL = regional screening level
SVOCs = semivolatile organic compounds
µg/kg = micrograms per kilogram

Table 4. Backfill Comparison Criteria for PAHs

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Acenaphthene	83-32-9	3,400,000	EPA RSL
Anthracene	120-12-7	17,000,000	EPA RSL
Benzo(a)anthracene	56-55-3	1,300	Parcel E-2 ROD RG (RBC)
Benzo(a)pyrene	50-32-8	330	Parcel E-2 ROD RG (RBC)
Benzo(b)fluoranther	205-99-2	1,300	Parcel E-2 ROD RG (RBC)

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Benzo(k)fluoranther	207-08-9	1,300	Parcel E-2 ROD RG (RBC)
Chrysene	218-01-9	15,000	EPA RSL
Dibenz(a,h)anthrace	53-70-3	1,100	Parcel E-2 ROD RG (RBC)
Fluoranthene	206-44-0	2,300,000	EPA RSL
Fluorene	86-73-7	2,300,000	EPA RSL
Indeno(1,2,3-cd)pyr	193-39-5	1,300	Parcel E-2 ROD RG (RBC)
2-Methylnaphthalene	91-57-6	230,000	EPA RSL
Naphthalene	91-20-3	75,000	Parcel E-2 ROD RG (RBC)
Pyrene	129-00-0	1,700,000	EPA RSL

1. EPA Region 9 RSL for residential soil.
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
PAHs = polycyclic aromatic hydrocarbons
RBC = risk-based criteria
RG = remediation goal
ROD = Record of Decision
RSL = regional screening level
µg/kg = micrograms per kilogram

Table 5. Backfill Comparison Criteria for Pesticides

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Total DDTs	N/A	46	Parcel E-2 ROD RG (RBC)
Aldrin	309-00-2	29	EPA RSL
alpha-hexachlorocyc	319-84-6	77	EPA RSL
beta-hexachlorocycl	319-85-7	270	EPA RSL
Chlordane	57-74-9	1,600	EPA RSL
Dieldrin	60-57-1	8	Parcel E-2 ROD RG (RBC)
Endosulfan I	959-98-8	370,000	EPA RSL for Endosulfan
Endosulfan II	33213-65-9	370,000	EPA RSL for Endosulfan
Endrin	72-20-8	45	Parcel E-2 ROD RG (RBC)
gamma-hexachlorocyc	58-89-9	520	EPA RSL

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Heptachlor	76-44-8	110	EPA RSL
Heptachlor epoxide	1024-57-3	5.3	EPA RSL
Methoxychlor	72-43-5	310,000	EPA RSL
Toxaphene	8001-35-2	440	EPA RSL

1. EPA Region 9 RSL for residential soil.
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
RBC = risk-based criteria
RG = remediation goal
ROD = Record of Decision
RSL = regional screening level
µg/kg = micrograms per kilogram

Table 6. Backfill Comparison Criteria for PCBs

Analyte	CAS No.	Comparison Criterion (ug/kg)	Comparison Criterion Reference
Aroclor-1016	12674-11-2	7,400	Parcel E-2 ROD RG (RBC)
Aroclor-1221	11104-28-2	140	EPA RSL
Aroclor-1232	11141-16-5	140	EPA RSL
Aroclor-1242	53469-21-9	740	Parcel E-2 ROD RG (RBC)
Aroclor-1248	12672-29-6	740	Parcel E-2 ROD RG (RBC)
Aroclor-1254	11097-69-1	740	Parcel E-2 ROD RG (RBC)
Aroclor-1260	11096-82-5	740	Parcel E-2 ROD RG (RBC)

1. EPA Region 9 RSL for residential soil.
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
PCBs = polychlorinated biphenyls
RBC = risk-based criteria
RG = remediation goal
ROD = Record of Decision
RSL = regional screening level
µg/kg = micrograms per kilogram

Table 7. Backfill Comparison Criteria for TPH

Analyte	Analyte ID	Comparison Criterion (mg/kg)	Comparison Criterion Reference
TPH-diesel range organics	-3527	1,500	New Preliminary Screening Criteria and Petroleum Program Strategy

Analyte	Analyte ID	Comparison Criterion (mg/kg)	Comparison Criterion Reference
TPH as gasoline-range organics	-3524	315	New Preliminary Screening Criteria and Petroleum Program Strategy
TPH-motor oil range organics	-3546	1,850	New Preliminary Screening Criteria and Petroleum Program Strategy
Total TPH	NA	3,500	New Preliminary Screening Criteria and Petroleum Program Strategy

1. No chemical abstracts service (CAS) numbers are assigned for multicomponent TPH mixtures; however, the listed numbers are from the NIRIS Electronic Data Deliverable specifications lookup values for Analyte_ID located on NIRIS.
2. Screening criteria for shallow soil, residential reuse, from the New Preliminary Screening Criteria and Petroleum Program Strategy.
3. Total TPH is defined as the sum of all TPH fractions.
EPA = U.S. Environmental Protection Agency
ID = identification
mg/kg = milligrams per kilogram
NIRIS = Navy Installation Restoration Information Solution
TPH = total petroleum hydrocarbons

Table 8. Backfill Comparison Criteria for Asbestos

Analyte	CAS No.	Comparison Criterion (%)	Comparison Criterion Reference
Asbestos	NA	0.25	DTSC

1. Comparison criterion assumes analysis will be performed by PLM with a 400-point count. A nondetect shall be an acceptable analytical result.
2. Screening level for naturally occurring asbestos at school sites (Department of Toxic Substances Control, 2004).
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
PLM = polarized light microscopy
NA = not applicable

Table 9. Backfill Comparison Criteria for pH

Analyte	CAS No.	Comparison Criterion (%)	Comparison Criterion Reference
pH	NA	pH<6.5 pH>8.5	SFRWQCB

1. Remediation goal from the "San Francisco Bay (Region 2) Water Quality Control Plan (Basis Plan) (SFRWQCB, 2011).
"San Francisco Bay (Region 2) Water Quality Control Plan (Basin Plan)" (SFRWQCB, 2011).
CAS = Chemical Abstract Service
EPA = U.S. Environmental Protection Agency
SFRWQCB = San Francisco Regional Water Quality Control Board
NA = not applicable

Table 10. Backfill Comparison Criteria for Radionuclides

Analyte	CAS No.	Comparison Criterion (pCi/g)	Comparison Criterion Reference
Cesium-137	10045-97-3	0.113	Parcel E-2 ROD RG
Cobalt-60	10198-40-0	0.252	Parcel E-2 ROD RG
Radium-226	13982-63-3	1.0 above background	Parcel E-2 ROD RG
Strontium-90	10098-97-2	0.331	Parcel E-2 ROD RG

1. Remediation goals from the Parcel E-2 Final ROD (Navy, 2012). Goals are based on 25 millirem per year (U.S. Environmental Protection Agency does not believe this U.S. Nuclear Regulatory Commission regulation is protective of human health and the environment, and the Hunters Point Naval Shipyard remediation goals are more protective). This regulation is an applicable or relevant and appropriate requirement only for radiologically impacted sites that are undergoing time-critical removal actions and any additional remedial action required for those sites
2. Remediation goal for cobalt-60 was revised to support efficient laboratory gamma spectroscopy analysis of soil samples. This revised remediation goal maintains morbidity risks within the EPA-defined acceptable range and permits an exposure level that does not increase the risk of cancer from a potential exposure to cobalt-60.
3. The radium-226 background level for surface soil is 0.633 pCi/g, and the radium-226 background level for storm drain and sewer lines is 0.485 pCi/g (Navy, 2012). These background levels are from the Parcel E-2 Final ROD (Navy, 2012) and are subject to regulatory agency approval.
4. Remediation goal for strontium-90 is based on a residential use exposure scenario. Residential use is not planned for Parcel E-2, but residential goals were proposed in the Parcel E-2 Final ROD (Navy, 2012) as an additional level of protection.
CAS = Chemical Abstract Service
RG = remediation goal
ROD = Record of Decision
pCi/g = picocuries per gram

Soil samples shall be collected from representative locations throughout the borrow source area or borrow source stockpile. Sampling locations will be defined using a sampling grid (i.e., sample quadrants). Sample locations within each grid will be selected at random. The number of samples collected for chemical analysis shall be determined by the size of the borrow area (i.e., a minimum of four samples shall be collected from borrow areas less than 2 acres) or the volume of a borrow area stockpile (a minimum of four samples for the first 1,000 cubic yards, plus one sample per each additional 500 cubic yards), in accordance with the DTSC Information Advisory

2.1.2.2 Geotechnical Assessment of Imported Fill Source

Imported fill samples will be analyzed as follows:
- Grain size analysis will be conducted by ASTM D422
- Atterberg limits analysis will be conducted by ASTM D4318
- Compaction analysis will be conducted by ASTM D698

Soil samples shall be collected from representative locations throughout the fill source area or fill source stockpile. Sampling locations will be defined using a sampling grid (i.e., sample quadrants). Sample locations

within each grid will be selected at random. The number of samples collected for geotechnical analysis shall be in accordance with specifications 3.2.2 of this section.

2.2 SUBGRADE

Excavation spoils will be reused on site to the extent possible. Refer to Design Drawings for placement location. Excavation material will be screened for low level radionuclide at the designated screening area and only uncontaminated soil will be used for fill as needed for cover. The contractor's radiological screening paln is to be usedfor fill as needed for cover. the contractor's radiological screening plan is to be included in the Sampling and Analysis Plan and must meet RASO requirements.

2.3 EROSION CONTROL BLANKET

The erosion control blanket shall be a machine-produced mat of 100 percent natural biodegradable fiber matrix. The matrix shall be of consistent thickness with fibers evenly distributed. The blanket shall be covered on the top and bottom with 100 percent biodegradable woven natural or poly fiber netting. The top netting shall form an approximate 0.5 inch by 1.0 inch mesh. The blanket shall be sewn togeather on 1.5 inchcenters with degradable thread.
The erosion control blanket shall have the following physical properties:

COMPOSITE STRUCTURE		
Property (min)	Test Method	Typical
Thickness	ASTM D6525	0.30 in max
Resiliency	ECTC Guidelines	80% min
Mass/Unit Area	ASTM D6475	9.5 oz/yd min
Swell	ECTC Guidelines	50% max
Smolder Resistance	ECTC Guidelines	Yes
Stiffness	ASTM 1388	0.4 oz-in min
Light Penetration	ECTC Guidelines	14% min
MD Tensile Strength	ASTM D6818	165 lbs/ft min
MDElongation (max)	ASTM D6818	7% min
TD Tensile Strength	ASTM 6818	225 lbs/ft min
TD Elongation (max)	ASTM D6818	10% min

2.3.1 Fasteners for Erosion Control Blanket

Ties for overlapping panels of erosion control blanket and staples for anchlring erosion control blanket to the soil must comply with the erosion control blanket manufacturer's application instructions.

2.4 COMPOSITE TURF REINFORCEMENT MATTING (CTRM)

The composite turf reinforcement mat (CTRM) shall be a machine-produced mat of 100 percent natural fiber matrix incorporated into a permanent three-dimensional netting structure. The matrix shall be stitch bonded between a heavy duty ultraviolet (UV) stabilized bottom net, crimped intermediate netting, and a heavy-duty, UV-stabilized top net. The crimped netting shall form prominent, closely spaced ridges across the entire width of the mat. The three nettings shall be stitched together with UV-stabilized polypropylene thread to form a permanent three-dimensional structure. Matting shall be three-dimensional geomatrix of heavy nylon monofilaments fused at their intersections. Ninety percent of the geomatrix shall be open space available for soil and root interaction with filaments. Matting shall have three-dimensional strength without laminated or stitched layers. The matting shall be a minimum weight of 8 ounces per square yard with a minimum thickness of 0.4 inches. In accordance with ASTM D 5035, the matting shall have a minimum tensile strength of 85 pounds per foot in each direction. The matting shall be for permanent service.

The permanent composite turf reinforcement mat shall have the following physical properties:

COMPOSITE STRUCTURE			
Property (min)	Test Method	Typical	MARV*
Thickness	ASTM D5199	0.60 in	0.58 in
Resiliency	ASTM D1777	88%	86%
Density	ASTM D792	0.48 oz/in3	0.46 oz/in3
Mass/Unit area	ASTM D5261	12.00 oz/yd3	10 oz/in3
Porosity	ECTC Guidelines	95.0%	92%
Open Volume per Area	ECTC Guidelines	800 in3/yd2	750 in3/yd2
Stiffness	ASTM D1388	3.1 oz-in	3.1 oz-in
Light Penetration	ECTC Guidelines	5.0%	4.5%
MD Tensile Strength	ASTM D5035	640 lbs/ft	450 lbs/ft
MD Elongation (max)	ASTM D5035	14.0%	18.0%
TD Tensile Strength	ASTM D5035	890 lbs/ft	700 lbs/ft
TF Elongation (max)	ASTM D5035	11.0%	13.0%
Tensile Strength at 10% Elongation			
MD Tensile Strength	ASTM D5035	320 lbs/ft	200 lbs/ft

TD Tensile Strength	ASTM D5035	520 lbs/ft	420 lbs/ft

NET STRUCTURE			
Property (min)	Test Method	Typical	MARV*
Thickness	ASTM D5199	0.50 in	0.42 in
Resiliency	ECTC Guidelines	65%	60%
UV Stability	ASTM D4355**	80%	N/A
MD Tensile Strength	ASTM D5035	500 lbs/ft	300 lbs/ft
MD Elongation (max)	ASTM D5035	30%	52%
TD Tensile Strength	ASTM D5035	800 lbs/ft	620 lbs/ft
TD Elongation (max)	ASTM D5035	15%	170%

*Minimum average roll values (MARV) are calculated as the typical plus or minus two standard deviations. Statistically, this calculation yields a 97.7 percent degree of confidence that any samples collected will exceed the value reported. "Typical" indicated the mean or average.
**ASTM D5035 (4 inch strip) Tensile Strength and % Strength Retention of material following 1,000 hours exposure in Xenon-Arc Weatherometer.
MD - Machine direction: TD - Transverse direction

2.5 BURIED WARNING AND IDENTIFICATION TAPE

Text

2.5.1 Buried Warning and Identification Tape

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. In addition, any underground piping associated with the landfill gas control system should be marked with warning and identification tape. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED UTILITY LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Yellow:	Gas, Oil; Dangerous Materials
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air

Text

2.5.2 Detectable Marking Tape

Provide detectable underground marking tape consisting of a maximum 5.0 <met>Mil</met> overall thickness, with a (0.00035") solid aluminum foil core. Construction is 0.8 <met>Mil</met> clear film, making the film permanently printed. The suggested print will read "CAUTION POTENTIAL BURIED HAZARDOUS MATERIALS NO GROUND DISTURBANCE ALLOWED WITHOUT APPROVAL" and include a Spanish translation that reads "AVISO POSIBILIDAD DE SUSTANCIAS PELIGRAOSAS EN EL SUBSUELO MOVER TIERRA NO PERMITIDO SIN APROBACION". Table 2 property values represent minimum average roll values. The tap shall be placed in a grid pattern with 10-foot spacing over the demarcation fabric. Refer to Drawings for placement.

MINIMUM PHYSICAL REQUIREMENTS FOR DETECTABLE MARKING TAPE			
Property	Acceptable Values	Units	Test Method
Thickness	5	Mil	ASTM D2103
Tensile Strength	35	lbs/inch	ASTM D882
Elongation	80%		ASTM D882
Bond Strength	5 hours without peel boiling water		

2.6 MATERIAL FOR RIP-RAP

Provide filter fabric, filter rock, and rip-rap armor rock. conforming to the requirements provided in Section 35 31 19 Coastal Protection..

2.7 MATERIAL FOR SLURRY WALL

Provide materials for the western boundry and near short slurry walls conforming to the requirements provided in Section 02 35 27 Soil-Bentonite (S-B) Slurry Wall.

2.8 MATERIAL FOR DRAINAGE

Provide concrete for freshwater wetlands headwalls, French drain apron, and revetment wall conforming to the requirements of section 03 30 00 Cast in Place Concrete. Provide concrete for surface water control outlet manhole and headwall conforming to the requirements of Section 03 40 00.00 10 Precast Concrete.
Provide piping for surface water control culvert, surface water control outlet, and freshwater wetlands outfalls conforming to the requirements of Section 33 60 01 Valves, Piping, and Equipment in Valve Boxes.

2.8.1 BEDDING MATERIAL

For underground pipes, provide bedding material consisting of sand, gravel, or crushed rock, well graded with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index of less than six.

2.9 MATERIAL FOR SERVICE ROAD

Material for the service road will be Class II aggregate base.

2.10 MATERIAL FOR PEDESTRIAN PATH

Base material for the pedestrian path will be Class II aggregate base. Provide asphalt for the pedestrian path conforming to the requirements of Section 32 12 16 Hot-Mix Asphalt.

PART 3 EXECUTION

3.1 SCHEDULE

Contractor is responsible for maintaining completed work and environmental controls (see Section 01 57 19.00 20 Temporary Environmental Controls) at all times, including gaps in construction activity.

3.2 SURFACE AND SUBGRADE PREPERATION<

Grading for construction should follow the Drawings. Prepare surface on which the geotextile will be placed to a relatively smooth condition. Surface shall be free from obstruction, debris, depressions, erosion, and vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all surfaces. Any loose material, soft or low density pockets of material, shall be removed; erosion features such as rills, gullies etc. shall be graded out of the surface before geotextile placement.

3.2.1 Stockpile Excavation Spoils

Materials removed from excavations and intended to be reused as fill below the soil cover later shall be stockpiled for radiological screening at an on-site location designated by the Contracting Officer.

3.2.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel- wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.3 PROTECTION

3.3.1 Drainage and Dewatering

3.3.1.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and

equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.3.1.2 Dewatering

Submit a Dewatering Work Plan for approval 15 days prior to starting work. Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.3.2 Stockpiles

Storage or stockpiling of material on the completed surface of the final subgrade surface will not be permitted.

3.3.3 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.3.3.1 Buried Tape and Detection Wire

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade. Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal.xt

3.3.4 Shoring

Submit a Shoring and Sheeting Plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are

backfilled, in a manner to prevent caving.

3.4 EXCAVATION AND BORROW PITS

3.4.1 General Excavation

Perform excavation of every type of material encountered within the project limits to the depths and dimensions indicated on the Drawings. Reuse excavated, screened, and uncontaminated materials to the extent possible in the areas below cover. Soil disturbed or weakened by Contractor's operations and soils softened or made unsuitable for subsequent construction caused by exposure to weather shall be removed and replaced. Excavated soil shall be stockpiled when necessary in the immediate area or at an on-site location as directed by the Contracting Officer. Keep excavations free from water while construction is in progress. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Notify the Contracting Officer immediately in writing if it becomes necessary to remove rock or hard, unstable, or otherwise unsatisfactory material. Blasting will not be permitted. Material failing screening will not be used on site and will be disposed of appropriately. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Compaction should follow the same provisions as for the soil covers. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph 3.9 Finishing Operations.Text

3.4.2 Utilization of Excavated Materials

Dispose excavated materials that do not passed radiological screening into designated waste disposal or spoil areas. Use passing screened material removed from excavations, insofar as practicable, in the construction of fills, embankments, and for similar purposes. Submit procedure and location for disposal of unused satisfactory material in the Materials Handling Plan. Submit proposed source of imported fill material. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.4.3 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structures as shown. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.4.4 Confirmation Screening Sampling Results

Preexcavation characterization samples will be collected to better define each excavation area. Samples will be collected at a rate of one sample for every 50 feet of proposed sidewall length and one sample for every 5 feet of proposed excavation depth. In addition, one bottom sample will be collected for every 250 square feet of proposed excavation area. This sampling frequency may be re-evaluated prior to implementation of the remedy (and included in a Sampling and Analysis Plan) and reduced in areas where existing soil data or physical limits (such as the limits of the Parcel E-2 Landfill) adequately define the proposed excavation.

3.5 MATERIAL STORAGE

Excavated material shall be placed in either temporary storage or transported directly for screening following the excavation. Storage units shall be in good condition and constructed of materials that are compatible with the materials to be stored. If multiple units are required for segregation, each unit shall be clearly labeled with an identification number and a written log shall be kept to track the material.

3.6 SOIL COVERS

Soil cover shall be constructed to the elevations and slopes indicated on the Drawings. The soil cover shall be compacted in 6-inch lifts to no less than 90 percent of maximum dry density at ± 3 percent of optimum moisture content. The top 6 inches shall be subject to one pass with a field packer resulting in a compaction to not greater than 85 percent of maximum dry density. During construction, placement of select fill shall conform to the following requirements:

a. The minimum allowable dry density shall be no less than 90 percent of maximum dry density for the base layers and no greater than 85 percent of maximum dry density for the top 6 inches.

b. The allowable moisture content range shall be ± 3 percent of optimum.

3.6.1 Installation

3.6.1.1 Select Fill Placement

No equipment shall be operated directly on the top surface of geosynthetics without permission from the Contracting Officer. Select fill shall be pushed out over geosynthetics in an upward tumbling motion so that wrinkles in geosynthetics do not fold over. Soil shall not be dropped directly onto geosynthetics from a height greater than 3 feet. On slopes, select fill shall be placed from the bottom of the slope upward.

3.6.1.2 Initial Lift of Select Fill Placed Over Geosynthetics

The first lift of soil placed over geosynthetics shall be a minimum of 12 inches in loose thickness. Equipment with ground pressures less than 7 psi shall be used to place and traffic compact the first lift of select fill. Traffic compaction shall consist of a minimum of 2 passes over all areas.

3.6.1.3 Subsequent Lifts of Select Fill

The loose lift thickness of each subsequent lift shall be no greater than 8 inches. Full scale placement and compaction equipment shall be allowed on

areas underlain by geosynthetics after the first loose lift of soil has been placed. Compaction shall consist of a minimum of 2 passes over all areas.

3.6.1.4 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.6.2 Construction Tolerances

Finished surfaces shall be uniformly graded and shall be free from depressions, mounds, or windows. The top surface of the select fill layer shall be no greater than 3 inches above the lives and grades shown on the Drawings. No minus tolerance will be permitted. Rigid grade stakes shall not be driven into the select fill layer to control placement.

3.6.3 Construction Tests

3.6.3.1 Select Fill Material TESTS

During construction of the select fill layer, representative samples shall be taken for testing at the frequencies listed in the table below from the imported source prior to placement. Test results must comply with the requirements listed in Part 2 Products or the material will be rejected for use.

SELECT FILL MATERIAL TEST FREQUENCIES

Test	Frequency	Method
Grain size analysis	2000 cubic yards	ASTM D422
Atterberg limits	2000 cubic yards	ASTM D4318
Compaction	5200 cubic yards	ASTM D698

Note 1: Compaction test results shall be compared with the results obtained during the imported fill source assessment. When there are significant differences, adjustments to the acceptable moisture content or density ranges shall be proposed by the Contractor for approval.

3.6.3.2 Moisture Content and Density Tests of In-Place Fill

Provide guidance from the manufacturer for protecting the geosynthetic demarcation layer from potential tearing from heavy equipment for the first lift above the material. Take precautions to ensure that the layer is not ruptured during construction and repair or replace as necessary.

SOIL COVER TESTIN REQUIREMENTS AND FREQUENCY

Tests	ASTM Method	Frequency	Required Minimum Criteria
Density & Moisture	D 6938-08a	One per 10,000 s.f	See SOIL COVER COMPACTION Table

Tests	ASTM Method	Frequency	Required Minimum Criteria
Density	D1556-07	One per 150,000 s.f. (minimum one	See SOIL COVER COMPACTION Table
Moisture	ASTM D2261	One per 150,000 s.f. (minimum one per day	Based on compaction curves
Compaction Curves	ASTM D1557	One per change in material	n/a
Identification of Soils	ASTM D2487	One per change in material	GW, GP, GM, SW, SM (bottom 6" per manufacturer's recommendations)

SOIL COVER COMPACTION

Fill Type	Maximum Loose Lift Thickness (	Mositure	Lift Density	Method of Test
All material greater than 2 feet from final cover elevation	6	3% of optimum	90% min	ASTM D6938 ASTM D1557
All material less than 2 feet from final cover elevation	6	3% of optimum	85% min	ASTM D6938 ASTM D1557

Note 1: Thinner lifts may be required to obtain adequate compaction.

Test Frequencies and Locations

Each day that select fill is placed, a minimum of one set of standard moisture content and density tests shall be performed. Nuclear density and moisture content tests shall be checked at the frequencies shown in the table above. Standard tests shall be performed at locations which are as close as possible to the locations of the nuclear tests being checked.

Nuclear Density and Moisture Content Test

Nuclear density readings shall be taken in the direct transmission mode. When ASTM D 6938 is used, the calibration curves shall be checked and adjusted using only the sand cone method as described in ASTM D 1556. ASTM D 6938 results in a wet unit weight of soil and when using this method ASTM D 6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 6938; the calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer.

Test Results

Field moisture content and density test results shall be compared to the compaction curve for the appropriate material type being tested. If test results are not within the acceptable range for moisture content or density, as described in subparagraph Moisture-Density (Compaction) Testing, 3 additional tests shall be performed near the location of the failed parameter. If all retests pass, no additional action shall be taken. If any of the retests fail, the lift of soil shall be repaired out to the limits defined by passing tests for that parameter. The area shall then be retested as directed.

3.6.4 Cover Protection

3.6.4.1 Damage

Erosion rills or other damages that occurs shall be repaired and grades re-established. Repairs to the select fill layer shall be documented including locations and volume of soil affected, corrective action taken, and results of retest.

3.7 SURFACE WATER CONTROL

Surface water controls will be established in accordance with the Drawings. Construct surface water control perimeter and slope ditches with invert elevations as shown. Install surface water control outlet, culvert, and freshwater wetlands outfalls in accordance with the Drawings, in alignments as shown. Subsurface drainage pertaining to the slurry wall is to be constructed in accordance with Section 02 35 27 Slurry Wall.

3.8 BACKFILL FOR APPURTANENCES

After the manhole, headwall, inlet, or similar structure has been constructed, place backfill in such a manner that the structure is not to be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.9 SERVICE ROAD

Construct service road in accordance with the Drawings.

3.10 PEDESTRIAN PATH

Place base material and construct pedestrian path in accordance with the Drawings. Asphalt is to be installed in accordance with Section 32 12 16 Hot-Mix Asphalt.

3.11 RIP-RAP CONSTRUCTION

Construct rip-rap in accordance with Section 35 31 19 Coastal Protection in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.11.1 Bedding Placement

Spread filter rock uniformly to a thickness of at least 6 inches on prepared subgrade as indicated. Finish bedding to present even surface free from mounds and windrows.

3.11.2 Stone Placement

Place armor rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.12 FINISHING OPERATIONS

Finish the surface of excavations, embankments, subgrades, roads, and pathways to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Finish gutters and ditches in a manner that will result in effective drainage. Repair graded or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.12.1 Grading

Construct finished grades as indicated within plus or minus one tenth (0.1) of one foot. Grade smooth existing surfaces that are to remain but have been disturbed by the Contractor's operations. Final grading shall not take place without subsequent placement of erosion resistant seeding layer within 2 calendar days or as weather conditions dictate. Grid spacing shall be 20-foot by 20-foot or smaller for survey verifications of thickness and grade.

3.12.2 Erosion Control Blanket

Install erosion control blanket in areas indicated on the Drawings and in accordance with manufacturer's instructions.

3.12.3 Composite Turf Reinforced Matting (CTRM)

Install matting in areas indicated on the Drawings and in accordance to manufacturer's instructions. Submit the MARV report(s).

3.12.3.1 Slopes

Prepare soil before installing matting, including any necessary application of lime, fertilizer, and seed. Begin at the top of the slope by anchoring the matting in a 6-inch deep by 6-inch wide trench with approximately 12 inches of matting extended beyond the up-slope portion of the trench. Anchor the matting with a row of staples/stakes approximately 12 inches apart in the bottom of the trench. Backfill and compact the trench after stapling. Apply seed to compacted soil and fold remaining 12-inch portion of matting back over seed and compacted soil. Secure matting over compacted soil with a row of staples/stakes spaced approximately 12 inches apart across the width of the matting. Roll the matting down the slope. Matting will unroll with appropriate side against soil surface. All matting must be securely fastened to soil surface by placing staples/stakes in appropriate locations according to manufacturer's recommendations. The edges of parallel matting must be stapled with approximately 2 inch to 5 inch overlap depending on manufacturer's recommendation. Consecutive matting spliced down the slope face must be placed end over end (shingle

style) with an approximate 3-inch overlap. Shingle all layers of CTRM such that upgradient panels overlay downgradient panels along slope transverse. Staple through overlapped area, approximately 12 inches apart across entire matting width.

3.12.4 Seeding

Provide as specified in Section 32 92 19 Seeding.

3.12.5 Protetion of Surfacess

Protect newly graded areas from traffic, erosion (see Section 01 57 19.00 20 Temporary Environmental Controls), and settlement that may occur. Repair or re-establish damaged grades, elevations, or slopes.

3.13 DISPOSAL OF SURPLUS MATERIAL

Dispose of all surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber, into an appropriate off-site disposal facility. All organic debris hauled off base shall be recycled at a local composting facility. Contractor shall minimize the generation of waste, inorganic trash, or debris whenever possible, recycle as much material as possible, and utilize local waste recovery sites available in the area.

3.14 FIELD QUALITY CONTROL

3.14.1 Sampling

Collect the number and size of samples required to perform the specified tests of source materials

3.14.2 Source Testing

Determine laboratory compaction characteristics and soil classification for each material used. Provide additional test for every source change.

Sample all imported materials once per source. Collect samples according to laboratory instruction. The laboratory shall analyze samples according to U.S. Environmental Protection Agency SW 846.

3.14.3 Field Density Tests

If a test location fails, the surrounding area shall be reworked up to at least half the distance to all nearby test locations that passed. Then, a new location within 10 feet of the previous test location shall be retested. Repeat until test location area passes.

Nuclear gauge results (ASTM D6938) shall be compared with and calibrated to oven-dried water content (ASTM D2216) and sand cone (ASTM D1556) tests according to the larger of the frequencies of the oven-dried water content and sand cone test.

3.14.3.1 Oversight

All earthwork will be overseen by a California Registered Civil Engineer or Geologist.

3.15 FINAL SOIL COVER SURVEY WITH AS-BUILT DRAWINGS

Perform a final cover survey of the cover once construction is complete. Include the final survey information on the As-Built Drawings.

3.15.1 Survey Information on Permanent Local Site Monuments

Install two permanent monuments on the final cover and two local monuments as designated on the Drawings.

-- End of Section --

and sand cone test.

3.14.3.1 Oversight

All earthwork will be overseen by a California Registered Civil Engineer or Geologist.

3.15 FINAL SOIL COVER SURVEY WITH AS-BUILT DRAWINGS

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Install two permanent monuments on the final cover and two local monuments as designated on the Drawings.

-- End of Section --

SECTION 31 05 19

GEOTEXTILE
03/13

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

Install geotextile for construction of the revetment in accordance with the Drawings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Unless otherwise noted, the latest version of each publication is to be used.

ASTM INTERNATIONAL (ASTM)

ASTM D123	(2012) Terminology Relating to Textiles
ASTM D4354	(1999; R 2009) Sampling of Geosynthetics for Testing
ASTM D4355	(2007) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491	(1999a; R 2009) Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2011) Trapezoid Tearing Strength of Geotextiles
ASTM D4632	(2008) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2004) Determining Apparent Opening Size of a Geotextile
ASTM D4833	(2007) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D4873	(2002; R 2009) Identification, Storage, and Handling of Geosynthetic Rolls and Samples

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

a. Geotextile

Geotextile samples for testing, if requested, to determine compliance with the requirements in this specification, a minimum of 60 days prior to the beginning of installation of the same textile. Upon delivery of the geotextile, submit duplicate copies of the written certificate of compliance signed by a legally authorized official of the manufacturer. The certificate shall state that the geotextile shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in Table 1. Upon request, supply quality control and quality assurance tests for the geotextile. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Samples submitted for testing shall be identified by manufacturers lot designation. For needle punched geotextile, the manufacturer shall certify that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

SD-07 Certificates

a. Geotextile

Manufacturer's certification of the geotextile material. All brands of geotextile and all seams to be used will be accepted on the basis of mill certificates or affidavits. Submit duplicate copies of the mill certificate or affidavit signed by a legally authorized official from the company manufacturing the geotextile. The mill certificate or affidavit shall attest that the geotextile meets the chemical, physical and manufacturing requirements stated in this specification.

1.4 DELIVERY, STORAGE, AND HANDLING

Delivery only approved geotextile rolls to the project site. All geotextile shall be labeled, shipped, stored, and handled in accordance with ASTM D4873. No hooks, tongs, or other sharp instruments shall be used for handling geotextile.

PART 2 PRODUCTS

2.1 FILTER LAYER GEOTEXTILE

2.1.1 General

Provide geotextile that is a woven pervious sheet of plastic yarn as defined by ASTM D123 matching or exceeding the minimum average roll values listed in Table 1, below. Strength values indicated in the table are for the weaker principal direction.

Table 1. Minimum Physical Requirements for Drainage Geotextile

Property	**Acceptable Values**	**Units**	**Test Method**
Grab Strength	250	lb	ASTM D4632

Property	Acceptable Values	Units	Test Method
Puncture	120	lb	ASTM D4833
Trapezoid Tear	60	lb	ASTM D4533
Apparent Opening	70	U.S. Sieve	ASTM D4751
Permitivity	0.28	sec -1	ASTM D4491
Ultraviolet Degradation	90	Percent at 500 Hrs	ASTM D4355

Obtain a guarantee from the selected manufacturer against failure of the geotextile material resulting from piping and subgrade erosion based on the existing subgrade conditions and the revetment material to be used.

2.1.2 Geotextile Fiber

Fibers used in the manufacturing of the geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. The maximum pins spacing shall be equal to or less than the values listed in Table 2, below. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contracting Officer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

Table 2. Maximum Spacing for Securing Pins

Embankment Slope	Spacing
Steeper than 1v on 3h	2 feet
1v on 3h to 1v on 4h	3 feet
Flatter than 1v on 4h	5 feet

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Geotextiles and factory seams shall meet the requirements specified above in Table 1. Randomly sample geotextiles in accordance with ASTM D4354 (Procedure Method A).

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site in accordance with ASTM D4354 (Procedure Method B) at a frequency of once per 100,000 square feet. Test samples to verify that the geotextile meets the requirements specified above, in Table 1. Identify samples by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Perform testing at an approved laboratory. Submit test results from the lot under review for approval prior to deployment of that lot of geotextile. Rolls which are sampled shall be immediately rewrapped in their protective covering.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and shall be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Any loose material, soft or low density pockets of material, shall be removed; erosion features such as rills, gullies etc. shall be graded out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile with the long dimension perpendicular to the shoreline and lay smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 24 inches of overlap for each joint of the demarcation geotextile. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the filter stone layer is placed will be allowed. Remove the temporary pins as the granular material is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Perform trimming in such a manner that the geotextile is not damaged in any way.

Geotextile should be secured within the revetment rock at both the crest and the toe of the structure as shown in the drawings. Not less than 5

feet of additional material should be per anchoring location. Anchoring method should be approved by the Contracting Officer.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replace with uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of bedding materials or riprap at no cost to the Government. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile. Protect the geotextile from damage prior to and during the placement of filter stone, riprap armor stone, or other materials. Before placement of filter stone or other materials, demonstrate that the placement technique will not cause damage to the geotextile. In no case shall any type of equipment be allowed on the unprotected geotextile.

3.4 PLACEMENT OF FILTER STONE MATERIAL

Perform placing of filter stone material in a manner to ensure intimate contact of the geotextile with the prepared surface. The placement shall also be performed in a manner that will not damage the geotextile including tear, puncture, or abrasion. On sloping surfaces place the filter material from the bottom of the slopes upward. During placement, the height of the drop of filter stone material shall not be greater than 12 inches or as specified in Section 35 31 19 COASTAL PROTECTION. Uncover any geotextile damaged beneath the filter stone

Refer to Section 35 31 19 COASTAL PROTECTION for additional information concerning the filter stone and its placement.

-- End of Section --

SECTION 31 21 00

PIPING; LANDFILL GAS
03/13

PART 1 GENERAL

NOTE: Treatment equipment has not been finalized and therefore some final materials in this section have not been finalized. Bracketed items/values below will be selected in the draft final design.

1.1 UNIT PRICES

Measurement and payment will be based on completed work performed in accordance with the drawings, specifications, and the contract payment schedules. No payment will be made under this section for excavation, trenching, or backfilling. Payment for such work will be made under Section 31 00 00 EARTHWORK.

1.1.1 Measurement

The length of pipe lines to be paid for will be determined by measuring along the centerline of the various sizes of pipe furnished and installed. Pipe will be measured from center of fitting to center of fitting and from connection to connection to wells or treatment units. No deduction will be made for the space occupied by valves or fittings.

1.1.2 Payment

Payment will be made for landfill gas piping at the contract unit price per linear foot for the various types and sizes of piping, and will be full compensation for pipes, joints, specials, and fittings, complete in place. Payment for valves, valve boxes, and standard valve manholes will be made at the respective contract unit price each for such items complete in place. Payment will include the furnishing of testing, plant, labor, and material and incidentals necessary to complete the work, as specified and as shown.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.2	(2000) Diaphragm-Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z400.1/Z129.1	(2010) Hazardous Industrial Chemicals - Material Safety Data Sheets - Preparation

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5L	(2007; Errata 2009; Addenda 1 2009; Addenda 2 2010; Addendum 2 2011; Addendum 3 2011; 44th Ed) Specification for Line Pipe
API Spec 6D	(2008; Errata 1 2008; Errata 2 2008; Errata 3 2009; Addendum 1 2009; Errata 4 2010; Errata 5 2010; Errata 6 2011; Addendum 2 2011; Addendum 3 2012) Specification for Pipeline Valves

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C218	(2008) Coating the Exterior of Aboveground Steel Water Pipelines and Fittings

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.40	(2008) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.8	(2010; Supplement 2010) Gas Transmission and Distribution Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A181/A181M	(2012) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B837	(2010) Standard Specification for Seamless Copper Tube for Natural Gas and Liquified Petroleum (LP) Gas Fuel Distribution Systems
ASTM C581	(2003; E 2008; R 2008) Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures, Intended for Liquid Service
ASTM C920	(2011) Standard Specification for Elastomeric Joint Sealants
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1598	(2002; R 2009) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D1693	(2012) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2466	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2006) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2513	(2012a) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2006; R 2011) Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM D2564	(2004; R 2009; E 2010) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007) Heat Fusion Joining Polyolefin Pipe

	and Fittings
ASTM D2672	(1996a; R 2009) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2683	(2010) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D2855	(1996; R 2010) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D2992	(2012) Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D3035	(2012) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3261	(2010a) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D3839	(2008) Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3892	(1993; R 2009) Packaging/Packing of Plastics
ASTM D3915	(2006) Rigid Poly(Vinyl Chloride) (PVC) and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Pressure Applications
ASTM E515	(2011) Leaks Using Bubble Emission Techniques
ASTM F1055	(2011) Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

ASTM F442/F442M	(2012) Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM F656	(2010) Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2008) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service

NACE INTERNATIONAL (NACE)

NACE SP0185	(2007) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe
NACE SP0274	(1974; R 2011) High Voltage Electrical Inspection of Pipeline Coatings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 58	(2011; TIA 10-1; Errata 10-1; TIA 11-2; TIA 11-3; Errata 11-2; Errata 12-3) Liquefied Petroleum Gas Code
NFPA 704	(2012) Standard System for the Identification of the Hazards of Materials for Emergency Response

PLASTICS PIPE INSTITUTE (PPI)

PPI TR-21	(2001) Thermal Expansion and Contraction in Plastic Piping Systems

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2012) Seismic Design for Buildings

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE	(2012) Flammable and Combustible Liquids and Gases Equipment Directory

1.3 SYSTEM DESCRIPTION

The landfill gas piping system shall consist of buried and above ground pipe, pipe supports, fittings, equipment and accessories. Submit Drawings containing graphical relationship of various components of the work, schematic diagrams of the systems, details of fabrication, layouts of particular elements, connections, clearance required for maintenance and operation, and other aspects of the work to demonstrate that the system has been coordinated and will properly function as a unit. Drawings to demonstrate that thermal expansion of plastic pipe exposed to ambient conditions as predicted by PPI TR-21 has been incorporated into the design. Submit a written certificate from the testing agency stating that the items have been tested and that they conform to the applicable requirements of the specifications. The certificate shall indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement that the items are in accordance with the applicable requirements of the specifications will be acceptable as evidence that the items conform with agency requirements.

1.3.1 Design Requirements

Provide piping in accordance with 49 CFR 192. Design for installation of plastic pipe above grade shall have provisions for movement due to thermal expansion and contraction documented to be in accordance with PPI TR-21. Seismic details shall be in accordance with UFC 3-310-04 and as shown on the drawings.

a. Soil bearing capacity: 500 psf.

b. Seismic parameters: S<SBS>ds</SBS> = 0.90g
(spectral response acceleration) S<SBS>d1</SBS> = 0.96g

c. Wind speed (maximum): 100 mph.

e. Ambient air temperature (maximum): 100 degrees F.

f. Ambient air temperature (minimum): 40 degrees F.

1.3.2 Performance Requirements

Capacity and design of the piping and accessories shall be suitable for 24-hour full load service in an outdoor location. Expansion of plastic pipe exposed to ambient conditions shall be calculated using the procedures from PPI TR-21. Pipe materials shall be compatible with each of the following gas properties.

a. Pipe segment:
Pressure (gauge maximum): 4 psig.
Pressure (gauge minimum): 2 psig.
Flow rate (maximum): 4 cubic ft/s.
Flow rate (minimum): 0.5 cubic ft/s.
Ambient temperature (maximum): 100 degrees F.
Ambient temperature (minimum): 40 degrees F.
Off-gas temperature (maximum): 130 degrees F.
Off-gas temperature (minimum): 50 degrees F.

b. Estimated chemical concentrations of gas:
pH: Minimum 2.0; Average 3.0; Maximum 6.5.
Sulfide: Maximum; 50 ppmv; Minimum 5ppmv; Average; 10ppmv as H<SBS>2</SBS>S .

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Materials and Equipment
Material Safety Data Sheet
Statement of Satisfactory Installation

SD-06 Test Reports

Destructive Joint Tests
Bubble Tests
Pressure Testing
Leakage Testing
Vacuum Testing
Hanger Acceptance Testing

SD-07 Certificates

Landfill gas Piping System
Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.5 QUALITY ASSURANCE

1.5.1 Contractor Qualifications

Contractor shall have had a minimum of 5 years of experience in the construction of piping systems for landfill gas, condensable gas, off-gas or vapor.

1.5.2 Single Source Supplier

Assign to a single supplier full responsibility for the furnishing of the off-gas piping system. The designated single supplier, however, need not

manufacture the system but shall coordinate the selection, assembly, installation, and testing of the entire system as specified herein.

1.5.3 Jointing Plastic and Fiberglass Reinforced Pipe

Use manufacturer's prequalified joining procedures. Joints shall be inspected by an inspector qualified in the joining procedures being used and in accordance with AGA XR0603. Joiners and inspectors shall be qualified at the job site by a person who has been trained and certified by the manufacturer of the pipe, to train and qualify joiners and inspectors in each joining procedure to be used on the job. Training shall include use of equipment, explanation of the procedure, and successfully making joints which pass tests specified in AGA XR0603. Notify the Contracting Officer at least 24 hours in advance of the date to qualify joiners and inspectors.

1.5.4 PRE-INSTALLATION MEETING

Pre-installation meeting will be required. Ensure that involved Sub-c ontractors, suppliers, and manufacturers are represented. The date and time of the conference shall be furnished to the Contracting Officer for approval.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Packaging

Plastic pipe shall be packed, packaged and marked in accordance with ASTM D3892.

1.6.2 Cleaners, Solvents and Glues

A material safety data sheet in conformance with ANSI Z400.1/Z129.1 shall accompany each chemical delivered for solvents, solvent cements, or glues used in pipe connections or pipe installation. Handling shall be in accordance with ASTM F402.

1.6.3 Storage

Classify and mark storage facilities in accordance with NFPA 704. Store materials with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) damage, or other damage. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendations. Piping bundles shall be stored on a prepared surface and should not be stacked more than two bundles high.

1.7 SEQUENCING AND SCHEDULING

Installation shall be as specified in Section 31 00 00 EARTHWORK, except as modified herein or required by ASTM D2774, ASTM D2855, ASTM D3839, or ASTM F402, as appropriate for the pipe material.

1.8 EXTRA MATERIALS

Three copies of anyspecial wrenches required for removal of locking covers shall be provided for each type of valve box or junction box.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment that are new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. Piping material and appurtenances shall be as specified and as shown on the drawings, and shall be suitable for the service intended. Submit manufacturer's descriptive data and technical literature for each piping system, including design recommendations, pressure and temperature ratings, dimensions, type, grade and strength of pipe and fittings, thermal characteristics (coefficient of expansion and thermal conductivity) and chemical resistivity for each chemical constituent in the off-gas stream. Manufacturer's recommended installation procedures including materials preparation, and installations.

2.1.1 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Pipe, valves, fittings and appurtenances shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Identification

Each piece of pipe shall bear the ASTM designation and the ASTM markings required for that designation. Each valve shall be marked in accordance with MSS SP-25 to identify the manufacturer, size, pressure rating, body disc and seat material. Securely attach a tag with the manufacturer's name, catalog number and valve identification.

2.2 DESIGN STRENGTH

Design strength of piping shall be suitable for the operating pressure and temperature ranges indicated and/or shown. With the exception of vacuum pipe segments, thermoplastic pipe shall not be used to transport air or vapors in exposed above ground locations.

2.3 STEEL PIPE

Steel pipe shall be Schedule 40 conforming to [Grade A or B, Type E or S of ASTM A53/A53M,] [API Spec 5L,] [ASME B31.8,] [or] [NFPA 58]. Pipe threads shall conform to ASME B1.20.1. Fittings for pipe 1-1/2 inches and smaller shall conform to ASME B16.11. Buttweld fittings for pipe 1-1/2 inches or less shall conform to ASME B16.9. Joint sealing compound shall conform to UL FLAMMABLE & COMBUSTIBLE, Class 20 or less. Polytetrafluoroethylene tape shall conform to ASTM D3308. Weld neck flanges shall be used. Connections shall conform to ASTM A181/A181M, Class 60, carbon steel. Carbon steel components shall be coated with materials suitable for exposure to condensates. Coatings and finishes shall be 100 percent VOC free.

2.3.1 Carbon Steel Located Above Grade

Surfaces of aboveground carbon steel components shall be [_____] coated in accordance with AWWA C218 [three-coat alkyd system 1-91-A] [three-coat alkyd system 1-91-W] [three-coat alkyd system 1-91-S] [four-coat alkyd system 2-91-A] [four-coat alkyd system 2-91-W] [four-coat alkyd system

2-91-S] [three-coat alkyd/silicone alkyd system 3-91-W] [three-coat alkyd/silicone alkyd system 3-91-S] [three-coat epoxy/urethane system 4-91-W] [three-coat epoxy/urethane 4-91-S] [three-coat inorganic or organic zinc/epoxy/urethane 5-91-W] [three-coat inorganic or organic zinc/epoxy/urethane 5-91-S] [two- or three-coat epoxy/coal tar epoxy 6-91-B] [two or three- coat water reducible epoxy-polyamid 7-91-W] [two- or three-coat water reducible epoxy-polyamid 7-91-S] [three-coat water reducible acrylic or alkyd-modified acrylic emulsion 8-91-W] [three-coat water reducible acrylic or alkyd-modified acrylic emulsion 8-91-S] [two- or three-coat epoxy/high-build aliphatic polyurethane over existing coated substrates 9-95-W] [two- or three-coat epoxy/high-build aliphatic polyurethane over existing coated substrates 9-95-S].

2.3.2 Silicone Coating

Surfaces of carbon steel components shall be blasted in accordance with SSPC SP 6/NACE No.3. Surface shall have an alkyd primer 2.5 mils dry film thickness followed by two alkyd modified silicone final coats.

2.3.3 Zinc Coating

Surfaces of carbon steel components shall be coated with zinc in accordance with ASTM A123/A123M or ASTM A153/A153M.

2.3.4 Thermoplastic Resin Coating System

[Surfaces of carbon steel components shall have a minimum of [4] [5] [6] coats of phenolic type coatings applied [1.6] [2] mils minimum dry film thickness per coat. Each coat shall be baked at 300 degrees F for 10 minutes. Full coating system shall be cured in oven at [375] [450] degrees F for 30 minutes.] [Continuously extruded polyethylene and adhesive coating system materials shall conform to NACE SP0185 Type A.]

2.3.5 Cathodic Protection

Buried ferrous pipe systems shall have cathodic protection.

2.4 COPPER TUBING

Copper tubing shall conform to ASTM B837.

2.5 POLYVINYL CHLORIDE (PVC) PIPING

Design and fabrication of below grade components of the landfill gas piping system shall be in accordance with ASTM D2513 except as modified herein.

2.5.1 PVC Pipe

Pipe shall be in accordance with ASTM F442/F442M, ASTM D2241, Schedule 80. Materials shall conform to ASTM D3915, ASTM D1784, Type IV, Grade 1, rigid (23447-B). The maximum eccentricity of the inside and outside circumferences of the pipe walls shall be 12 percent. Pipe shall be provided which does not fail, balloon, burst, or weep as defined in ASTM D1598.

2.5.2 PVC Joints

Joints shall be pressure rated solvent cemented bell joints in accordance with ASTM D2672 except where flanged or threaded fittings are required at

expansion joints, valves, flowmeter, equipment connections or otherwise shown. Flanges shall be joined to pipe by solvent cementing. Primer shall conform to ASTM F656. Solvent cement shall conform to ASTM D2564.

2.5.3 PVC Fittings

Fittings shall be in accordance with [ASTM D2466] [ASTM D2467].

2.6 POLYETHYLENE (PE) PIPING

Design and fabrication of below grade components of the landfillgas piping system shall be in accordance with ASTM D2513 except as modified herein.

2.6.1 PE Pipe

Pipe shall be in accordance with ASTM D3035, SDR 17. Wall thickness shall be SDR 11 [_____]. Melt flow shall be less than 1.5 g/10 min. with method ASTM D1248, Condition F. Environmental stress crack resistance shall exceed 1000 hours, ASTM D1693, Condition C.

2.6.2 PE Joints and Fittings

Fittings shall be pressure rated electrofusion fittings in accordance with ASTM F1055, butt heat fusion fittings in accordance with ASTM D3261 or socket-type fittings in accordance with ASTM D2683 except where flanged connections are required at expansion joints, valves, flowmeter, equipment connections or otherwise shown. Flanges shall be joined to pipe by heat fusion in accordance with ASTM D2657.

2.7 REINFORCED EPOXY RESIN PIPING

Design and fabrication of below grade components of the LANDFILL gas piping system shall be in accordance with ASTM D2992 except as modified herein.

2.7.1 Epoxy Resin Pipe

Pipe shall be in accordance with ASTM D2517. Resin shall be chemically resistant to condensates as determined by ASTM C581.

2.7.2 Epoxy Resin Joints and Fittings

Joints and fittings shall be in accordance with ASTM D2517.

2.8 FLANGED CONNECTIONS

2.8.1 Flanges

Flanges shall be Class [150] [_____], socket weld, flat face in accordance with ASME B16.5. Drilling and dimensions of flanges, bolts, nuts, and bolt patterns shall be in accordance with ASME B16.5, Class [150] [_____]. Bolts and nuts shall [conform to ASTM A307] [be 304 stainless steel].

2.8.2 Gaskets

Gaskets shall be full face, non-asbestos compressed material compatible with the expected condensates in accordance with ASME B16.21, 1/8 inch minimum thickness, full face or self-centering flat ring type. Gaskets

shall be aramid fibers bonded with nitrile butadiene rubber (NBR) or glass fibers bonded with polytetrafluoroethylene suitable for 200 degrees F service and meeting applicable requirements of [ASME B31.8.]

2.8.3 Sealants

Sealants shall conform to ASTM C920.

2.9 EQUIPMENT AND APPURTENANCES

2.9.1 Manually Operated Valves

Ball valves shall be in accordance with MSS SP-72. Gate, plug, ball, and check valves shall be in accordance with API Spec 6D. Thermoplastic gas shutoffs and valves shall be in accordance with ASME B16.40.

2.9.2 Relief Valves (for compressed air only)

Relief valve with manually adjustable pressure differential shall be provided for each blower or vacuum pump. Relief valve shall be [weighted] [spring] [pilot-operated diaphragm type] with a [_____] percent accumulation. Relief valve diameter shall be line sized or as otherwise indicated and shall be rated to relieve [_____] cubic feet per minute at a set pressure of [_____] psig or a vacuum of [_____] inches Hg. Materials shall be [aluminum] [bronze] [cast iron] [stainless steel] [_____] body, [bronze] [316 stainless steel] [_____] trim, and [Buna-N] [EPR] [nitrile] [Viton] [Teflon] [_____] elastomers. Maximum operating temperature and pressure shall be [_____] degrees F and [_____] psi.

2.9.3 Unloading Valves (for compressed air only)

Unloading valves shall be included to minimize pump/motor overloading during start and stop operations. Unloading valves shall be [pilot-operated diaphragm type with auxiliary solenoid operator] [actuated butterfly valve control by blower system controls]. Unloading valve shall be rated to relieve [_____] cubic feet/minute at a set pressure of [_____] psi or a vacuum of [_____] inches Hg. Materials shall be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Maximum operating temperature and pressure shall be [_____] degrees F and [_____] psig respectively.

2.9.4 Vacuum Breakers

Vacuum breakers shall be provided to protect blowers and vacuum pumps from damage due to excessive vacuum surges. Vacuum Breakers shall be [pilot-operated diaphragm type with auxiliary solenoid operator] [actuated butterfly valve control by blower system controls]. Valve shall be rated to relieve [_____] cfm at a set pressure of [_____] psi or a vacuum of [_____] inches Hg. Materials shall be [aluminum] [bronze] [stainless steel] body, [bronze] [316 stainless steel] trim, and [Buna-N] [EPR] [Viton] [Teflon] elastomers. Maximum operating temperature and pressure shall be [_____] degrees F and [_____] psi.

2.9.5 Dielectric Fittings

Dielectric fittings shall be installed between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains. Dielectric fittings shall prevent metal-to-metal contact of dissimilar metallic piping elements and shall be suitable for the

required working pressure.

2.9.6 Meters

Gas meters shall conform to AGA ANSI B109.2.

2.9.7 Insulation

Not used.

2.9.8 Supports for Aboveground Piping

Furnish pipe hangers and supports complete with necessary inserts, bolts, nuts, rods, washers, and accessories. Design and construction shall be in accordance with MSS SP-58. Specific application shall be in accordance with MSS SP-69. Hanger and supports shall be capable of adjustment after placement of piping. Hangers and supports shall be the product of one manufacturer. Hangers, supports and accessories shall be hot dip galvanized in accordance with ASTM A123/A123Munless copper or plastic coated. Restrained joints and thrust protection shall be provided. Concrete and metal cradles, collars, floor stands, supports, kickers, and block shall be provided as recommended by manufacturer. Pipe cradle cushion material shall be elastomer sheet strapped to pipe to prevent chafing at pipe support. Elastomer sheet shall be utilized around top of pipe to prevent chafing of pipe strap.

2.9.9 Valve Boxes

Valve boxes shall be adjustable extension type with screw or slide-type adjustments constructed of cast iron not less than 3/16 inch thick. Valve boxes shall be provided with locking covers that require a special wrench for removal and the word "gas" cast in the box cover.

2.10 FACTORY TESTS

Test [steel piping] [a representative unit of each diameter of steel piping] by the manufacturer or a nationally recognized testing agency in compliance with NACE SP0274.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 MANUFACTURER'S REPRESENTATIVE

Provide the services of a manufacturer's field service representative who is experienced in the installation of the materials and equipment furnished and who has complete knowledge of the proper operation and maintenance of the system. Submit the name and qualifications of the manufacturer's representative and written certification from the manufacturer that the representative is technically qualified.

3.3 CONDENSATE CONTROL

Slope off-gas piping uniformly between control elevations to enhance the

removal of liquids as shown in the Contract Drawings. Make provisions to collect and drain liquids from condensation in each pipe run. Liquid removal sumps and traps shall be located in the piping systems.

3.4 PRESSURE REGULATOR AND METER INSTALLATION

Install a valve on each side of each meter or regulator for isolating the regulator for calibration, maintenance. and removal. An insulating joint constructed to prevent flow of electrical current shall be installed between metallic pipe and the meter or regulator.

3.4.1 Pressure Regulators

Not used.

3.4.2 Meters

Install meters in accordance with ASME B31.8.

3.4.3 Vents

Not used.

3.5 INSTALLING PIPE UNDERGROUND

Installation shall be as specified in Section 31 00 00 EARTHWORK, except as modified herein; and as required by ASTM F402 and ASTM D2855 for using solvents and cleaners, ASTM D2774 for polyvinyl chloride and polyethylene pipe, and ASTM D3839 for fiberglass pipe.

3.5.1 Valve Boxes

Install valve boxes at each underground valve except where concrete or other type of housing is indicated. When the valve is located in a roadway, protect the valve box by a suitable concrete slab at least 3 square feet. When in a sidewalk, the top of the box shall be in a concrete slab 2 feet square and set flush with the sidewalk. Valve boxes shall be separately supported, not resting on the pipe, so that traffic loads cannot be transmitted to the pipe.

3.5.2 Magnetic Tape

When non-metallic piping is installed underground, place foil backed magnetic tape above the pipe to permit locating with a magnetic detector. Tape shall be marked "GAS PIPE BELOW".

3.5.3 Pipe Coatings

Repair any damage to the protective covering during transit and handling before installation.

3.6 INSTALLING PIPE ABOVEGROUND

With the exception of vacuum pipe segments [A-B] [B-C] [D-E] [_____] as indicated and/or shown, thermoplastic pipe shall not be installed aboveground. Install vertical pipe plumb in all directions. Perpendicular piping shall be installed parallel to building walls. Piping at angles and

45 degree runs across corners will not be accepted unless specifically shown. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Piping shall be located to avoid ducts, equipment, and beams. Piping shall be installed to avoid obstructing corridors, walkways, work areas, and like spaces. Provide a minimum headroom clearance of 7 feet under piping, unless otherwise indicated. Temporary caps or plugs shall be provided at pipe openings at the end of each day's work. Run piping in groups where practicable. Minimum clearance shall be 1 inch between pipe and other work.

3.6.1 Hangers and Supports

Install pipe hangers and supports in accordance with MSS SP-58 and MSS SP-69 at locations where pipe changes direction. Hanger rods shall be installed straight and vertical. Chain, wire, strap or perforated bar hangers will not be permitted. Hangers shall not be suspended from piping. Where proper hanger or support spacing does not correspond with joist or rib spacing, suspend pipe from structural steel channels attached to joists or ribs. Contact between dissimilar metals shall be prevented when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports. Isolate thin walled stainless steel piping from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl. Use galvanized or stainless steel hangers and supports in basins or submerged locations. Maximum support spacing, unless otherwise shown or approved for standard weight steel pipe, shall be as follows:

Pipe Size	Spacing
Less than 2 in	6 feet
2 to 3 in	10 feet
Greater than 3 in	12 feet

Maximum support spacing for pipe other than standard weight steel shall be two-thirds of the corresponding spacing for steel pipe unless otherwise shown or approved.

3.6.2 Insulation

Not used.

3.6.3 Coatings or Finishes

Coatings and finishes shall be in accordance with SectionPAINTS AND COATINGS. Repair damage to the factory covering during transit and handling before installation. Painting is not required where piping is insulated, stainless steel, galvanized steel or nonferrous. Factory painted items requiring touching-up in the field shall be cleaned of foreign material and shall be primed and top coated with the manufacturer's standard factory finish. Paint exposed ferrous surfaces with two coats of enamel paint. Factory primed surfaces shall be solvent cleaned before painting. Prepare and prime surfaces that have not been factory primed in accordance with the enamel paint manufacturer's recommendations.

3.7 JOINING PIPE

Join non-metallic piping by performance qualified joiners using qualified procedures in accordance with AGA XR0603. Joints shall be inspected by an

inspector qualified in the joining procedures being used and in accordance with AGA XR0603.

3.7.1 O-Ring Joints

Clean jointing surfaces and adjacent areas before making joint. Gaskets and "O"-rings shall be lubricated and adjusted in accordance with manufacturer's recommendations. Check each gasket for proper position around full circumference of the joint after "O"-rings are compressed and before pipe is brought fully home. Jointing pipe shall be done in accordance with ASTM D3139 and manufacturer's recommendations.

3.7.2 Mechanical Joints

The plain end shall be centered and pushed into the bell. The gasket shall be firmly pressed evenly into the bell. The gland shall be slipped to the bell for bolting. The bolt threads shall be oiled. Bolts shall be tightened alternately 180 degrees opposite to each other to seat the gasket evenly. Apply bituminous coating to ferrous bolts and nuts before assembly. The maximum torque on bolts shall be as follows:

Bolt Size	Applied Torque
5/8 in	50 ft-lb
3/4 in	80 ft-lb
1 in	90 ft-lb
1-1/4 in	110 ft-lb

3.7.3 Flanged Joints

Use hexagon head nuts and bolts. Bolt projection through the end of the nut shall be limited to [1/4] [_____] inch maximum. Manufacturer's rating and instructions for specified service shall be followed.

3.7.4 Expansion Couplings

Provide expansion couplings in tension to facilitate their removal. Stretcher bolts shall be set for maximum allowable elongation of expansion coupling as recommended by the manufacturer. Expansion couplings shall be provided as shown and as recommended by the manufacturer.

3.7.5 Destructive Joint Tests

Each day, prior to making heat fusion joints, a joint of each size and type to be installed that day shall be made by each person assembling these joints that day and shall be destructively tested. Cut at least 3 longitudinal straps from each joint. Each strap shall be visually examined, shall not contain voids or discontinuities on the cut surfaces of the joint area, and shall be deformed by bending, torque, or impact, and if failure occurs, it must not initiate in the joint area. If a joint fails the visual or deformation test, the qualified joiner who made that joint shall not make further field joints in plastic pipe on this job until that person has been retrained and requalified. The results of the destructive tests shall be recorded to include the date and time of the tests, size and type of the joints, ambient conditions, fusion iron temperature and names of inspectors and joiners.

3.8 CONNECTIONS

3.8.1 Transitions Between Types of Pipe

Provide necessary adapters, specials and connector pieces when connecting different types and sizes of pipe or pipe furnished by different manufacturers. Underground connecting joints shall be encased with 6 inches minimum, Class B concrete unless otherwise shown, or recommended by manufacturer. Connections between piping and equipment, where required, shall be made using [approved] [proper] fittings to suit the actual conditions.

3.8.2 Connections to Source and Discharge Points

Connect the landfill gas pipelines to the source and discharge locations. Notify the Contracting Officer, in writing, 10 days before final connections and activation of the system.

3.8.3 Connection to Equipment

Provide connections to the equipment in accordance with approved procedures. Isolation of equipment shall only be done at the valve location shown on the drawings.

3.8.4 Location of Existing Piping

Locations of existing piping shown should be considered approximate. Contractor is responsible for determining exact location of existing piping which may be affected by the work during all operations.

3.8.5 Removing Existing Pipelines from Service

Pipelines shall not be removed from service unless specifically listed or approved by Contracting Officer. Notify the Contracting Officer at least 48 hours prior to removing each pipeline from service.

3.9 PRESSURE AND LEAKAGE TESTS

Perform tests on pipe sections that can be isolated. Joints shall be tested in sections prior to backfilling when trenches have to be backfilled before the completion of other pipeline sections. Labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection during the tests. The Contractor shall be responsible for the cost of repair, replacement, and retesting required because of failure to meet testing requirements. Prior to testing the system, the interior shall be blown out, cleaned and cleared of foreign materials. Meters, regulators, and controls shall be removed before blowing out and cleaning and reinstalled after clearing of foreign materials. Maintain safety precautions for pressure testing during the tests. Notify Contracting Officer 48 hours in advance of pressure, leakage and/or vacuum testing. Conduct tests in the presence of the Contracting Officer unless otherwise directed. During the test, the entire system shall be completely isolated from compressors and other sources of pressure. Perform testing with due regard for the safety of employees and the public during the test. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. Leakage test shall be conducted only after satisfactory completion of pressure test.

3.9.1 Bubble Tests

Test each joint in accordance with ASTM E515 prior to backfilling or concealing any work.

3.9.2 Pressure Testing

Backfill shall be placed and compacted to at least the pipe centerline before testing. Allow concrete blocking to reach design strength. Blocking shall be backfilled and compacted to assure restraint by harnessed joints before testing. Thermoplastic pipe section to be tested shall be slowly filled with water. Corporation cocks shall be installed as necessary to remove air and water. Test pressure shall be applied for one hour and gauge pressure shall be observed. Leaks shall be continuously checked while test pressure is being maintained. The landfill gas piping system shall be tested after construction and before being placed in service using water as the test medium. The pressure test shall continue for at least 8 hours from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the pipe has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. The temperatures shall be representative of the actual trench conditions. There shall be no indication of reduction of the test pressure, 10 psig, applied at the lowest elevation of the pipeline section, during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2)=T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial and final readings. Lines which fail to hold specified test pressure or which exceed the allowable leakage rate shall be repaired and retested.

3.9.3 Leakage Testing

Allow pipe to stand full of water at least 12 hours prior to starting leakage test. Exposed pipe, joints, fittings and valves shall be examined. Visible leakage shall be stopped, and the defective pipe, fitting or valve shall be replaced. The line under test shall be refilled to reach the required test pressure. The amount of water permitted as leakage shall be placed in a container attached to the supply side of the test pump. Container shall be sealed. No other source of supply to the pump or line under test shall be attached. Water shall be pumped into the line with the test pump to hold [_____] psig for [2] [4] [8] hours. Water remaining in the container and the amount used during the test shall be measured and recorded on the test report. Test shall be considered as failed upon exhaustion of supply and/or inability to maintain the required pressure.

3.9.4 Vacuum Testing

Test shall be performed on [the entire system] [individual sections] as approved by the Contracting Officer. Openings shall be sealed in system or section to be tested. Vacuum [_____] psig shall be pulled for one hour (isolating system from vacuum by closing valves). System shall be allowed to normalize and then the initial vacuum readings shall be recorded. The vacuum shall be recorded at intervals of [15 minutes] [1 hour] [_____] for the duration of the [8] [_____] hour test. Measurable leakage (loss of vacuum) after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2)=T(2)P(1), in which

T and P denote absolute temperature and total pressure, respectively, and the numbers denote initial and final readings, shall be repaired and retested.

3.9.5 Hanger Acceptance Testing

Pipe systems shall be brought up to operating pressures and temperatures. Systems shall be recycled to duplicate operating conditions. Submit reports of all inspections or tests, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used shall be identified and test results shall be recorded.

3.9.6 Demonstration

Upon completion of the work and before final acceptance, submit a Statement of Satisfactory Installation signed by the principal officer of the contracting firm stating that: the installation is satisfactory and in accordance with the contract plans and specifications; the manufacturer's prescribed procedures and techniques have been followed; and at a time designated by the Contracting Officer. The services of a qualified engineer shall be provided for a period of not less than [8] [_____] hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under this Section. Submit [6] [_____] copies, in indexed booklet form, of site specific operation and maintenance manual for the piping system including system operation, system maintenance, equipment operation, and equipment maintenance manuals described below. If operation and maintenance manuals are provided in a common volume, they shall be clearly differentiated and separately indexed. The field instructions shall cover the items contained in the bound instructions.

a. The System Operation Manual shall include but not be limited to the following:

(1). Maps showing piping layout and locations of system valves and line markers.

(2). Step-by-step procedures required for system startup, operation, and shutdown. System components and equipment shall be indexed to the maps.

(3). Isolation procedures and valve operations to shut down or isolate each section of the system. Valves and other system components shall be indexed to the maps.

(4). Descriptions of Site Specific Standard Operation Procedures including permanent and temporary pipe repair procedures, system restart and test procedures for placing repaired lines back in service, and procedures for abandoning piping and system components.

(5). Descriptions of Emergency Procedures including: isolation procedures including required valve operations with valve locations indexed to the map, recommended emergency equipment, and checklist for major emergencies.

b. The Equipment Operation Manual shall include but not be limited to detail drawings, equipment data, and manufacturer supplied operation manuals for equipment, valves and system components.

c. The System Maintenance Manuals shall include but not be limited to:

(1). Maintenance check list for entire system.

(2). Descriptions of site specific standard maintenance procedures.

(3). Maintenance procedures for installed cathodic protection systems.

(4). Piping layout, equipment layout, and control diagrams of the systems as installed.

(5). Identification of pipe materials and manufacturer by location, pipe repair procedures, and jointing procedures at transitions to other piping materials or piping from different manufacturer.

d. The Equipment Maintenance Manuals shall include but not be limited to the following:

(1). Identification of valves and other equipment by materials, manufacturer, vendor identification and location.

(2). Maintenance procedures and recommended maintenance tool kits for valves and equipment.

(3). Recommended repair methods, either field repair, factory repair, or whole-item replacement for each valve component or piece of equipment or component item.

(4). Routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide.

-- End of Section --

SECTION 32 12 16

HOT-MIX ASPHALT (HMA) FOR ROADS
03/13

PART 1 GENERAL

This section is being deferred to the Draft Final version of the RD.

-- End of Section --

SECTION 32 31 26

WIRE FENCES AND GATES
03/13

PART 1 GENERAL

1.1 DESCRIPTION

This section covers the requirements for both temporay and permanent chain link fencing for the site. Further details on the placement of the fencing and the construction details are shown in the Drawings. Existing fence should be used in the temporary fencing of the site to the extent practical where it will not be obstructive to the work area. Reuse temporary fence meterials where practical for the construction of the final fence,

1.2 RELATED SECITONS

Section 31 00 00 Earthwork

1.3 SUBMITTALS

The following shall be submitted in accordance with Seciton 01 33 00 Submittal Procedures.

1.3.1 SD-03, Manufacturer's Catalog Data

a. Fencing components
b. Accessories

1.3.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 Gates

FS RR-F-191/2; Type I, single swing or Type II, double swing, as indicated on the drawings. Gate dimensions shall be as indicated on the drawings. Framing and bracing members, round or square of steel alloy. PVC-coated over zinc- or aluminum-coated steel. Use minimum sizes for gate frames and braces listed in FS RR-F-191/3D for each Class and Grade. Coating for steel latches, stops, hinges, keepers, and accessories, PVC-coated over zinc- or aluminum-coated steel. Gate latches, fork type. For double swing gate, drive 1-foot of 3/4-inch nominal diameter galvanized water pipe flush to ground surface to receive vertical slider. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding will not be permitted. Arrange padlocking latches to be accessible from both sides of gate, regardless of latching arrangement. Padlocks shall have case-hardened shackles with bodies of a nonferrous alloy. Ten padlock keys shall be provided for each padlock, sequentially numbered and reading “DO NOT DUPLICATE.”

2.1.1 Posts and Braces

FS RR-F-191/3D line posts; Class 1, steel pipe, Grade A or B. End, corner, and pull posts; Class 1, steel pipe, Grade A or B. Braces and rails; Class 1, steel pipe, Grade A or B, in minimum sizes listed in FS RR-F-191/3 for each class and grade. Provide PVC color coating, minimum thickness, 0.10 inch.Text

2.1.2 Fencing Accessories

Shall conform to the requirements of FS RR-F-191/4D. Provide wire ties constructed of the same material as the fencing fabric. Provide accessories with polyvinyl (PVC) coatings similar to that specified for chain-link fabric or framework.

2.1.3 Concrete

Shall conform to the requirements of Section 03 30 00 Cast-in-Place Concrete.

PART 3 EXECUTION

3.1 SITE PREPERATION

3.1.1 Excavation

Excavate to dimensions indicated for concrete-embedded items as shown on the drawings. Follow excavation procedures as specified in Section 31 00 00 Earthwork.

3.2 FENCE INSTALLATIONN

Consult Contracting Officer before construction of fence to determine which fences to install.

Install fence to line as indicated on the drawings, a four-sided square enclosure. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.1 Post Setting

Set post plumb. Provide concrete bases of dimensions as indicated on the drawings. Compact concrete to eliminate voids and finish to a dome shape. Allow concrete to cure a minimum of 72 hours before performing other work on posts.

3.2.2 Bracing

Brace gate with a diagonal truss rod and truss tighter used as a tension member.Text

3.2.3 Fabric

Pull fabric taught and secure fabric to tension wire and posts. Secure fabric to posts using stretcher bars, ties, or clips spaced 15 inches on center, or by integrally weaving to integral fastening loops of end, corner, pull, and gate posts for full length of each post. Install fabric on opposite side of posts from area being secured. Install fabric so that bottom of fabric is minimum 2 inches above ground level.

3.3 FENCE ACCESSSORIES INSTALLATION

3.3.1 Post Caps

Install post caps as recommended by the manufacturer.

3.3.2 Gates

Install gates on side of enclosure that alows gate to swing open at least 135 degrees. Provide Contracting Officer with padlock and keys.

3.4 CLEANUP

Remove waste fencing materials and other debris from the site.

-- End of Section --

SECTION 32 92 19

SEEDING AND PLANTING
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2007) Agricultural Liming Materials

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Vegetation Establishment Plan

SD-03 Product Data

Seed Mixes

Mixture, percent pure live seed, minimum percent germination and hard seed, maximum percent weed seed content, date tested, and state certification (California Seed Law).

Fertilizer

Chemical analysis, composition percent if used.

Straw mulch

Weight receipts from scales shall be required.

Lime

Calcium carbonate equivalent and sieve analysis if used.

SD-06 Test Reports

Soil composition tests (reports and recommendations).

SD-07 Certificates

State certification and approval for seed (California Seed Law)

1.3 WORK SCHEDULE

The work shall progress as soon as the site becomes available consistent with normal seasonal limitations. The optimal seeding periods are between October 15th April 15th. Submit a Vegetation Establishment Plan.

1.4 DELIVERY, STORAGE, AND HANDLING

1. All products shall be delivered to the site in manufacturer's unopened standard containers bearing original labels showing quantity, analysis and name of manufacturer.

2. All materials shall be stored in designated areas and in such a manner as to protect them from weather or other conditions that might demage or impair the effectiveness of the product.

1.5 ANALYSIS OF SAMPLES AND TESTS

1. Samples: The owner reserves the right to take and analyze samples of materials for conformity to the specifications at any time. On request, seed shall delivered to owner 30 days prior to seeding so seed can be tested. Seed samples shall be drawn in accordance with procedures outlined in AOSA, Association of Official Seed Analysts.

2. Rejected material: Rejected materials shall be removed immediately from the site at Contractor's expense. Contractor shall pay the cost of testing replacement materials.

1.6 FINAL ACCEPTANCE AND WARRANTY PERIOD

Upon completion of each 25% of the specified work, the owner shall accept each area. The contractor shall not provide warranty beyond those granted by any of the material manufacturers. It shall be the right of the owner to inspect work for compliance to the specifications and advise the contractor, in writing, of any work that is found to deviate from specifications.

PART 2 PRODUCTS

2.1 SEED MIXES

2.1.1 Classification

Provide State-certified seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Seed Mixture by Weight

45 Total Pounds/Acre			
Pounds/Acre	**Species**	**Common Name**	**% by Weight**
25	*Bromus carinatus*	California Brome	53.8%
10	*Hordeum brachyantherum*	Meadow Barley	21.5%
6	*Vulpia microstachys*	Small Fescue	12.9%
4	*Trifolium wildenovii or obtusiflorum*	Tomcat or Clammy Clover	8.6%
1.5	*Eschscholzia californica*	California Poppy	3.2%

2.1.3 Quality

All seed shall be in conformance with the California State Seed Law of the Department of Agriculture. Each seed bag shall be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee, and dates of test. In addition, the container shall be labeled to clearly reflect the amount of Pure Live Seed (PLS) contained. Prior to seeding at the request of the owner, the contractor shall provide a letter of certification, original Association of Official Seed Analysts (AOSA) seed test results, and calculations of PLS content.

Seed shall not exceed 0.5 percent weed content by weight. If seed available on the market does not meet the minimum purity and germination percentages specified, the Contractor must compensate for a lesser percentage of purity or germination by furnishing sufficient additional seed to equal the specified product. Product comparison shall be made on the basis of pure live seed in pounds. The formula used for determining the quantity of pure live seed shall be: Pounds of seed x (Purity x Germination) = pounds of Pure Live Seed. Samples may be drawn by the Engineer for testing.

2.2 SOIL AMENDMENTS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein. Submit soil composition tests to verify the amendments listed below.

2.2.1 Fertilizer

Text

2.2.2 Lime

Commercial grade hydrate or burnt limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602.

2.3 STRAW MULCH

Straw shall be derived from irrigated wheat or barley fields or from rice

straw. The contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw from outside the county in which it is to be used is delivered to the site of the work. Straw that has been used for bedding is prohibited.

Contractor shall use a commercial type mulcher for the application of slurry or loose broadcast. The areas to be seeded shall be mulched so as to provide uniform distribution of mulch without waste.

2.4 WATER

Irrigation water shall not contain a total dissolved solids level of greater than the salt tolerance of the plant species for any growth regime, irrigation practice used, and local climate. Water shall be applied at rate such that seeding machinery operates smoothly, but that minimizes surface runoff and leaching once applied.

2.5 Wetlands Plants and Soil Requirements

See design drawing C25 for wetlands plants list and Section 3.9 of the Design Basis Report for soil quality requirements.

PART 3 EXECUTION

3.1 SOIL PREPARATION

1. Verify that all areas to receive seed are free of vegetation and other objectionable material.

2. Verify that grades are final for permanently treated areas and within reasonable standard for temporary treatments.

3. All sloped areas will be uniformly compacted.

3.2 SEEDING

3.2.1 Seeding Time

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy, frozen or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seed shall be sown according to supplies instructions. Seeding shall take place as soon as final grade has been achieved and heavy equipment has been retired from the project. If seeding is performed outside the preferred seeding times shown in Paragraph 1.3 Work Schedule, provide water, as needed according to supplier instruction.

3.2.2.1 Planting Conditions

Planting operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, or other

unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to the planting operations, proposed times shall be submitted to and approved by the Contracting Officer.

3.3 FINAL ACCEPTANCE OF VEGETATION

3.3.1 Preliminary Inspection

Not less than 21 days prior to the completion of the Vegetation Establishment Period, a preliminary inspection will be held by the Contracting Officer. Date and time for the inspection will be established in writing and will be communicated to the Contractor 14 days prior to the inspection date. The acceptability of the vegetation in accordance with the Vegetation Establishment Period shall be determined. An unacceptable stand of vegetation shall be repaired as soon as conditions permit.

3.3.2 Final Inspection

Within 7 days of the end of the Vegetation Establishment Period, a final inspection will be held by the Contracting Officer to determine that deficiencies noted in the preliminary inspection have been corrected. Date and time for the inspection will be established in writing and communicated to the Contractor 14 days prior to the inspection date.

-- End of Section --

SECTION 33 24 00.00 20

GAS EXTRACTION WELLS
03/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A312/A312M	(2012) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2487	(2011) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2009a) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4397	(2010) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D5088	(2002; R 2008) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2004; E 2010; R 2010) Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM F480	(2012) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010;

	Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600-4-89-034	(1990) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

1.2 DESCRIPTION OF WORK

Provide gas extraction wells including drilling, casing, well screen, gravel packing, grouting, and incidental related work complete and ready for operation.

1.3 GENERAL REQUIREMENTS

Each system, including equipment, materials, installation, and performance, shall be in accordance with local, State, and Federal regulations, ASTM D5092, and EPA 600-4-89-034 except as modified herein. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" has been substituted for the word "should" wherever it appears. Reference to the "Project Representative" and the "Owner" shall be interpreted to mean the Contracting Officer. Additional requirements are included under Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Mark and secure monitoring well(s) to avoid unauthorized access and tampering.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Well construction

SD-03 Product Data

Well casing

Well screen

Filter pack

Neat cement grout

Bentonite seal

SD-07 Certificates

Well Drilling Material Handling Plan

Health and Safety Plan

Field Sampling and Laboratory Testing Plan

Treatment facility permit

Installation Survey Report

Borehole Analysis Report

SD-11 Closeout Submittals

Well Development Report

Well Construction Permit

Shipment manifests

Delivery certificates

Treatment and disposal certificates

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store plastic piping, jointing materials, and rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

1.6 QUALITY ASSURANCE

1.6.1 Required Drawings

Submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Drawings shall be prepared by a State certified professional geologist or hydrogeologist, or by a State registered professional civil engineer, hereafter referred to as the Contractor's Professional Consultant (CPC). Drawings shall be sealed.

1.6.2 Well Drilling Material Handling Plan

A material handling plan shall be furnished by the Contractor 15 days prior to initiation of the work that describes phases of dealing with the potentially contaminated soil and groundwater, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling, material hauling, proposed equipment, handling of the contaminated materials, soil and water testing requirements, and safety precautions and requirements.

1.6.3 Health and Safety Plan (HASP)

Describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and EM 385-1-1. Identify safety equipment and procedures to be available and used during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.

1.6.4 Field Sampling and Laboratory Testing Plan

Describe field sampling methods and quality control procedures. Identify laboratory and laboratory methods to be used for contamination testing. Sample reports shall show sample identification for location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, and quality control procedures.

1.6.5 Treatment Facility Permit

Verification that the proposed treatment facility is permitted to accept the contaminated materials specified, prior to the start of excavation.

1.6.6 Well Development Report

Provide report, containing the following data for each groundwater well: project name and location, well designation, date and time of well installation, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.

1.6.7 Well Construction Permit

Submit a completed permit application and a proposed method of construction to the appropriate state agency prior to construction of the well. Construction of the wells will not be allowed until an approved Well Construction Permit has been submitted to the Contracting Officer.

1.6.8 Shipment Manifests

Copies of manifests and other documentation required for shipment of waste materials within 24 hours after removal of waste from the site. Shipment manifests shall be signed by the Contracting Officer.

1.6.9 Delivery Certificates

Verification that the wastes were actually delivered to the approved treatment facility, within 7 days of shipment.

1.6.10 Treatment and Disposal Certificates

Verification that the wastes were successfully treated and remediated to the levels specified herein.

PART 2 PRODUCTS

2.1 WELL CASING

2.1.1 Stainless Steel Piping

ASTM A312/A312M, Type 304, Schedule 40S, with flush threaded joint end fittings. Threaded joints shall be wrapped with flouropolymer tape, and provided with nitrile O-ring gaskets.

2.1.2 PVC Piping

ASTM F480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule 80, with flush threaded joint fittings. Threaded joints shall be wrapped with flouropolymer tape, and provided with nitrile O-ring gaskets.

2.1.2.1 PVC Slip Joint

Slip joint (expansion fitting) shall be PVC, REP Series 1000 or approved equal. Solid casing shall be inserted a minimum of 3 feet into the slip joint and perforation section.

2.2 WELL SCREEN

Well screens shall be located as indicated. The length of eachscreen shall be as indicated. Perforation size shall be 1/2 inch. Perforations shall be distributed uniformly around the circumference of the screen as shown in the Contract Drawings.

2.2.1 Stainless Steel Screens

ASTM A312/A312M, Type 304, Schedule 40S, continuous slot construction, wire wound, with flush threaded joint ends.

2.2.2 PVC Screens

ASTM D1785, PVC 1120, NSF wc or NSF pw, Schedule80, screen, machine-slotted construction, flush threaded joint ends. Slots shall be even in width, length, and separation.

2.3 PRIMARY FILTER PACK

Provide course gravel (drain rock) consisting of permeable aggregate material, clean, washed, rounded to subrounded, non-carbonate and free of organic matter. The material shall meet the following gradation requiremtns in accordance with ASTM C136:.

U.S. Sieve Size	Range ot Percent Passing
3 inches	100
2 inches	50 to 100
1 inch	0 to 50
1/2 inch	0

2.4 SECONDARY FILTER PACK

Gradation in accordance with ASTM D5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack shall not contain organic matter or friable materials.

2.5 ANNULAR SEALANTS

2.5.1 Bentonite Seal

Provide powdered, granular, pelletized, or chipped sodium montmorillonite in sealed containers from a commercial source, free of impurities. Diameter of pellets shall be less than one fifth the diameter of the borehole annular space to prevent bridging. Bentonite base grout shall be in accordance with ASTM D5092.

2.5.2 Neat Cement Grout

Provide neat cement grout in accordance with ASTM D5092. Cement shall be in accordance with ASTM C150/C150M. Quick setting admixtures shall not be allowed. Drilling mud or cuttings shall not be used as a sealing material.

2.6 BOTTOM PLUGS

Provide flush threaded solid plug at the bottom of the well. Plug shall be the same material as the well casing to which it is attached. Joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.

2.7 LOCKING WELL CAP

Not used.

2.8 WELL HEAD COMPLETIONS

Clearly mark and secure the well to avoid unauthorized access and tampering. Cast the words "GAS EXTRACTION WELL" on the well head cover. Provide stamped metal identification tag as follows:

DO NOT DISTURB
ID #: Date:
Installed By:
Total Depth:
Screened Interval:
TOC Elevation:
Other:
For Information, Call:

2.8.1 Aboveground Completions

In areas accessible to vehicles provide 6 inch diameter steel pipe bollards, filled with concrete as indicated to protect the exposed well head.

2.8.1.1 Protective Outer Casing and Bollards

ASTM A53/A53M, Type E or S, Grade B.

2.8.1.2 Well Casing Cap

Provide cap on top of the casing. Cap shall be of the same material as the protective outer casing. Threaded joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.

2.8.2 At-Grade Completions

Provide aluminum vault box, 30 by 30 inches, with watertight frame and cover. Vault shall support H-20 loading for traffic areas. The frame shall be 6 inches deep, and shall be set in a concrete collar a minimum of 8 inches thick, and extending 4 inches beyond the edge of the frame in all directions. Frame and concrete collar shall be set 3 inches above the existing grade.

2.9 POLYETHYLENE SHEETING

ASTM D4397.

PART 3 EXECUTION

3.1 GENERAL

Notify the Contracting Officer at least 15 days prior to commencement of work. Location(s) of well(s) shall be as indicated. Drilling, installation, and development of the extraction well(s) shall be supervised, directed, and monitored by the CPC. Drilling, sampling, and well development equipment introduced to the well shall be decontaminated before and after each use in accordance with ASTM D5088.

3.2 DRILLING

Borehole shall be advanced using conventional 24-inch bucket auger drilling methods. If it is the opinion of the CPC that an alternate drilling method is required, justification for a boring method change shall be submitted to the Contracting Officer, and approval for the change granted prior to drilling. Drill crew shall be experienced and trained in drilling and safety requirements for contaminated sites.

3.2.1 Sampling

Log boring in accordance with ASTM D2487 and ASTM D2488. If groundwater is encountered cease drilling and notify Contracting Officer. Initial and 24-hour groundwater elevations shall be indicated.

3.2.2 Analysis

The CPC shall review the log data from each borehole and compare the data with the well design requirements. The CPC shall verify the adequacy of the well design, or shall offer a proposed modification to the design based on the geologic and hydrogeologic data obtained from the borehole. This review and analysis shall be conducted for each borehole. The CPC shall submit the borehole boring logs, the analysis of the well design, and any proposed design modifications to the Contracting Officer in a Borehole Analysis Report. Any modifications to the well design approved by the Contracting Officer shall be considered a change to the contract documents and shall be negotiated in accordance with the "CHANGES" clause.

3.3 SOIL AND WASTE REMOVED FROM THE BOREHOLE

3.3.1 Temporary Containment of Soil and Waste Removed from the Borehole

Soil and wasteremoved from the borehole shall be placed in a temporary containment area. Provide a temporary containment area near the well site. Cover containment area with 10 mil reinforced polyethylene sheeting. Place soil and waste removed from the borehole(s) on the impervious barrier and cover with 6 mil reinforced polyethylene sheeting. Provide a straw bale berm around the outer limits of the containment area and cover with polyethylene sheets. Secure edges of sheets with weights to keep the polyethylene sheeting in place. Water runoff shall be diverted from the stockpiled material. As an option, soil and waste may be stockpiled in trucks or covered bins suitable for transporting contaminated soiland wastes as specified herein.

3.3.2 Testing Requirements for Stockpiled Soils and Waste

3.3.2.1 Sampling

A minimum of one composite sample shall be developed and analyzed for each required test for every 100 cubic yards or fraction thereof from a composite stockpile of soil and waste removed from all well sites. To develop a composite sample of the size necessary to run the required tests, the Contractor shall take several samples from different areas along the surface and in the center of the stockpile. These samples shall be combined and thoroughly mixed to develop the composite sample.

3.3.2.2 Testing

a. The soil and waste shall contain no free liquid as demonstrated by EPA 530/F-93/004, Method 9095, paint filter liquids test.

b. The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by using EPA 530/F-93/004, Method 5030/8020.

c. TPH (total petroleum hydrocarbons) concentrations shall be determined by using EPA 530/F-93/004, Method (8015) , which has been modified for use with soil.

d. Material shall be tested for TOX (total organic halogens) in accordance with EPA 530/F-93/004, Method 9020.

e. Material shall be analyzed for full TCLP in accordance with EPA 530/F-93/004, Method 1311 and for ignitability, corrosivity, and reactivity.

f. Material shall be tested for polychlorinated biphenyls (PCB's) in accordance with EPA 530/F-93/004, Method 8080.

g. Moisture content of the sample shall be determined in accordance with EPA Method 160.3.

3.3.2.3 Disposal of Stockpiled Soil and Wastes

See Section 31 00 00 EARTHWORKS for soil disposal requirements.

3.4 WELL INSTALLATION

Well installation shall be in accordance with ASTM D5092 and EPA 600-4-89-034, and as indicated on the well construction drawings submitted by the CPC and approved by the Contracting Officer. Borehole shall be stable and shall be verified straight before beginning installation.

3.4.1 Casings and Screens

Well casings, screens, plugs, and caps shall new and be decontaminated prior to delivery by the manufacturer and shall be certified clean. Materials shall be delivered, stored, and handled in such manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation. If directed by the Contracting Officer, the well screen and casing assembly shall be cleaned with high pressure water prior to installation. Centralizers shall be used to ensure that the well screen and casing assembly is installed concentrically in the borehole. When the assembly has been installed at the appropriate elevation, it shall be adequately secured to preclude movement during placement of the filter packs and annular seals. The top of the well casing shall be capped during filter pack placement.

3.4.2 Primary and Secondary Filter Packs

Primary and secondary filter packs shall be placed as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Control speed of filter placement to prevent bridging and to allow for settlement. Prior to commencement of work, equipment and methods required to place filters shall be approved by the Contracting Officer.

3.4.3 Bentonite Seal

Bentonite shall be placed as a slurry through a tremie pipe. Control speed of bentonite placement to prevent bridging or segregation of slurry. Additional water shall be added to the annular space as directed by the CPC to ensure complete hydration of the bentonite.

3.4.4 Well Head Completions

Well head completions shall be as indicated and as specified herein.

3.5 WATER FROM WELL DEVELOPMENT OPERATIONS

Water from the well development operations shall be containerized in accordance with State and local regulations. One sample shall be taken and analyzed for each required test for every 1000 gallons of stored water from well development operations.

Water will be tested and disposed of in accordance with Federal, State, and local laws and regulations.

3.6 TRANSPORTATION OF CONTAMINATED SOIL, WASTE, AND WATER

The Contractor shall be solely responsible for complying with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and shall bear responsibility and cost for any noncompliance. In addition to those requirements, the Contractor

shall do the following:

a. Inspect and document vehicles and containers for proper operation and covering.

b. Inspect vehicles and containers for proper markings, manifest documents, and other requirements for waste shipment.

c. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.

3.7 DISPOSAL OF CONTAMINATED SOIL, WASTE, AND WATER

Contaminated materials removed from the site shall be disposed of in a treatment/disposal facility permitted to accept such materials.

3.8 INSTALLATION SURVEY

Upon completion of well installation and development and acceptance by the Contracting Officer therefore, the vertical and horizontal position of each well shall be determined by a registered land surveyor licensed in the State of California. The survey shall document the vertical elevations of the top of the casing pipe and the ground surface elevation adjacent to each well. The survey shall also determine the horizontal location of each well based on the California State plane coordinate system. Survey shall be accurate to the nearest .01 foot. This data shall be submitted with a well location map as the Installation Survey Report.

3.9 CLEANUP

Upon completion of the well construction, remove debris and surplus materials from the jobsite.

-- End of Section --

SECTION 33 24 13

GROUNDWATER MONITORING WELLS
08/08

PART 1 GENERAL

1.1 UNIT PRICES

Payment for each specified item is made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test holes or monitoring wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Contractor. Submit catalog data for monitoring well screens (to include the screen slot size), casing, riser pipe, filter pack material, bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, and chemical specifications on drill lubricants and tracers, if used. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes, and Samples," the additional depth is paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment is made for the test hole.

1.1.2 Monitoring Well Drilling and Sampling

If the total depth of the monitoring well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth is paid for at the contract unit price for "Additional Monitoring Well Depth."

1.1.3 Geophysical Logging

The "Geophysical Logging" unit price includes interpretation of the logs and their delivery to the Government.

1.1.4 Casing/Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the well. Payment includes compensation for decontamination and installation of the casing/riser pipe, cap, tail piece (if any), end cap and centralizers; and for the furnishing and installing of the well identification tag with information recorded thereon, or well marking in accordance with contract.

1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.6 Filter Pack Construction

Filter pack construction is measured by the cubic foot. Payment includes compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.1.7 Bentonite Seal

The bentonite seal is measured by the cubic foot. Payment includes full compensation for hydrating, and tremieing necessary for the work.

1.1.8 Grout Placement

The cement and/or bentonite grout ASTM C1107/C1107M, and ASTM D4380,used in the annulus above the bentonite seal is paid by the cubic foot used. Payment includes compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, bailing, sample photograph, discharge water containers, and disposal.

1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, and protective steel posts.

1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test hole and for the required well or test hole abandonment records.

1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition, in accordance with paragraph SITE CLEANUP. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring well.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2005) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A312/A312M	(2012) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C1107/C1107M	(2011) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2011) Standard Specification for Portland Cement
ASTM C387/C387M	(2011b) Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2488	(2009a) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4380	(1984; R 2006) Standard Test Method for Density of Bentonitic Slurries
ASTM D4750	(1987; R 2001) Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
ASTM D5088	(2002; R 2008) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2004; R 2010e1) Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D5299	(1999; R 2005) Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
ASTM D5521	(2005) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2010) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM D6725	(2004; R 2010) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers

ASTM F480	(2012) Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(1999) Munsell (R) Soil Color Charts

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R	(2009) Geological Rock Color Chart (Munsell)

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2012) Plastics Piping System Components and Related Materials

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.3 SYSTEM DESCRIPTION

Construct each monitoring well to yield chemically representative ground water samples of the screened interval for chemical analysis, and to allow for the accurate measurement of ground water depths relative to the top of the well riser, by use of electrical, wetted tape, or acoustical methods. The screened interval is that portion of a monitoring well which is directly open to the host aquifer by way of openings in the well screen and indirectly open to the aquifer by way of the filter pack (or other permeable material) extending continuously below and/or above the screen.

1.3.1 Prepacked Screen Monitoring Wells

Materials and installation of prepacked screen monitoring wells are to conform to the requirements of ASTM D6725.

1.3.2 Installation Plan

Submit a plan, describing the drilling methods, sampling, and monitoring well construction and well development 30 calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal

of the plan. Provide the plan approved and signed by a geologist experienced in hazardous waste projects as specified in paragraph QUALIFICATIONS. Incorporate the following requirements into the Contractor's Monitoring Well Installation Plan and follow in the field. Sampling and Testing is to be conducted in accordance with the guidelines as stated in: "Department of Defense Policy and Guidelines for Acquisitions Involving Environmental Sampling or Testing", November 2007. Include in the plan, but do not limit to a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Forms to be used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, state well registration forms, and well abandonment records.

e. Description of contamination prevention and well materials and equipment decontamination procedures.

f. Description of protective cover surface completion procedures, including any special design criteria/features relating to frost heave prevention. Include the maximum frost penetration for the site in this description.

g. Description of well development methods to be used.

h. List of applicable publications, including state and local regulations and standards.

i. List of personnel assignments for this project, and personnel qualifications.

j. Description of well decommissioning/abandonment procedures.

k. Description of in-situ permeability determination techniques, if testing is required.

l. Description and discussion of geophysical techniques to be employed at the site.

1.3.3 Performance Requirements

Install each monitoring well to prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical or horizontal seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with EPA 530/F-93/004, EPA 600/4-79/020, and EPA SW-846.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Installation Diagrams
- Survey Maps and Notes

SD-03 Product Data

- Borehole Logs
- Installation Diagrams
- Well Development Records
- Geophysical Logs
- Well Decommissioning/Abandonment Records
- Project Photographs
- Monitoring Wells
- Qualifications
- Permits
- Installation Plan
- Documentation and Quality Control Reports

SD-06 Test Reports

- Water Source
- Filter Pack
- Drilling Fluid Additive

1.5 QUALITY ASSURANCE

1.5.1 Notification

Notify the Installation Environmental Coordinator (IEC)7 days prior to drilling. The Contractoris responsible for contacting the State of CA USEPA in accordance with the applicable reporting requirements.

1.5.2 Qualifications

Submit personnel qualification documentation. Provide an onsite geologist with at least 3 years experience in hazardous waste projects, soil and rock logging, and monitoring well installation, registered in the state of CA, responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Provide a driller licensed in the state of CA, according to the state requirements. Perform and provide geophysical log interpretation done by a qualified log analyst, demonstrating competence through background, training, and experience when so called upon. Furnish Contractor documentation proving a minimum of 5 years of monitor well installation experience, and appropriate health and safety personnel on staff as specified in Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES, and personnel qualified to perform the necessary chemical sampling as presented in the approved Sampling and Analysis Plan.

1.6 DELIVERY, STORAGE, AND HANDLING

Store and maintain monitoring well materials in a clean, uncontaminated condition throughout the course of the project.

1.7 SITE CONDITIONS

Access to each monitoring well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work is the responsibility of the Contractor. Submit a copy of all permits, licenses, or other requirements necessary for execution of the work. Before beginning work,notify local United States Geological Survey office (USGS) and the State Environmental Protection office of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells. Furnish a copy of all such correspondence. Obtaining rights-of-entry is the responsibility of the Contractor. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site. If clearing or relocation is necessary, the Contractor and the Installation Environmental Coordinator will agree on a suitable clearing, or relocation plan and the location of any required access road.

PART 2 PRODUCTS

2.1 WELL CASING

Provide new monitoring well casing/riser 4 inch nominal internal diameter, schedule 40 flush-joint threaded ASTM D1785 polyvinyl chloride (PVC) pipe, meeting the requirements of NSF/ANSI 14, with required fittings conforming to ASTM F480 flush thread male by female fittings Type 304 stainless steel. The minimum wall thickness shall be schedule 5S meeting the requirements of ASTM A312/A312M. Do not use pop rivets or screws. Provide a PVC locking cap, that threads or slips onto the top of the well casing.

2.2 CENTRALIZERS

Attach stainless steel centralizers to the well casing when monitoring wells are over 40 feet in length. Centralizers are not required if the monitoring wells are installed through hollow-stem augers.

2.3 WELL SCREEN

Provide monitoring well screen, designed and constructed in accordance with paragraph SYSTEM DESCRIPTION, consisting of new commercially fabricated flush-joint threaded 4 inch nominal internal diameter polyvinyl chloride (PVC) schedule 40 slotted, non-clogging design. Provide schedule 40 end fittings on the continuous wrap screen. Provide required fittings conforming to ASTM F480, flush thread male by female. Provide screen slot size as determined by the Contractor, and approved by the Government 0.010 inch, and screen length of 10 feet or as determined by the Contractor. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 6 inches of the open portion of the screen.

2.4 FILTER PACK

Provide filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Submit filter pack material test results; sieve and chemical analyses. Organic matter,

soft, friable, thin, or elongated particles are not permissible. Determine the gradation of the filter pack using the grain size analysis data obtained as required in paragraph Sampling. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight pint size glass container with a sample of filter pack material and furnish to the Contracting Officer for each well to serve as a quality control.

2.5 BENTONITE SEAL

Provide a bentonite seal, intended to keep grout from entering the filter pack, consisting of hydrated granular, or pelletized, sodium montmorillonite furnished in sacks or buckets from a commercial source, free of impurities which adversely impact the water quality. If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.6 CEMENT AND BENTONITE GROUT

Provide cement grout with a mixture of a maximum of 7 gallons of approved water per 94 lb bag of portland cement, conforming to ASTM C150/C150M, Type I. Add no more than 5 percent by weight of bentonite powder to reduce shrinkage, hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout. Mix water from an approved source with these powders or granules to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. The slurry shall contain at least 20 percent solids by weight and have a density of 9.4 lb per gallon of water or greater. Provide additional construction details for grout placement above the bentonite seal for frost heave protection as directed in paragraph Protective Cover Placement.

2.7 CONCRETE PAD

Construct a concrete pad around the protective cover at the ground surface.

2.8 PROTECTIVE COVERS

Equip monitoring wells with a steel lockable protective casing/enclosure set over the well casing, set in the concrete pad or surface seal. Provide weather resistant padlocks which use the same key (keyed-alike) on the protective covers, or lockable caps for all wells. Cap any well that is to be temporarily removed from service or left incomplete due to delay in construction with a watertight cap and equipped with a vandal resistant cover.

2.9 PROTECTIVE POSTS

Not used.

2.10 CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS

Provide D.O.T. approved drums, containers, or vessels for containment of water removed during development and testing operations, and cuttings from the drilling operations, as specified in 49 CFR 172. Furnish polyethylene and steel drums with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

a. drum number,
b. site name,
c. well name and number,
d. contents and date,
e. approximate depth of material contained in each drum, and
f. the name and phone number of the Contracting Officer.

PART 3 EXECUTION

3.1 PROTECTION OF EXISTING CONDITIONS

Maintain all existing survey monuments and monitoring wells, and protect them from damage from equipment and vehicular traffic. Immediately report and repair any items damaged by the Contractor. Re-install monitoring wells requiring replacement due to Contractor negligence according to these specifications. Protect wells scheduled for abandonment from damage so that abandonment may be performed according to these specifications. Prior to excavation, obtain written approval from the local utility companies to drill at each site, to avoid disturbing buried utilities.

3.2 PREPARATION

3.2.1 Decontamination

a. Clean the drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each monitoring well location. Perform decontamination in accordance with ASTM D5088 ASTM D5608, at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.

b. Clean screen and well casing with high-pressure hot water immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the Sampling and Analysis Plan.

c. Use only water for cleaning from a Government approved source. Sample and test the water source used for cleaning for the constituents specified in the Sampling and Analysis Plan prior to use at the site.

3.2.2 Decontamination Station

a. Construct a temporary decontamination pad onsite, bermed and slightly inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place plywood sheeting, exterior grade, over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.

c. Pump water collected in the sump using a "trash" pump to transfer water to a 55 gallon drum labeled "Decontamination Pad Sump Water." Transfer solid waste to a separate 55 gallon drum labeled "Decontamination Pad Sump Sludge."

3.2.3 Water Source

If well drilling/installation requires the use of water, prior to its use at the site, sample and test the water source, and obtain approval from the Contracting Officer for the constituents specified in the Sampling and Analysis Plan. Submit decontamination and drilling water source analytical test results. The Contractor is responsible for locating the source, obtaining the water from the source, transporting it to, and storing it at the site. Obtain a water sample from the container used in transporting the water to the site before the water is used for decontamination, and sample, test, and secure approval in accordance with the above requirements.

3.3 INSTALLATION

3.3.1 Drilling Method

a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Make the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer(s), filter pack, seal and grout.

b. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Any drilling fluid additive used shall be inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material, and prevent runoff from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

3.3.2 Test Hole Requirements

Drill one test hole for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph Decontamination.

3.3.3 Geophysical Logging

Geophysically log the total depth of each test hole drilled. Document geophysical logging in accordance with paragraph Geophysical Logs. Perform log analyses and interpretations by a person qualified in accordance with paragraph QUALIFICATIONS.

3.3.4 Borehole Diameter and Depth

Provide sufficient diameter in borings for monitoring well installation to permit at least 2 inches of annular space between the boring wall and all sides of the centered riser pipe and screen. Determine depths of individual borings as specified in the approved Monitoring Well Installation Plan as indicated on the drawings, with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.3.5 Screen, Well Casing/Riser Pipe Placement

a. Provide the monitoring well screen in length as shown on the drawings, as determined by the Contractor and approved by the Government, with specified bottom cap securely attached, set to the appropriate depth.

b. Place the bottom of the well screen no more than 3 feet above the bottom of the drilled borehole. Place the well screen in the appropriate location in the borehole so that the completed monitoring well functions in accordance with paragraphs SYSTEM DESCRIPTION and WELL ACCEPTANCE.

c. Provide sieve analyses of all drive sampled material, conducted in accordance with ASTM C136. Place the well screen as specified on the drawings. Join the screen and well casing/riser pipe sections by flush threaded watertight joints, with the well casing/riser pipe extending upwards from the screen to an elevation appropriate for the surface completion described in paragraph Protective Cover Placement. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole. Clean the screen and well casing/riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning.

d. Provide watertight flush threaded joints and fastenings ; solvent glue or set screws are not permitted.

e. Make the well centered and plumb by the use of stainless steel centralizers, in accordance with paragraph CENTRALIZERS, spaced 120 degrees apart at intervals not exceeding 20 feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal. Verify the alignment of the well by passing a 5 foot long section of rigid pipe 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing/riser pipe prior to placement of the filter pack and sealing materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

3.3.6 Filter Pack Placement

a. After the screen and well casing have been concentrically placed in the hole, construct the approved filter pack around the screen by filling the entire space between the screen and the wall of the hole over the selected screened interval. Place the lowermost 1 foot of filter pack in the boring prior to installation of the well screen, serving as a base on which to place the screen. Lower a tremie pipe having an inside nominal diameter of not less than 1 inch, to the bottom of the annulus between the hole and well. Clean the tremie pipe with high pressure hot water/steam prior to each use. Arrange the tremie pipe so that water and filter pack material fed at uniform rates are discharged as the filter pack material fills the hole from the bottom up. Raise the tremie pipe at a rate that will keep the bottom of the pipe no more than 5 feet above the top of the surface of the filter pack level, and no more than 2 feet below the surface of the filter pack level at all times.

b. Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed to a minimum of 3 feet above the top of the screen in the monitoring well, to a height equal to 20 percent of the length of the screen, to within no more than 20 feet of the top of the ground surface. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph Water Source.

c. Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals. Remove temporary drill casing, if installed, or auger simultaneously with the above operation. Minimize lifting of the riser pipe when withdrawing the temporary casing/auger. Place filter pack material in lifts no greater than 3 foot prior to retraction of the temporary casing/auger. Leave a minimum of 6 inches of filter pack in the temporary casing/auger at all times during filter pack installation. Take frequent measurements inside the annulus during retraction to ensure that the filter pack is properly placed.

3.3.7 Bentonite Seal

Place a minimum 3 foot thick hydrated bentonite seal on top of the filter pack in a manner which prevents bridging of the bentonite in the annulus, such that the bottom of the bentonite seal is a minimum of 3 feet above the top of the filter pack. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. If the bentonite seal is located above any borehole fluid levels, place a 1 foot layer of fine sand at the top of the bentonite seal.

3.3.8 Grout Placement

Mechanically mix a non-shrinking cement, in accordance with paragraph CEMENT AND BENTONITE GROUT, and placed in one continuous operation into the annulus above the bentonite seal to within 2 feet of the ground surface. Make grout injection in accordance with ASTM D5092. If the casing interval

to be grouted is less than 15 feet, and without fluids after any drill casing is removed, place the grout either by pouring or pumping. Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well. Construct the bottom of the tremie pipe to direct the discharge to the sides rather than downward, keeping the discharge end of the tremie pipe submerged at all times. Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within 24 hours after cement grouting. Verify the alignment of the well by passing a 5 foot long section of rigid PVC pipe 1/4 inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well will not be accepted. Thoroughly clean the pipe section with high pressure hot water/steam prior to each test.

3.3.9 Concrete or Gravel Pad Placement

Construct a concrete pad with a minimum radius of 2 feet from the protective casing and 4 inch thick, sloped away from the well around the well casing at the final ground level elevation. Prior to placement of the gravel blanket, backfill any depression existing around the well borehole to the level of the surrounding ground surface with near-surface drill cuttings from the well clay. Furnish pre-packaged, dry, combined concrete materials for the well pads conforming to ASTM C387/C387M normal weight, normal strength concrete. Combine the dry materials with potable water and mix in an approved mixer or container until uniform in consistency and color. Limit water to the minimum amount possible.

3.3.10 Protective Cover Placement

Provide all monitoring wells with a steel lockable protective enclosure set in the annular seal over the well casing with keyed-alike locks on the protective covers for all wells.

3.3.10.1 Protective Steel Casing

a. Install a protective steel casing around the well casing/riser pipe by placing the protective casing into the annular seal. Clean the protective casing with high-pressure hot water/steam prior to installation to ensure that it is free of any contamination. Provide a protective casing with an inside diameter of at least 4 inches greater than the nominal diameter of the well riser. Fit the protective casing with a locking cap and install so that there is a maximum 0.2 foot clearance between the top of the in-place inner well casing cap and the bottom of the protective casing locking cap when in the locked position.

b. Position and maintain the protective casing in a plumb position. Extend the bottom of the protective casing a minimum of 2.5 feet below the top of the ground surface; extending a minimum of 2.5 feet below the maximum depth of frost penetration (frost line); and anchored into the cement grout annular seal; and also extending at least 2.5 feet above the surface of the ground. Seal and immobilize the protective casing in concrete placed around the outside of the protective casing, then place dry bentonite pellets, or granules, in the annular space below ground level within the protective casing.

c. Provide the protective casing with a 1/4 inch diameter drain hole installed just above the top of the concrete pad. Place coarse sand or pea gravel in the annular space between the protective casing and the riser pipe, above the drain hole, to within 3 inches from the top of

the riser pipe.

3.3.10.2 Flush-to-Ground Utility Vault

Install a flush-to-ground protective steel utility vault or manhole around the well casing/riser pipe which has been cut off below grade. Construct the flush mounted protective utility vault or manhole with a concrete ground surface seal. Extend the ground surface seal to, but not beyond, the total depth of the flush mounted protective utility vault. Install the ground surface seal around the flush mounted protective utility vault but do not place between the flush mounted protective utility vault and the well casing. Do not install the flush mounted protective utility vault in areas subject to ponding or flooding. Provide the wording "ground water monitoring well" on the flush mounted protective cover's lid or manhole cover on its outer surface. Install flush mounted protective utility vaults through an impervious surface such as asphalt or concrete. If an impervious surface does not exist, create one to support the weight of the traffic in the area. Provide a flush mounted protective utility vault consisting of a watertight metal casing with an inside diameter at least 4 inches greater than the inside diameter of the monitoring well casing, made of one continuous metal piece or two metal pieces which are joined with a continuous weld; and a minimum length of 12 inches. Allow no more than 8 inches between the top of the monitoring well casing and the top of the flush mounted protective utility vault after installation. Provide the flush mounted protective utility vault with an exterior flange or lugs. Do not allow the flush mounted protective utility vault to extend below the top of the cement/bentonite annular space seal. To prevent damage from frost heave, extend the concrete surrounding the utility vault a minimum of 1 foot below the frost line. Provide the flush mounted protective utility vault or the monitoring well with a locking mechanism and a watertight cap.

3.3.11 Well Identification

Affix a corrosion resistant metal tag to the exterior and interior of the protective cover. Provide the metal tag stamped with the U.S. Army Corps of Engineers CE, well identification number, elevation of the highest point on the rim of the well casing or riser pipe, elevation of the ground surface at the well, well coordinates, date of well installation, and the top of the protective casing elevation in feet as determined according to paragraph SURVEYS. Use identification numbers for the monitoring wells as indicated on the drawings.

3.3.12 Well Development

Within 7 days of completion of each well, but no sooner than 48 hours after cement grouting is completed, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521. Include details of the proposed development method in the Monitoring Well Installation Plan. Maintain a well development record in accordance with paragraph Well Development Records. Development is complete when:

a. Well water is clear to the unaided eye,

b. Sediment thickness in the well is less than 1 percent of the screen length,

c. A minimum of three times the standing water volume in the well plus three times the volume of all added water and drilling fluid lost

during drilling and installation of the well is removed, and

d. Temperature, specific conductivity, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity readings, measured before, twice during and after development operations, have stabilized. Stabilization means variation of less than 0.2 pH units, variation of ± 1 degree Fahrenheit, ± 3 percent change in specific conductance; ± 10mV for ORP; and ± 10 percent for DO, and turbidity, measured between three consecutive readings with one casing volume of water removed between each reading. Determine ORP in accordance with AWWA 10084. Conduct temperature, specific conductance, DO, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and photographed using 35 mm color print film. Suitably backlight the subject in the photograph (minimally 5 x 7 inch) close-up to show the clarity of the water and any suspended sediment. The photograph and negative are a part of the well development record. Water removed during development and testing operations shall be contained in D.O.T. approved drums, containers or vessels and disposed of by Contractor, in accordance with paragraphs CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and Drilling Waste Disposal discharged to the ground surface at least.

3.3.13 In-Situ Permeability Determination

Determine the in-situ permeability for each well following development but no sooner than 48 hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Monitoring Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.14 Drilling Waste Disposal

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, and well development procedures; and fluids from material/equipment decontamination activities by the Contractor at an approved offsite facility.

3.4 SURVEYS

Establish coordinates and elevations for each monitoring well/test hole. Determine horizontal coordinates to the closest 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 0.01 foot using the National Geodetic Vertical Datum of 1988. If the datum is not readily available, use the existing local vertical datum. Plot the location, identification, coordinates, and elevations of the well and monuments on maps with a scale large enough to show their location with reference to other structures.

3.5 WELL DECOMMISSIONING/ABANDONMENT

Any well disapproved by the Contracting Officer, or any well decommissioned/abandoned by the Contractor for any reason shall be decommissioned/abandoned according to the requirements of the State of CA, ASTM D5299, and the requirements of these specifications. Well decommissioning/abandonment includes the removal of all materials left in the borehole/well, excluding the filter pack, and including backfill materials, casing, screen, and any other material placed into the hole before the decision was made to abandon the borehole/well. Grout test holes decommissioned/abandoned for any reason from the bottom to within feet of the top of the ground surface according to the protocol for grout/bentonite placement established in paragraph Grout Placement, using the grout mix specified in paragraph CEMENT AND BENTONITE GROUT. Backfill the top of the ground surface with material appropriate for the intended land use. Maintain a well decommissioning/abandonment record as specified in paragraph Well Decommissioning/Abandonment Records. Measure groundwater levels, if encountered before the decision is made for decommissioning/abandonment, in all borings prior to backfilling. Include these water levels in the well decommissioning/abandonment records. No well may be decommissioned/abandoned without the approval of the Contracting Officer.

3.6 WELL ACCEPTANCE

It is the responsibility of the Contractor to properly design, construct, install, develop, and test all monitoring wells according to the requirements of this specification so that they are suitable for the intended purpose. If the Contractor installs wells that are not functional or not in accordance with these specifications, the Contracting Officer will disapprove the well and direct the Contractor to repair or replace it, and to abandon the disapproved well in accordance with this specification.

3.7 SITE CLEANUP

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work . Backfill excavation and vehicular ruts and dress to conform with the existing landscape or terrain. Utilities, structures, roads, fences, or any other pre-existing item which must be repaired or replaced due to the Contractor's negligence are the Contractor's responsibility; accomplish repair or replacement prior to completion of this contract.

3.8 DOCUMENTATION AND QUALITY CONTROL REPORTS

Submit reports for well construction and development. Establish and maintain documentation and quality control reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to, the following:

3.8.1 Borehole Logs

Submit original borehole logs, within 30 working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Provide the log scale at 1 inch equals 1 foot. Keep copies current and complete of all well logs in the field at each well site and make available at all times

for inspection by the Contracting Officer. Include, as a minimum, the following:

a. Name of the project and site.

b. Boring/well identification number.

c. Location of boring (coordinates, if available).

d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.

e. Date boring was drilled.

f. Reference data for all depth measurements.

g. Name of driller and name and signature of geologist preparing log.

h. Nominal hole diameter and depth at which hole diameter changes.

i. Total depth of boring.

j. Method of drilling, including sampling methods and sample depths, including those attempted with no recovery. Indication of penetration resistance such as drive hammer blows given in blows per 6 inches of driven sample tubes. Include in information hammer weight and drop distance. Record information such as rod size, bit type, pump type, etc.. Also include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use, and, if measured, mud viscosities and weight.

k. Depth of each change of stratum. If location of strata change is approximate, it shall be so stated.

l. Description of the material of which each stratum is composed, in accordance with ASTM D2488 and/or standard rock nomenclature, as necessary. Include in soil parameters for logging , but do not limit to, classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity.

m. Include in rock core parameters for logging , but do not be limit to, rock type, formation, modifier denoting variety (shaly, calcareous, siliceous, etc.), color (using GSA RCC00100R), hardness, degree of cementation, texture, crystalline structure and orientation, degree of weathering, solution or void conditions, primary and secondary permeability, and lost core.

n. Also include the results of any chemical field screening on the boring log. Prepare classification in the field at the time of sampling. Also duly note and record the results of visual observation of the material encountered, and any unusual odor detected.

o. Depth of any observed fractures, weathered zones, or any abnormalities encountered.

p. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.

q. Depth to water, and any non-aqueous phase liquids (NAPLs) and date measured before, during, and after each drilling shift, and prior to well installation. Provide and maintain at each well under construction a portable water, and NAPL level measuring device of sufficient length to measure the water/NAPL level to 165 foot depth. Make the device onsite at all times and provide graduated measuring wire in 0.01 foot. Take water and NAPL level measurements to the nearest 0.01 foot.

r. Box or sample number. Depths and the number of the core boxes and/or samples shall be recorded at the proper interval.

s. Percent Rock Core Recovery. The percent core recovery for the individual drill runs, if rock is cored, shall be shown.

3.8.2 Installation Diagrams

Submit installation diagram for each monitoring well within 30 working days of the completion of the installation. The well will not be accepted before the geologic logs and installation diagrams are received. Submit as-built installation diagram for each monitoring well installed, prepared by the geologist present during well installation operations, within 30 working days of the completion of the well installation procedure. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit to the following items:

a. Name of the project and site.

b. Well identification number.

c. Name of driller and name and signature of the geologist preparing diagram.

d. Date of well installation.

e. Description of material from which the well is constructed, including well casing/riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground).

f. Total depth of well.

g. Nominal hole diameter.

h. Depth to top and bottom of screen, and filter pack.

i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).

j. Type of cement and/or bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations/depths/heights of key features of the well, such as top of well casing/riser pipe, top and bottom of protective casing, ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.

l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.

m. Well location by coordinates. A plan sheet shall also be included showing the coordinate system used and the location of each well. A plan sheet is not required for each well installation diagram; multiple wells may be shown on the same sheet.

n. Static water level upon completion of the well.

o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.

p. Description of surface completion.

3.8.3 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within 30 working days of the completion of development. Include the following information on the well development record , but do not limit to the following:

a. Date, time, and elevation of water level in the well, before development.

b. Depth to bottom of well, name of project and site, well identification number, and date of development.

c. Method used for development, to include size, type and make of equipment, bailer, and/or pump used during development.

d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.

e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.

f. Volume of water added to the well, if any.

g. Volume and physical character of sediment removed, to include changes during development in color, and odor.

h. Source of any water added to the well.

i. Clarity of water before, during, and after development. Nephelometric turbidity unit (NTU) measurements.

j. Total depth of well and the static water level in accordance with ASTM D4750from top of the casing, immediately after pumping/development, and 24 consecutive hours after development.

k. Readings of pH, specific conductance, DO, ORP, and temperature taken

before, during, and after development.

l. Name and job title of individual developing well.

m. Name and/or description of the disposal facility/area, for the waters removed during development.

3.8.4 Geophysical Logs

Prepare, complete, and submit geophysical logs for each monitoring well/test hole installed, within 30 working days of the completion of said logging. Include the following information on the logs as a minimum:

a. Project name.

b. Test hole/monitoring well identification number.

c. Location of test hole (coordinates, and state, and county name).

d. Date test hole was drilled.

e. Fluid level in test hole before logging.

f. Fluid type and temperature.

g. Fluid resistance in ohm-m.

h. Casing type, diameter, and elevation (top and bottom).

i. Cement type and elevation (top and bottom).

j. Screen type, diameter, and elevation (top and bottom).

k. Date and time test hole was logged.

l. Reference elevation for all depth measurements.

m. Operator's name.

n. Equipment name and address.

o. Logger type and number.

p. Tool type.

q. Detector type (Nuclear Log only).

r. Source type (Nuclear Log only).

s. Source size (Nuclear Log only).

t. Source spacing (Nuclear Log only).

u. Tool length, cable head to detector.

v. Calibration.

w. Logging speed ft/min.

x. Log vert. scale ft/in.

y. Module settings.

z. Recorder settings.

aa. Document all field problems, including equipment malfunctions. This should include the steps taken to solve the problem and how the log might have been affected.

3.8.5 Well Decommissioning/Abandonment Records

Submit well decommissioning record, for each well, or test hole abandoned, within 30 working days of the completion of the abandonment procedure. Include in decommissioning/abandonment records, as a minimum, the following:

a. Project name.

b. Well or test hole number.

c. Well/boring location, depth and diameter.

d. Date of decommissioning/abandonment.

e. Method of decommissioning/abandonment.

f. All materials used in the decommissioning/abandonment procedure and the interval in which test materials were placed.

g. Casing, and or other items left in hole by depth, description, and composition.

h. Description and total quantity of grout used initially.

i. Description and daily quantities of grout used to compensate for settlement.

j. Water or mud level (specify) prior to grouting and date measured.

k. The reason for decommissioning/abandonment of the monitoring well/test hole.

3.8.6 Project Photographs

Submit photographs taken before, during, and after completion of the work, of each well installation site. Also photographs of any rock that is cored at the site; take a minimum of one view of each well installation. If rock is cored at the site, after the core has been logged dampen the core, if it has dried, neatly arrange in the core box, and take 3 inchx5 inch color print photographs, mounted and enclosed back-to-back in a double face clear plastic sleeve punched to fit standard three ring binders. Provide color prints with an information box, showing (typewritten) the following information:

Project No. Contract No.

Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.8.7 Survey Maps and Notes

Prepare and submit a tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets, consisting of the designated number of the well or monument, the X and Y coordinates, and all the required elevations within 30 working days after completion of the survey.

-- End of Section --

SECTION 33 60 01

VALVES, PIPING, AND EQUIPMENT IN VALVE BOXES
03/13

PART 1 GENERAL

Bracketed items/values below will be selected in the draft final design.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.20	(2007) Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral Wound, and Jacketed
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2009; Supp 2010) Valves - Flanged, Threaded and Welding End
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2012) Power Piping
ASME B40.100	(2005; R 2010) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2011) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A193/A193M	(2012a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2012) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service,

	or Both
ASTM A234/A234M	(2011a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A733	(2003; E 2009; R 2009) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM F1139	(1988; R 2010) Steam Traps and Drains

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2008) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-45	(2003; R 2008) Bypass and Drain Connections
MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(2006) Class 3000 Steel Pipe Unions Socket Welding and Threaded

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 29	(2002; E 2004) Zinc Dust Sacrificial Primer, Performance-Based

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Piping and Fittings
Valves

Condensate Sump Pumps
Expansion Joints

SD-04 Samples

SD-10 Operation and Maintenance Data

Condensate Sump and Controls
Data Package 2

1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit detail drawings 30 days after notice to proceed for condensate sump pump piping and equipment such as valves, sump pumps, pressure gauges, air filters and pulse counters, including a complete list of equipment and materials, manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, installation instructions, and complete wiring and schematic diagrams. Show on the drawings pipe anchors and guides, and layout and anchorage of equipment and appurtenances in valve boxes, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all materials and equipment delivered and placed in storage from the weather, excessive humidity, and excessive temperature variation; dirt, dust, or other contaminants.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 NAMEPLATES

Each major item of equipment such as sump pump, motor, steam trap, and pressure reducing valve shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.3 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products will not be allowed.

2.4 ELECTRICAL WORK

Motors, manual or automatic motor control equipment, and protective or signal devices required for the operation specified shall be provided under this section in accordance with NFPA 70.

2.5 PIPING AND FITTINGS

2.5.1 General Requirements

Piping, fittings and piping accessories inside the valve boxes shall conform to the requirements of ASME B31.1 and shall be suitable for the working pressure and temperature requirements of the system. To the greatest extent possible, the piping and fittings inside the valve boxes shall match the piping and fittings located on the outside of the valve box. All piping in valve boxes shall be steel with joints welded except that joints 3/4 inch and smaller may be threaded. When threaded joints are used on High Temperature Water Systems, the interface area where the pipe threads meet the threaded fittings shall be seal welded (continuous fillet weld) to preclude any water leakage. No supports, anchors, or stays shall be attached to any piping system in places where either the installation of or the movement of the pipe and its contents will cause damage to the construction.

2.5.2 Steel Pipe

Pipe shall be black steel, seamless or electric-resistance welded, conforming to the requirements of ASTM A53/A53M, Grade B or ASTM A106/A106M, Grade B. Pipe up to and including 10 inches in diameter shall be schedule 40. Pipe 12 inches in diameter and greater shall be 0.375 inch nominal wall thickness. Gauge piping [, condensate piping,] [drip piping,] [sump pump dicharge] and piping 3/4 inch in diameter and smaller shall be schedule 80.

2.5.2.1 Nipples

Nipples shall conform to ASTM A733 as required to match adjacent piping.

2.5.2.2 Pipe Threads

Pipe threads shall conform to ASME B1.20.1. Pipe threads may be used only on pipe 3/4 inch or smaller. All pipe which is to be threaded shall be schedule 80.

2.5.3 Fittings

All fittings, valves, flanges and unions shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently

identify the manufacturer.

</2.5.3>2.5.3.1 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M, buttwelded or socket welded, as required to match connecting piping. Buttwelded fittings shall conform to ASME B16.9, and socket welded fittings shall conform to ASME B16.11.

2.5.3.2 Unions

Unions shall conform to MSS SP-83 as required to match adjacent piping.

2.5.3.3 Ball Valves

Ball valves shall conform to MSS SP-72 for flanged or buttwelded valves or MSS SP-110 for threaded ball valves.

2.5.4 Insulating Flanges and Dielectric Waterways

2.5.4.1 Insulating Flanges

For systems in which cathodic protection is provided, insulating flanges or flange gasket kits shall be installed in the valve box at the pipe connection to or from the heat distribution system and at dissimilar metals and when the carrier pipe and appurtenances are supported in such a way as to electrically ground or alter the cathodic protection system voltages or currents. The kit shall consist of flanges, a flange gasket, nuts and bolts, bolt sleeves, and one insulating washer and one steel washer for both ends of each bolt. The manufacturer shall certify that the gasket kits are capable of electrically isolating the pipe at the [_____] psig pressure and [_____] degrees F temperature of the heating medium at the point of application. Evidence of satisfactory installations operating not less than 2 years shall be submitted in accordance with paragraph SUBMITTALS before materials are delivered. Ensure that these kits are provided and properly installed according to manufacturer's published instructions. Bolts shall be torqued to the correct tightness and in the correct bolt pattern as recommended by the manufacturer's published instructions. Steel flanges shall conform to ASME B16.5 Class [150] [and] [or] [300] and shall match valves or flanged fittings on which used. Steel flanges shall be flat faced. Gaskets shall be non-asbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self centering flat ring type. Bolts shall conform to the requirements of ASTM A193/A193M, Grade B7. The bolt head shall be marked to identify the manufacturer and the standard to which the bolt complies. Lengths of bolts shall be such that not less than two full threads extend beyond the nut with the bolt tightened to the required tension and the washer seated. Nuts shall conform to the requirements of ASTM A194/A194M, Grade 7.

2.5.4.2 Dielectric Waterways

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping and shall be used for joining dissimilar metals on 3/4 inch and smaller threaded pipe. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.5.4.3 Gaskets Non-Insulating

Provide spiral wound, non-asbestos gasket with centering ring in accordance with ASME B16.20.

2.6 VALVES

Unless otherwise specified, valves shall comply with the material, fabrication, and operating requirements of ASME B31.1. Valves shall be suitable for the temperature and pressure requirements of the system on which used. Valves for [steam] [hot water] shall conform to ASME B31.1 Class [150] [and] [or] [300], as suitable for the application. [Valves for condensate services shall conform to ASME B31.1 Class 150.] Valves 3/4 inch and smaller may be bronze where seal welding is not required. Valves 6 inches and larger shall have a 1 inch minimum gate or globe bypass valve sized in conformance with MSS SP-45.

2.6.1 Steel Valves

Steel globe, gate, angle, and check valves shall conform to the requirements of ASME B16.34 and ASME B31.1 for the temperature and pressure requirements of the system. Gate valves 2-1/2 inches and smaller shall be rising stem. Gate valves 3 inches and larger shall be outside screw and yoke.

2.6.2 Bronze Valves

2.6.2.1 Globe, Gate, and Angle Valves

Bronze globe, gate, and angle valves shall conform to requirements of MSS SP-80, union bonnet type.

2.6.2.2 Check Valves

Bronze check valves shall conform to the requirements of MSS SP-80.

2.6.2.2.1 Butterfly Valves

Butterfly valves installed in polyethylene pipes shall be 150 lb. flat faced flanged PVC butterfly valves with PVC disk, 316 stainless steel stem, and polytetrafluoroethylene (e.g., Viton) seats and seals, or approved equal.

2.6.2.2.2 Flange Hardware

All PVC butterfly flange mounting hardware for valves, either exposed or buries, shall be stainless steel.

2.6.2.2.3 Operator

All below grade butterfly valves shall have a gear operator. All above grade butterfly valves 6 inchesand greater shall have a 10 position locking handle. All valves and gear operators shall be right-hand close.

2.6.2.2.4 Steel Butterfly Valves

Unless otherwise specified, butterfly valves installed in stainless steel piping shall be high performance valves with steel lug style body, 316

stainless steel disk and stem and Teflon seats, Jamesbury, Posi-seal, or approved equivalent. For below grade valves, operator shall have square head nut and CONTRACTOR shall supply operator extension handles. If valve is deeper than 30-inches, CONTRACTOR shall install a permanent extension handle to within 12-inchesbelow vault lid.

2.6.2.2.5 Labeling

All butterfly valves shall carry a nameplate securely fastened to the body including the Manufactruers's ID, valve size, Manufacturer's serial number, seat material and shat material. The information shall be clearly legible.

2.6.2.2.6 Flange Ends

HDPE flange backup rings shall be stainless steel or fused epoxy coated cast iron. HDPE flange adapters shall be finished or spacers provided to allow full 90 degreeoperation of the valve.

2.6.3 Packing

Packing used with valves shall not contain asbestos. Valve stem packing shall be die-formed, ring type specifically designated as suitable for the temperature and pressure of the service and compatible with the fluid in the system. Packing shall be polytetrafluoroethylene with minimum 50 percent graphite filament. Valves 1-1/2 inches and smaller shall have four or five packing rings and valves 2 inches and larger shall have at least six packing rings. Spiral or continuous packing will not be acceptable. A metal insert shall be provided having proper clearance around the valve stem at the bottom of the stuffing box and acting as a base for the packing material. Packing glands shall be furnished with a liner of noncorrosive material and shall be of one piece construction with provisions for not less than two bolts for packing adjustment.

2.7 STEAM TRAPS

Class of trap bodies shall be suitable for a working pressure of not less than 1.5 times the steam supply pressure, but not less than 200 psi, and traps shall be capable of operation under a steam-supply pressure as indicated. Traps shall have capacities as shown when operating under the specified working conditions. Traps shall fail open.

2.7.1 Bucket Traps

Bucket traps shall be inverted-bucket type with automatic air discharge and conform to ASTM F1139.

2.7.2 Thermostatic Traps

Traps shall be thermostatic type; bimetallic element with automatic air discharge and conform to ASTM F1139.

2.8 STRAINERS

Strainers shall be basket or y-type with connections the same size as the pipe lines in which the connections are installed. The strainer bodies for steam systems shall be heavy and durable, of cast steel, with bottoms drilled and plugged. The strainers shall be suitable for the temperature and pressure requirements of the system on which they are installed. The

bodies shall have arrows clearly cast on the sides to indicate the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment basket. The body or bottom opening shall be equipped with nipple and gate valve for blowdown. The basket for steam systems shall be not less than 0.025 inch thick stainless steel, Monel or sheet brass, with small perforations of sufficient number to provide a net free area through the basket of at least 2.5 times that of the entering pipe. The flow shall be into the basket and out through the perforations. For high temperature hot water systems, only cast steel bodies and stainless or Monel baskets shall be used.

2.9 PRESSURE GAUGES

Gauges shall conform to ASME B40.100, and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Minimum dial size shall be 4-1/4 inches.

2.10 DIAL THERMOMETERS

Dial type thermometer shall be 3-1/2 inches in diameter with stainless steel case, remote-type bulb or direct-type bulb as required. The thermometer shall have an accuracy of plus or minus 2 degrees F. Thermometer wells of the separable socket type shall be provided for each thermometer with direct-type bulb. The thermometer shall have a white face with black digits graduated in 2 degrees F increments.

2.11 COATINGS

Coat steel manhole piping with an organic zinc undercoat that conforms to SSPC Paint 29 Type II followed by a thermal barrier coating having a manufacturer’s documented minimum thermal conductivity of 0.058 Btu/hr•ft•°F. The undercoat and thermal barrier coating shall have continuous use service temperature ratings that exceed the nominal system operating temperature by a minimum of 50 degrees F.

2.13 SUMP PUMPS AND DRAINERS

2.13.1 Condensate Sump Pumps

The sump pumps furnished shall be a manufacturer's standard commercial product. Sump pumps shall be pneumatically driven and submersible, capable of operating while completely submerged. The pumps shall be capable of continuously pumping liquids at a temperature of 200 degrees F. The pumps shall be capable of running without damage when not submerged. Sump pumps shall have permanently lubricated bearings, stainless steel shafts, stainless steelwetted parts, screened inlets and housings of stainless steel. Each sump pump shall be capable of passing a 3/8 inch sphere. The condensate sump pump shall be a pneumatic submirsible, environmental-duty pump, QED AP-2BL, or approved equal. Stainless steel body shall be 2-inch nominal diameter, bottom loading, short style, rated for up to 240-feet water pressure discharge.

2.13.1.2 Pump Connections

The sump pumps shall have the following minimum connection sizes and types:

Service	Size Connection	Supplied Connection
Liquid discharge	3/4 inch	FNPT
Liquid gravity inlet	4 inch	ANSI flange
Pressure equalizing line	1/2 inch	FNPT

The condensate liquid inlet(s) to the sump shall be 4-inch diameter minimum, with internal factory saddle weld, exterior extrusion weld, and a minimum of two reinforcing gussets. Liquid inlet(s) shall be vacuum rated for at least -29.8 inchesmercury vacuum. The condensate discharge line and header equalization hose within the sump shall be constructed of reinforced heavy duty PVC hose.

2.13.1.3 High Level Alarm Indicator

Provide a switch to indicate high water level at the treatment facility sump, and connect to an emergency warning light mounted at the treatment facility control panel. This high water level alarm shall be set at a level which is below the bottom of the lfg header pipe inlet to the sump.

2.12 Condensate Sump and Controls

This section describes the acceptable materials that shall be used for the construction oif the condensate sump. The sump shall be Real Environmental Products Series 7000 Auto-Sump, or approved equivalent (REP Inc., 209/296-7900). The condensate sump shall be an in-line style, weld fabricated with type 3408 high density polyethylene (HDPE). the sump shall be designated and fabricated to withstand test vacuum ot -29.8 inchesof mercury and test pressure of 5 PSIG. The sump shall have an 8-inch deep solids settling area. The submersible pump shall be installed in a screened isolation well for solids separation. The sump interior depth shall be as shown in the Contract Drawings. The LFG header shall drain continuously to the sump to maintain a clear header under a vacuum application of -50 inches water column (in w.c.).

2.13 CONCRETE VALVE BOXES AND ACCESSORIES

2.13.1 Valve Box Construction

Valve box dimensions shall be as indicated. All control components of the condensate pump shall be located in a water-tight parkway-rated vault that is integrally mounted on top of the condensate sump. Service connections, including the liquid discharge, and pressure balance line, shall be mounted on the exterior wall of the vault. All bolts, nuts, and washers shall be mounted on the exterior wall of the vault. All bolts, nuts, and washers shall be 304 stainless steel. The excavation sor the sump, vault, and connection piping shall extend a minimum of 12 inchesaround all sides of the sump unit. The backfill shall consist of controlled low strength material (CLSM) from the base of the excavation to within 3-inchesof the top flange of the sump, and compacted engineered backfill for the remainder of the excavation to the ground surface. CLSM is specified in Section 033300, Concrete. Soil backfill shall comply with specifications for engineered backfill in Section 02200 and shall be approved by the Project Manager. The select backfill material placed adjacent to the condensate

sump, vault, and piping shall be fine graded and no objects shall be present that could cause damage to the sump components or piping

2.14.3 Pipe Sleeves

Pipe sleeves of sufficient diameter to protect valve box shall be provided. Pipe sleeves shall be zinc-coated steel pipe, conforming to the requirement of ASTM A53/A53M, Schedule 40 or standard weight. The pipe sleeves shall be secured in the proper position and location during construction of the valve box. The space between the sleeve and the pipe casing shall be selected so there shall be load transfer between the pipe sleeve and the pipe casing.

2.13.2 Pipe Supports

Pipe Supports shall be in accordance with MSS SP-58 and MSS SP-69, type as shown. Chains, straps, or single point supports shall not be used.

2.14 EXPANSION JOINTS

Submit manufacturer's descriptive data and technical literature, performance charts, catalog cuts and installation instructions.

]

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 SITE WORK

3.2.1 Excavation, Trenching, and Backfilling

Excavation, trenching, and backfilling of the valve boxes shall be as shown and in accordance with Section 31 00 00 EARTHWORK.

3.2.2 Electric Work

Any wiring required for the operation of the equipment specified, but not shown on the electrical drawings, shall be provided under this section in accordance with Sections 26 00 00 20 GENERAL ELECTRICAL REQUIREMENTS.

3.3 PIPING

3.3.1 General

All piping in valve boxes shall be stainlesssteel. Pipe shall be accurately cut and shall be worked into place without springing or forcing. Pipe shall clear all openings and equipment. Excessive cutting or other weakening of structural members to facilitate piping installation will not be permitted. Burrs shall be removed from ends of pipe by reaming. Installation shall permit free expansion and contraction without damage to joints or hangers.

3.3.2 Welded Joints

Joints between sections of pipe, between sections of pipe and valves, and between sections of pipe and fittings shall be welded [except where joints are allowed to be screwed for pipe sizes 3/4 inch and smaller]. The welding shall conform to the requirements specified in paragraph WELDING.

3.3.3 Flanged and Threaded Joints

3.3.3.1 Flanged Joints

Flanged joints shall be faced true, provided with gaskets, and made perfectly square and tight. Flanged joints shall be used only for electrical isolation and in other special cases where connected equipment is available with only flanged joints, or when specifically shown on the drawings. Electrically isolated flange joints shall be provided at all connections to or from the heat distribution system and between dissimilar metals.

3.3.3.2 Threaded Joints

Threaded joints shall have graphite or inert filler and oil, graphite compound, or polytetrafluoroethylene tape applied to the male threads only. Unions shall be provided at all screwed valves, strainers and connections to equipment 3/4 inch and smaller. Dielectric unions shall be used at connections of dissimilar metals in 3/4 inch and smaller piping. When used on High Temperature Water Systems, threaded joints shall be seal welded.

3.3.4 Reducing Fittings

Eccentric reducers in horizontal runs shall be installed with the straight side down. Changes in horizontal piping sizes shall be made through eccentric reducing fittings.

3.3.5 Branch Connections

Branches from mains shall branch off top of mains as indicated or as approved. Connections shall ensure unrestricted circulation, elimination of air pockets, and shall permit the complete drainage of the system. Branch connections may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings where used shall be forged and shall be no larger than two nominal pipe sizes smaller than the main run. Branch outlet fittings shall be reinforced to withstand external strains and designed to withstand full pipe bursting strength.

3.3.6 Pipe Supports in Valve Boxes

Horizontal and vertical runs of pipe in valve boxes shall be securely supported.

3.4 VALVE BOXES AND ACCESSORIES

3.4.1 Piping and Equipment in Valve Boxes

Piping and equipment in valve boxes shall be installed to provide easy access without stepping on piping or equipment, and to provide sufficient working room. Piping and equipment in valve boxes shall be installed and

supported as shown on the drawings. All globe, angle and gate valves shall be installed with the stems horizontal or above. Submit Data Package 2 as related to all equipment provided for the project in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished. Detail in the operation manuals the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams indicating location of electrical components with terminals designated for wiring, as installed.

3.4.2 Sump Pumps Installation

Sump pumps shall be installed as indicated. All electrical connections shall be hard wired.

3.5 TESTS

Tests of piping in the valve boxes will be performed as part of the testing of the direct buried conduit system. These tests shall include the piping in the valve box and performed in accordance with the system supplier's Approved Brochure or the contract specifications.

-- End of Section --

SECTION 35 31 19

COASTAL PROTECTION
03/13

PART 1 GENERAL

Install stone revetment along shoreline in accordance with the Drawings.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Unless otherwise noted, the latest version of each publication is to be used.

ASTM INTERNATIONAL (ASTM)

ASTM C127	(2012) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C295/C295M	(2012) Petrographic Examination of Aggregates for Concrete
ASTM D3740	(2012) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D4992	(2007) Evaluation of Rock to be Used for Erosion Control
ASTM D5312	(2004) Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions
ASTM D5313	(2004) Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions
ASTM D5519	(2007) Particle Size Analysis of Natural and Man-Made Riprap Materials

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 144	(1992) Standard Test Method for Resistance of Rock to Freezing and Thawing
COE CRD-C 148	(1969) Method of Testing Stone for Expansive Breakdown on Soaking in Ethylene Glycol
COE CRD-C 169	(1997) Standard Test Method for Resistance of Rock to Wetting and Drying

1.2 DEFINITIONS

1.2.1 Revetments

The term "revetment" applies to various types of stabilization structures that are constructed along shorelines.

1.2.2 Stone Protection

Stone Protection is defined as a system which includes a layer of filter stone material beneath a layer of riprap armor stone.

1.2.3 Stone

Stone for riprap is normally produced by mechanical methods, with a jaw crusher and grizzly after the stone has been mined by blasting in a quarry.

1.3 BULK SPECIFIC GRAVITY OF STONE REDESIGN

If the Contractor, after award of the contract, requests approval of stone from a source(s) which has a range of bulk specific gravity (SSD), whose limits are lower or higher than the specified design range of 2.5 to 2.9 as specified in paragraph 2.1.1.1 Evaluation Testing of Stone paragraph (a) in this specification, consideration will be given to revising the project design through modification of the design range under the following conditions:

a. Only one (1) such proposal for modification will be allowed. In addition, the required completion time shall not be extended more than thirty (30) calendar days as a result of redesign for any reason, including acts of the Government.

b. The modified design range of bulk specific gravity (SSD) to be used shall not have a lower limit of less than 2.30 nor higher than 3.50.

c. The stone sections of the required structure are to be redesigned by the Government. Such redesign will be based upon the Contractor's proposed modifications to the specified design range of bulk specific gravity (SSD) and will include any required revisions to allowable tolerances. Only one such redesign will be made. A charge of $5,000 to the Contractor will be assessed, whether the redesign is used or not.

d. Any proposal to modify the specified design range shall be submitted within fifteen (15) calendar days after receipt of the Government's redesign and shall include a statement as to the savings which will result from the modification. If a formal proposal is not submitted within the time limit, the work shall be performed in accordance with the specified design, in which case the Contractor shall not be allowed to use stone having a bulk specific gravity (SSD) less than the specified design range.

e. If the Contractor elects to perform the work in accordance with the redesign, the estimated quantities to be shown in the BIDDING SCHEDULE will be the quantities derived from the Government's redesign.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control

approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

a. Riprap Armor Stone; G

b. Filter Stone; G

c. Filter Fabric

Stone hauling vessel gaging tables and a copy of the data and calculations for the preparation of the tables.

d. Bulk Specific Gravity of Stone and Redesign; G

A formal proposal to perform the work in accordance with the redesign, within fifteen (15) calendar days after receipt of the Government's redesign; if the Contractor proposes to utilize stone having a specific gravity outside of the specific design range, and as a result thereof, the Government provides the Contractor with a redesign. The submittal shall include a statement of the direct savings to the Government and tabulation in the form of a revised BIDDING SCHEDULE showing unchanged unit prices for the revised quantities.

SD-04 Samples

a. Riprap Armor Stone; G

b. Filter Stone Material; G

Suitable stone samples prior to delivery of any such material to the work site if stone is not from an approved vendor.

SD-07 Certificates

a. Riprap Armor Stone

b. Filter Stone Specific Gravity

b. Filter Fabric

Certificates of compliance attesting that the materials meet specification requirements.

1.5 QUALITY ASSURANCE

1.5.1 Riprap Armor Stone and Filter Stone Material

1.5.1.1 General

All stone shall be durable material as approved by the Contracting Officer. Selected stone from the required excavation may be used if it satisfies all requirements as to quality and dimensions. Show that an adequate quantity of material is available from the source area and provide quality test data. Stone shall be of a suitable quality to ensure permanence in the structure and in the climate in which it is to be used. It shall be free from cracks, blast fractures, bedding, seams and other defects that

would tend to increase its deterioration from natural causes. Inspections for cracks, fractures, seams and defects shall be made by visual examination. If, by visual examination, it is determined that 20 percent or more of the stone produced contains hairline cracks, then all stone produced by the means and measures which caused the fractures shall be rejected. A hairline crack that is defined as being detrimental shall have a minimum width of 4 mil and shall be continuous for one-third the dimension of at least two sides of the stone. The stone shall be clean and reasonably free from soil, quarry fines, and shall contain no refuse. The stone shall be clean and adequately free from all foreign matter. Any foreign material adhering to or combined with the stone as a result of stockpiling shall be removed prior to placement.

1.5.1.2 Sources

Stone shall be furnished from any source designated by the Contractor and accepted by the Contracting Officer, subject to the conditions herein stated. In order for stone to be acceptable on the basis of service records, stone of a similar size must have been placed in a similar thickness and exposed to weathering under similar conditions as are anticipated for this contract, and must have satisfactorily withstood such weathering for a minimum of 20 years. In addition to an acceptable 5 year service record, the Contracting Officer has the option to elect to have representative samples taken and tested.

a. List of Sources.

(1) Category I Sources: Category I sources have been inspected and evaluated within the last five years by the Government and have produced stone materials of acceptable quality from satisfactory geological formations. The Category I sources have previously demonstrated effective quality control programs at the source and the test results of the materials furnished have been verified that some material are of satisfactory quality. In a like manner, the source would be capable of providing the quality, quantity, and gradation of required stone materials. Further evaluation and testing of the source will not be required unless the preparation of the required demonstration stockpile reveals an adverse condition not previously taken into account.

(2) Category II Sources: Category II sources either have not been inspected and evaluated within the past five years or have had a deficiency in the past which may or may not affect its qualifications to provide stone materials for this project. Deficiencies may include, but are not limited to: ineffective quality control program; unsatisfactory production techniques; unacceptable quality of material in the geological formation being quarried; insufficient quantities of required materials; or unsatisfactory durability of stone materials previously furnished. These factors of this kind do not disqualify the source for this project. A current inspection and evaluation of the source by the Contractor would be necessary to determine whether acceptable stone can be produced from the proposed source before allowing the source to proceed with preparation of demonstration stockpiles. Disapproval of a proposed Category II source based on the inspection and evaluation would necessitate having the Contractor name a replacement source.

b. Selection of Source. Designate in writing only one source or one

combination of sources from which he proposes to furnish stone. He shall notify the Contracting Officer at least 60 workdays before the stone leaves the quarry. It is the Contractor's responsibility to determine that the stone source or combination of sources selected is capable of providing the quality, quantities and gradation needed and at the rate needed to maintain the scheduled progress of the work.

c. Acceptance of Materials. Acceptance of a source of stone is not to be construed as acceptance of all material from that source. The right is reserved to reject materials from certain localized areas, zones, strata, or channels, when such materials are unsuitable for stone as determined by the Contracting Officer. The Contracting Officer also reserves the right to reject individual units of produced specified materials in stockpiles at the quarry, all transfer points, and at the project construction site when such materials are determined to be unsuitable. During the course of the work, the stone may be tested by the Government, if the Contracting Officer determines that testing is necessary. If such tests are determined necessary, the testing will be done in the Government's testing laboratory or commercial laboratory selected by the Government. Materials produced from a listed or unlisted source shall meet all the requirements herein. During the contract period, both prior to and after materials are delivered to the job site, visual inspections and measurements of the stone materials may be performed by the Contracting Officer. If the Contracting Officer, during the inspections, finds that the stone quality, gradation or weights of stone being furnished are not as specified or are questionable, re-sampling and re-testing by the Contractor is required. Sampling of the delivered stone for testing and the manner in which the testing is to be performed shall be as directed by the Contracting Officer. This additional sampling and testing shall be performed at the Contractor's expense when test results indicate that the materials do not meet specified requirements. When test results indicate that materials meet specified requirements, an equitable adjustment in the contract price will be made for the sampling and testing. Any material rejected shall be removed or disposed of as specified and at the Contractor's expense.

1.6 CONSTRUCTION TOLERANCES

The finished surface and stone layer thickness shall not deviate from the lines and grades shown by more than the tolerances listed below. Tolerances are measured perpendicular to the indicated neatlines. Extreme limits of the tolerances given shall not be continuous in any direction for more than five (5) times the nominal stone dimension nor for an area greater than 200 square feet of the structure surface.

NEATLINE TOLERANCES		
MATERIAL	ABOVE NEATLINE (inches)	BELOW NEATLINE (inches)
Filter Stone Layer	+2	-2
Riprap Armor Stone Layer	+18	-42

The intention is that the work shall be built generally to the required elevations, slope and grade and that the outer surfaces shall be even and present a neat appearance. The Contractor will determine the methods for confirmation that the neatline tolerances have been met with approval from Contracting Officer. Placed material not meeting these limits shall be removed or reworked as directed by the Contracting Officer. Payment will not be made for excess material which the Contracting Officer permits to remain in place.

PART 2 PRODUCTS

2.1 STONE

2.1.1 General

2.1.1.1 Evaluation Testing of Stone

In lieu of vendor certifications for the same properties listed below the Contractor shall have evaluation tests performed on stone samples collected from the proposed source. The quarry investigation shall be performed by a registered geologist or registered engineer. The tests to which the stone shall be subjected include petrographic examination (ASTM C295/C295M), bulk specific gravity (SSD), unit weight, absorption (ASTM C127), resistance of stone to freezing and thawing (COE CRD-C 144 or ASTM D5312), and if argillaceous limestone and sandstone are used, resistance to wetting and drying (COE CRD-C 169 or ASTM D5313). The laboratory to perform the required testing shall be validated based on relevant paragraphs of ASTM D3740, and no work requiring testing shall be permitted until the laboratory has been inspected and validated. A copy of the documents, provided by the Materials Testing Center (MTC) at CEWES or other governmental agency, that validates that the laboratory can perform the required tests. The individual tests shall be listed for which the validation covers along with the date of the inspection. The first inspection of the facilities shall be at the expense of the Government and any subsequent inspections required because of failure of the first inspection shall be at the expense of the Contractor.

a. Bulk Specific Gravity Range. All stone shall have a minimum bulk specific gravity, saturated surface dry (SSD), of 2.50 and a maximum bulk specific gravity of not more than 2.90 based upon water having a unit weight of 62.4 pounds per cubic foot. The method of test for bulk specific gravity (SSD) shall be ASTM C127. Provide Bulk Specific Gravity of Stone and Redesign and Filter Stone Specific Gravity as submittals.

b. Unit Weight and Absorption. Stone shall weigh more than 155 pounds per cubic foot have a bulk specific gravity, saturated surface dry, greater than 2.48. The stone shall have an absorption less than 1 percent unless other tests and service records show that the stone is satisfactory. The method of test for unit weight and absorption shall be ASTM C127.

c. Petrographic Examination. Stone shall be evaluated in accordance with ASTM C295/C295M which shall include information required by ASTM D4992, paragraph 10. COE CRD-C 148 shall be used to perform Ethylene glycol tests required on rocks containing smectite as specified in ASTM D4992 and on samples identified to contain swelling clays.

d. Resistance to Freezing and Thawing. Stone shall have a maximum loss of

5 percent after the number of cycles specified in ASTM D5312, Figure 1, when determining the durability of stone when subjected to freezing and thawing in accordance with COE CRD-C 144 and ASTM D5312, except the surface area of one side of the sample shall be between 144 and 2304 square inches.

e. Resistance of Rock to Wetting and Drying. Stone shall have a maximum loss of 1 percent when determining the durability of stone when subject to wetting and drying in accordance with COE CRD-C 169 and ASTM D5313, except the surface area of one side of the sample shall be between 144 and 2304 square inches.

f. Samples. Samples of stone from a source not listed at the end of this section shall be taken by a representative of the Quarry under the supervision of the Contracting Officer for testing and acceptance prior to delivery of any stone from this source to the site of the work. Information provided with the samples shall include the location within the quarry from which the sample was taken along with a field examination of the quarry. The field examination shall include the information outline in ASTM D4992, paragraph 7. Samples shall consist of at least three pieces of stone, roughly cubical in shape and weighing not less than 150 pounds each from each unit that shall be used in the production of the required stone. If the source is an undeveloped quarry, or if the operation has been dormant for more than one year such that fresh samples are not available, expose fresh rock for 20 feet horizontally and for the full height of the face proposed for production, prior to the field evaluation. The Contracting Officer may also require documentation of subsurface exploration of an undeveloped quarry in order to determine whether or not sufficient reserves are available. The samples shall be shipped at the Contractor's expense to a laboratory validated by the government to perform the required tests.

g. Tests. Conduct the tests in accordance with applicable ASTM and Corps of Engineers methods of tests, given in the Handbook for Concrete and Cement, in a laboratory validated by the government. The cost of testing shall be borne by the Contractor.

2.1.1.2 Gradation Tests for Stone

To be performed if testing from the vendor is not performed or deemed adequate by the Contracting Officer.

a. Gradation Test Method for Riprap Armor Stone and Filter Stone. Gradation tests shall be performed in accordance with ASTM D5519

b. Select a representative sample (Note No. 1), weigh and dump on hard stand.

c. Select specific sizes (see example) on which to run "individual weight larger than" test (See Note No. 2). Procedure is similar to the standard aggregate gradation test for "individual weight retained".

d. Determine the largest size stone in the sample. (100 percent size).

e. Separate by "size larger than" the selected weights, starting with the larger sizes. Use reference stones, with identified weights, for visual comparison in separating the obviously "larger than" stones. Stones that appear close to the specific weight must be individually

weighed to determine size grouping. Weigh each size group, either individually or cumulatively.

f. Paragraph (c) above will result in "individual weight retained" figures. Calculate individual percent retained (heavier than), cumulative percent retained, and cumulative percent passing (lighter than). Plot percent passing, along with the specification curve on ENG Form 4794-RM 4794-R.

NOTE NO. 1: Sample Selection: The most important part of the test and the least precise is the selection of a representative sample. No "standard" can be devised; larger quarry run stone is best sampled at the shot or stockpile by given direction to the loader; small graded stone is best sampled by random selection from the transporting vehicles. If possible, all parties should take part in the sample selection and agree before the sample is run that the sample is representative.

NOTE NO. 2: Selection of Size for Separation: It is quite possible and accurate to run a gradation using any convenient sizes for the separation, without reference to the specifications. After the test is plotted on a curve, then the gradation limits may be plotted. Overlapping gradations with this method are no problem. However, it is usually more convenient to select points from the gradation limits, such as the minimum 50 percent size, the minimum 15 percent size, and one or two others, as separation points. For these types of stone gradations the separation points need to be selected as the smallest size stone at each break in the gradation specified.

2.1.1.3 Stone Stockpile

Storage of riprap armor, stone, or filter stone at the worksite is not to be confused with off-site stockpiling of riprap armor, stone, or filter stone. If the Contractor elects to provide off-site stockpiling areas, the Contracting Officer shall be notified of all such areas. The Contractor's stockpile shall be a maximum of 12 feet high and formed by a series of layers of truckload dumps, where the rock essentially remains where it is placed. Subsequent layers shall be started 10 feet from the edge of the previous layer so that the rock will not roll down the edges of the previous layers. The first layer shall be a maximum of 6 feet high. After being stockpiled, any riprap armor, stone, or filter stone which has become contaminated with soil or refuse shall not be put into the work unless the contaminating material has been removed from the riprap armor, stone, or filter stone prior to placement.

a. Worksite Stockpile. Riprap armor, stone, or filter stone delivered to the work sites, which requires temporary storage landward of top of slope, shall be placed in a container suitable for storing the riprap armor, stone, or filter stone without waste, or a sand-clay-gravel or crushed stone pad may be constructed for the storage area and removed upon completion of the work. If the sand-clay-gravel or crushed stone pad method is used, the pad shall have a minimum thickness of at least 6 inches. The container or sand-clay-gravel or crushed stone pad method shall be subject to approval prior to delivery of the riprap armor, stone, or filter stone. Upon completion of the work, the storage areas shall be cleaned of all storage residues and returned to their natural condition. Temporary storage of riprap armor, stone, or filter stone at the worksite will be allowed, provided the stockpile toe of the riprap armor, stone, or filter stone be no closer than 60 linear feet from the closest edge of the shoreline's upper top slope, and the

amount shall not exceed 200 T unless otherwise approved.

b. Off-site Stockpile. In areas where riprap armor, stone, or filter stone is stockpiled for placement, the area shall have excess rock removed prior to completion of work. All rock and spalls greater than 3 inches in diameter shall be removed. Where rocks may have become buried due to soft ground or operation of the equipment, the rock shall be disposed of as directed. After the rock has been removed, the storage area shall be graded, dressed, and filled to return the ground surface as near as practical to the condition that existed prior to construction.

2.1.2 Riprap Armor Stone

Riprap armor stone shall be well graded and shall conform to the table below.

TABLE 1	
PERCENT LIGHTER LIMITS OF STONEBY WEIGHT (SSD)	**LIMITS OF STONE WEIGHT, LB.**
95-100%	900
0-50%	450
0-15%	180
0-5%	75

All points on individual grading curves obtained from representative samples of riprap material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated gradation limits plotted on ENG FORM 2087 or similar form. The individual gradation curves within these limits shall not exhibit abrupt changes in slope denoting either gap grading or scalping of certain sizes or other irregularities.

Riprap meeting the grading for CalTrans 1/4 Ton Class rock size 3 will be accepted in lieu of the grading shown on Table 1.

2.1.3 Filter Stone

Stone shall be well graded and shall conform to the table below.

TABLE 2	
PERCENT LIGHTER LIMITS OF STONEBY WEIGHT (SSD)	**LIMITS OF STONE WEIGHT, LB.**
95-100%	45
0-50%	22.5
0-5%	9

All points on individual grading curves obtained from representative samples of riprap material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated gradation limits plotted on

ENG FORM 2087 or similar form. The individual gradation curves within these limits shall not exhibit abrupt changes in slope denoting either gap grading or scalping of certain sizes or other irregularities.

2.1.4 Filter Fabric

See SECTION 31 05 19 Geotextiles for filter fabric.

PART 3 EXECUTION

3.1 DEMONSTRATION SECTION

Prior to placement of stone, construct a section of stone protection consisting of filter fabric, filter stone, and riprap armor stone layers to demonstrate his proposed operations for production placement. The section shall demonstrate procedures and capability of grading, placing toe stone and bank protection within the tolerances specified. The demonstration section shall be 100 feet in length and shall conform to all applicable specifications.

3.1.1 Methods and Equipment

Methods and equipment employed for placement shall demonstrate the adequacy for use in placement of riprap armor stone and filter stone layers and shall conform with the requirements specified. The quantities of all materials placed within the section shall be accurately tabulated and provided immediately to the Contracting Officer for comparison with computed quantities.

3.1.2 Demonstration Section Evaluation

Do not proceed with placing stone protection prior to the approval of the demonstration section. Within a period of 7 days after completion of the section, the Contracting Officer shall determine the adequacy of the section to function as part of the permanent construction. The Contractor will be notified as to the acceptability of the section and may be directed to modify methods of construction and remove the section if necessary.

3.1.3 Removal of Demonstration Section

If removal of the demonstration section is required, it shall be conducted in such a manner as to maintain the integrity of the underlying subgrade. Make arrangements for disposal in areas not located on the site.

3.2 BASE PREPARATION

Areas on which filter fabric and filter stone are to be placed shall be graded and/or dressed to conform to cross sections shown on the contract drawings within an allowable tolerance of plus 2 inches and minus 1 inch from the theoretical slope lines and grades. The prepared base shall be approved by the Contracting Officer. Where such areas are below the allowable minus tolerance limit they shall be brought to grade by fill with earth similar to the adjacent material or with sand fill and then compacted to a density equal to the adjacent in place material. Subaqueous areas on which filter stone materials and riprap armor stone are to be placed shall be graded and/or dressed to conform to cross sections shown on the contract drawings within an allowable tolerance of plus 1 foot and minus 2 feet from the specified slope line and grades. Where such areas are below the allowable minus tolerance limit they shall be filled with sand fill. As an

alternative, these areas may be filled with filter stone material. Immediately prior to placing the geotextile and filter stone, the prepared base will be inspected by the Contracting Officer and no material shall be placed thereon until that area has been approved. Prepared base layers shall not be exposed to incoming water unless authorized by the Contracting Officer.

3.3 FILTER LAYER

3.3.1 Geotextile

Installation of geotextile shall be as specified in Section 31 05 19 GEOTEXTILES USED AS FILTERS.

3.3.2 Placement of Filter Stone on Geotextile

The filter layer, composed of geotextile and filter stone shall be placed on the prepared base, in accordance with the details shown on the contract drawings, and within the limits either shown on the contract drawings or staked in the field.

The Filter stone shall be spread uniformly on the geotextile to the slope lines and grades as indicated on the contract drawings and in such manner as to avoid damage to the geotextile. Loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. Placing of filter stone by methods which tend to segregate the particle sizes within the filter layer will not be permitted. Any damage to the surface of the geotextile during placement of filter stone shall be repaired before proceeding with the work. Compaction of material placed on the geotextile will not be required, but the surface shall be finished to present an adequately even surface, free from mounds or windrows.

3.4 PLACEMENT OF FILTER STONE AND RIPRAP ARMOR STONE

3.4.1 General

Filter stone shall be placed on the filter fabric layer within the limits shown on the contract drawings

Riprap armor stone shall be placed on the finished and approved filter stone layer within the limits shown on the contract drawings.

3.4.2 Placement

3.4.2.1 Above Water

Filter stone and riprap armor stone shall be placed in a manner which will produce a well-graded mass of rock with the minimum practicable percentage of voids, and shall be constructed, within the specified tolerances to the lines and grades shown on the contract drawings. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results.

All dump trucks used in placing the riprap shall be equipped with bottom hinged tailgates. The gate releasing mechanism shall be arranged so that it may be operated only from, at, or near the front of the truck.

Filter stone and riprap armor stone shall be placed to the full depth of each distinct material layer in one operation. Placing filter stone or riprap armor stone in multiple layers within an individual material layer will not be permitted.

Placing filter stone or riprap armor stone by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted. Placing filter stone or riprap armor stone by dumping it at the top of the slope and pushing it down the slope will not be permitted. No equipment shall be operated directly on the completed stone protection system.

No stone shall be dropped through air from a height greater than 3 feet. The drop height of riprap with a top size greater than 500 pounds shall be less than 1 foot, but can be increased by placing a cushioning layer of sand or other protective material on top of the geotextile before placing the riprap, or other methods deemed necessary if demonstrated in the field to not damage the geotextile.

Rearranging of individual stones will be required to the extent necessary to obtain a well- graded distribution of stone sizes as specified above. Maintain the stone protection until accepted by the Contracting Officer; any material displaced by any cause shall be replaced, with no additional payment, to the lines and grades shown on the drawings.

The larger stones shall be well distributed and the entire mass of stones in their final position shall be roughly graded to conform to the gradations specified in Tables 1 and 2 of this specification. The finished layers of filter stone and riprap armor stone shall be free from objectionable pockets of small stones and clusters of larger stones.

Allowable construction tolerances from the slope lines and grades shown on the contract drawings will be allowed at the finished neatline surfaces of the filter stone and the riprap armor stone layers, except that either extreme of such tolerance shall not be continuous over an area greater than 200 square feet. The average tolerance of the entire job shall have no more than 50 percent of the tolerance specified above. Allowable construction tolerances are provided in Part 1.6 of this specification.

3.4.2.2 Under Water

Under water placement rates shall be used when the top of the layer to be placed is covered by more than 3 feet of water.

Prior to starting work, submit the proposed method of placing filter stone or riprap armor stone under water. Filter stone or riprap armor stone to be placed in the wet shall be done during periods of low water levels.

3.5 CORRECTIVE EARTHWORK

3.5.1 Grading

Grading shall consist of the sloping of banks, either by filling or excavation, for the preparation of the subgrade.

Excavation shall be required where protrusion of existing stone or other objects above adjacent surface is objectionable, or to remove material from the shoreline in order to meet the subgrade surface as shown on the drawings.

Large areas may not require excavating throughout. Excavation will be required only for a distance of 5 feet outside the perimeter of the failure

To the extent practical, material resulting from the excavation operation shall be used for making required fills. Material used in making fills or restoring the subgrade shall be free from roots, brush or other debris. Each layer shall be thoroughly compacted to a density at least equal to that of the adjacent undisturbed earth.

3.6 TESTS AND INSPECTIONS

Surveys made by the Contractor are required on each material placed for determining that the materials are acceptably placed in the work. Make checks as the work progresses to verify lines, grades and thicknesses established for completed work. At least one (1) check survey as specified below shall be made for each twenty-five (25) foot section as shown as practicable after completion. Following placement of each type of material, the cross section of each step of the work shall be approved by the Contracting Officer before proceeding with the next step of the work. Approval of cross sections based upon check surveys shall not constitute final acceptance of the work. Cross sections shall be taken on lines 25 feet apart, measured along the structure reference line, with readings at 5 -foot intervals and at beaks along the lines. However, other cross section spacing and reading intervals may be used if determined appropriate by the Contracting Officer. Additional elevations and soundings shall be taken as the Contracting Officer may deem necessary or advisable. The surveys shall be conducted in the presence of an authorized representative of the Contracting Officer, unless this requirement is waived by the Contracting Officer.

a. Above Water: The elevation of stone above the water surface shall be determined by the use of a leveling instrument and a rod having a base 12 inches in diameter. If approved by the Contracting Officer other means may also be used.

b. Below Water: For portions of the work that are under water, sounding surveys shall be performed either by means of a sounding pole or a sounding basket weighing about 8 1/2 pounds, each of which has a base measuring 12 inches in diameter.

c. Gage Board: The gage shall be checked prior to any survey. Install a gage board at the project site.

d. Electronic Depth Recorder Method: When using an electronic depth recorder the following procedures shall be used.

   (1) The depth recorder shall be calibrated and adjusted for the gage, with check bar, at least six (6) times within a normal eight (8) hour work day.

   (2) Normal calibration times shall be at the beginning of the work day, mid-morning, close of morning's work, start of afternoon's work, mid-afternoon, and the end of the day.

(3) Further calibrations shall be performed whenever there is any malfunction within the depth recorder or transducer which might affect the soundings, a major gage change, or change in water temperature due to industrial discharge or other causes.

(4) The check bar shall be set at approximately the deepest sounding in the area to be sounded.

(5) The depth recorder shall be calibrated to read at low water datum.

(6) When checking the calibration at mid-morning, end of morning, mid-afternoon and end of work, the same setting used for the previous calibration shall be used.

(7) If the calibration check does not agree with the previous calibration, the depth recorder shall be calibrated to the proper setting.

(8) Under no circumstances shall the setting of the depth recorder be changed between calibrations.

e. Electronic Depth Recorder: The survey depth recorder used must be a standard model acceptable to the Contracting Officer using a sounding chart that can be read directly to the nearest foot and estimated to the nearest tenth (0.1) of a foot. Accuracy shall be better than 1/2 of 1 percent.

f. Tagline Method of Horizontal Location Along Station: If a tagline is used with a depth recorder, the soundings shall be marked with a fix every 5 feet.

g. Predetermined Transit Angle Method or Ranges Method: The interval between predetermined angles or ranges along a sounding line shall not exceed 200 feet along the entire length of the sounding line. No predetermined angle shall form an intersection with the sounding line of less than 45 degrees.

h. Speed of the Sounding Boat: When sounding, the speed of the sounding boat shall be as constant as possible, preferably between 180 and 220 feet per minute.

i. Checking Gage: The gage shall be checked prior to each calibration and recorded on the sounding chart or in the field notes.

EXAMPLE GRADATION SPECIFICATIONS	
PERCENT LIGHTER BY WEIGHT	STONE WEIGHT IN LBS
100	400-160
50	160-80
15	80-30

EXAMPLE WORKSHEET				
STONE SIZE LBS	**INDIVIDUAL WT. RETAINED**	**INDIVIDUAL PERCENT RETAINED**	**CUMULATIVE RETAINED**	**PERCENT PASSING**
400	0	0	0	100
160	9,600	30	30	70
80	11,200	35	65	35
30	8,000	25	90	10
0-30	3,200	10	100	
TOTAL	32,000 pounds			
NOTE: Largest stone 251 pounds				

G R A D A T I O N T E S T D A T A S H E E T

Quarry _____ Type of Stone Tested _____

Date of Test _____ Testing Rate _____

T E S T R E P R E S E N T S		
Contract No.	District	Tons
	TOTAL	

G R A D A T I O N					
			Cumulative		
Stone Size (lbs)	Weight Retained	Individual % Retained	% Retained	% Passing	Specification % Finer by Wt
Total Weight					
Max Size Stone					
Remarks:					

I certify that the above stone sample is representative of the total tonnage covered by this test report.

Contractor Representative _____

Government Representative _____

STONE SOURCES		
LATITUDE/LONGITUDE	QUARRY LOCATION, ADDRESS, & TELEPHONE	MAIN OFFICE ADDRESS & TELEPHONE NUMBER
STATE		
STATE		

-- End of Section --

Appendix D Preliminary Radiological Risk Modeling

Table of Contents

SECTION D1. PURPOSE D-1

SECTION D2. METHODOLOGY FOR RADIOLOGICAL RISK MODELING D-3

SECTION D3. RESULTS OF RADIOLOGICAL RISK MODELING D-4

SECTION D4. REFERENCES D-5

List of Tables

Table D-1. Default and Modified RESRAD Input Parameters
Table D-2 Radiological Risk Results, 3-Foot Cover

List of Attachments

Attachment D1. RESRAD Modeling and Risk Calculations *(provided on CD only)*

Acronyms and Abbreviations

ERRG	Engineering/Remediation Resources Group, Inc.
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
RESRAD	Residual Radioactivity (Model)
RI/FS	Remedial Investigation/ Feasibility Study
ROCs	radionuclides of concern
RSRS	Radiological Survey and Remedial Services, LLC

Section D1. Purpose

As described in the Record of Decision for Parcel E-2 (Department of the Navy [Navy], 2012), the selected remedy for Parcel E-2 consists of three primary components: (1) excavation of contaminated soil, sediment, and debris; (2) containment of remaining contamination; and (3) monitoring, maintenance, and institutional controls. As part of the excavation process, the Navy will perform a final radiological surface survey throughout Parcel E-2 to identify and remove radiological contamination to a depth of 1 foot (the maximum effective depth of the surface survey). Deeper soil excavation will be performed, if necessary, to ensure that the residual radiological risk at the final ground surface (following installation of a demarcation layer and soil cover) is acceptable.

The survey and risk modeling procedures will be outlined in the Remedial Action Work Plan. However, as described in Section 3.4.4 of the Design Basis Report, the Navy performed preliminary radiological risk modeling to help inform the design process and guide future radiological remediation activities. Specifically, preliminary risk modeling was performed to identify an upper bound of acceptable radiological contamination that can remain below the soil cover and demarcation layer without posing a future risk that exceeds the risk management range specified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (10^{-6} to 10^{-4}). The preliminary risk modeling was performed using procedures initially developed in the radiological addendum to the Remedial Investigation/Feasibility Study (RI/FS) Report (Engineering/Remediation Resources Group, Inc. [ERRG] and Radiological Survey and Remedial Services, LLC [RSRS], 2011).

This appendix presents the methodology and evaluations used to estimate the potential radiological risk to humans from exposure to remaining radioactivity under the final 2-foot-thick soil cover and demarcation layer. When combined with the minimum 1-foot-thick foundation[1] that will be free of radioactive contamination exceeding the remediation goals, the total thickness of the radiologically cleared surface soil will be 3 feet. Accordingly, this preliminary risk modeling evaluates the shielding provided by a 3-foot-thick soil cover.

The remainder of this appendix is organized as follows:

[1] This statement refers to the upper 1 foot of soil that will be surveyed and, if necessary, remediated prior to placement of the final cover (see Section 3.3.4 of the Design Basis Report). As described in Section 3.5 of the Design Basis Report, the foundation soil layer will be no less than 2 feet thick.

- Section D2 presents an overview of the methodology used for the radiological risk modeling.
- Section D3 discusses the results of the radiological risk modeling.
- Section D4 presents the references cited in this appendix.

Tables and attachments are presented after Section D4.

Section D2. Methodology for Radiological Risk Modeling

The computer code Residual Radioactive (RESRAD) Model (Argonne National Laboratory, 2009) was used to perform the preliminary risk modeling. The site-specific RESRAD modeling uses the isotopes specified as radionuclides of concern (ROCs) in all radiologically impacted areas within Parcel E-2 (radium-226, cesium-137, and strontium-90) and includes the long-lived daughter products of these isotopes (specifically, lead-210 which is a daughter product of radium-226). Cobalt-60 was previously identified as an ROC in one portion of Parcel E-2, referred to as the Ship-Shielding Area; however, the Navy performed a time-critical removal action in this area that demonstrated the activity levels for cobalt-60 (the ROC associated the previous activities) were less than the remediation goal (Shaw Environmental, Inc., 2013). Accordingly, cobalt-60 was omitted from the radiological risk modeling described herein.

RESRAD was used to analyze a residential exposure scenario. Although the residential exposure scenario does not align with the planned open space reuse of Parcel E-2 (City and County of San Francisco, 2010), it represents an upper-bound estimation of risk from exposure to ROCs at the parcel and is a conservative basis for the design.

Table D-1 summarizes changes to RESRAD default parameters that were previously used in the risk analysis presented in the radiological addendum to the RI/FS Report (ERRG and RSRS, 2011). These parameters, which were repeated in this preliminary risk modeling, were developed to make the receptor scenarios closely match the nonradiological human health risk assessment scenarios (as provided in the RI/FS Report [ERRG and Shaw Environmental, Inc., 2011]). All other RESRAD parameters were left at default values. The methodology for the radiological risk analysis is detailed in the radiological addendum to the RI/FS Report (ERRG and RSRS, 2011).

Section D3. Results of Radiological Risk Modeling

Radiological dose and risk were estimated for three different scenarios of residual radioactivity that could be present under the 3-foot-thick cover; which, as described in Section D1, represents the final 2-foot-thick soil cover underlain by a demarcation layer and at least 1 foot of radiologically cleared soil. The following three scenarios include a lower and upper bound of potential residual radioactivity:

- Scenario 1, residual radioactivity equal to the remediation goals (below the 3-foot cover)
- Scenario 2, residual radioactivity equal to 100 times the remediation goals (below the 3-foot cover)
- Scenario 3, residual radioactivity equal to the highest reported activity at Parcel E-2 (below the 3-foot cover); these activity levels were associated with radiological anomalies (i.e., devices) that were previously removed

Table D-2 summarizes the total radiological risk (including risk attributed to background activity levels) for each of the above three scenarios. The total radiological risk associated with Scenario 1 is well below the risk management range specified in the NCP (10^{-6} to 10^{-4}). The total radiological risk associated with Scenario 2 is at the lower end of the risk management range, while the total radiological risk associated with Scenario 3 is at the upper end of the risk management range. The dose and risk calculations, detailing the contribution from each ROC and each individual exposure pathway, are presented in Attachment B1.

The results of the preliminary risk modeling indicate that the highest reported activity at Parcel E-2 represents an upper bound of acceptable radiological contamination that can remain below the soil cover and demarcation layer without posing a future risk that exceeds risk management range specified in the NCP (10^{-6} to 10^{-4}). This finding indicates that a 3-foot cover would provide effective shielding from residual radioactivity at depth. This finding is attributed to the fact that the external radiation pathway is the critical pathway contributing to potential risk, and can be effectively controlled by a soil cover. As the cover depth increases, the resulting risk to the receptor is reduced.

The radiological risk modeling approach will be refined in the Remedial Action Work Plan and provided to the regulatory agencies for review and approval prior to implementing final radiological surveys.

Section D4. References

Argonne National Laboratory (ANL), 2009. "RESRAD Version 6.5 Computer Code." Environmental Science Division. October. Available Online at: <http://web.ead.anl.gov/resrad/home2/>.

City and County of San Francisco, 2010. "Amended Redevelopment Plan, Hunters Point Shipyard Redevelopment Plan." Map 2, titled "Land Use Districts Map." August 3, 2010 (amendment to July 14, 1997 plan). Available Online at: <http://www.sfredevelopment.org/index.aspx?page=160>.

Department of the Navy (Navy), 2006. "Final Basewide Removal Action, Action Memorandum – Revision 2006, Hunters Point Shipyard, San Francisco, California." April 21.

Engineering/Remediation Resources Group, Inc. (ERRG), and Shaw Environmental, Inc., 2011. "Final Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

ERRG and Radiological Survey and Remedial Services, LLC, 2011. "Final Radiological Addendum to the Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." March.

Shaw Environmental, Inc., 2013. "Final Removal Action Completion Report, Time-Critical Removal Action for the Experimental Ship Shielding Range, Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." February 13.

Tables

Table D-1. Default and Modified RESRAD Input Parameters

Parameter	RESRAD Default	Resident	
		Adult	Child
Exposure duration (years)	30	24	6
Fraction of time spent indoors (unitless)	0.5	0	0
Fraction of time spent outdors (unitless)	0.25	0.959	0.959
Inhalation rate (m^3/yr)	8,400	7,000	3,500
Soil ingestion rate (g/yr)	36.5	35	70

Notes:

g/yr Grams per year
m^3/yr Cubic meters per year

Table D-2. Radiological Risk Results, 3-Foot Cover

Modeled Scenario	Total Radiological Risk (Residential Exposure)[a, b]
Scenarion 1, Radioactivity Level Equal to Remediation Goals (below 3-foot cover)[c]	1.065E-08
Scenario 2, Radioactivity Levels Equal to 100 Times Remediation Goals (below 3-foot cover)	1.044E-06
Scenario 3, Radioactivity Levels Equal to Historic Maximum Detection (below 3-foot cover)[d]	1.368E-04

Notes:

a As indicated in Section B2, residential reuse of the site is not anticipated.

b Risk values are highest estimates for the sum of adult and child receptors, and include contribution of background radioactivity.

c Remediation goals are as follows:

Radionuclide of Concern	Remediation Goal (pCi/g)
Cesium-137 (^{137}Cs)	0.113
Strontium-90 (^{90}Sr)	0.331
Lead-210 (^{210}Pb)	1.633
Radium-226 (^{226}Ra)	1.633

d Maximum historic detection for each radionuclide of concern are as follows (these detections were associated with radiological surface anomalies (e.g., devices) that were subsequently removed; ^{210}Pb activity levels are conservatively assumed to be equal to ^{226}Ra activity levels

Radionuclide of Concern	Maximum Historic Activity Level (pCi/g)
^{137}Cs	234
^{90}Sr	849
^{210}Pb	20,953
^{226}Ra	20,953

pCi/g = picocuries per gram

Attachment D1. RESRAD Modeling and Risk Calculations

(RESRAD modeling and risk calculations provided on CD only.)

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	1.130E-01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.633E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	3.310E-01	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	7.000E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.400E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.500E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	1.130E-01
Thickness:	2.00 meters	Ra-226	1.633E+00
Cover Depth:	0.91 meters	Sr-90	3.310E-01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.784E-04	4.770E-04	4.743E-04	4.650E-04	4.394E-04	3.608E-04	2.058E-04	2.884E-05
M(t):	1.914E-05	1.908E-05	1.897E-05	1.860E-05	1.758E-05	1.443E-05	8.231E-06	1.154E-06

Maximum TDOSE(t): 4.784E-04 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.437E-07	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.776E-04	0.9984	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.346E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.784E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.437E-07	0.0016
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.776E-04	0.9984
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.346E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.784E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.267E-07	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.763E-04	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.162E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.770E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.267E-07	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.763E-04	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.162E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.770E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.938E-07	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.736E-04	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.812E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.743E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.938E-07	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.736E-04	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.812E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.743E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	5.901E-07	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.644E-04	0.9987	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.733E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.650E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.901E-07	0.0013
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.644E-04	0.9987
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.733E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.650E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	3.715E-07	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.391E-04	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.633E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.394E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.715E-07	0.0008
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.391E-04	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.633E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.394E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.352E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.607E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.382E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.608E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.352E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.607E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.382E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.608E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.184E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.058E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.605E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.058E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.184E-10	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.058E-04	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.605E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.058E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.627E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.884E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.173E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.884E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.627E-17	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.884E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.173E-22	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.884E-05	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	1.130E-01	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	1.633E+00	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	3.310E-01	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	7.437E-07	7.267E-07	6.938E-07	5.901E-07	3.715E-07	7.352E-08	7.184E-10	6.627E-17
Ra-226	Ra-226	1.000E+00	4.776E-04	4.763E-04	4.736E-04	4.644E-04	4.391E-04	3.607E-04	2.058E-04	2.884E-05
Pb-210	Ra-226	1.000E+00	5.978E-12	1.765E-11	3.979E-11	1.058E-10	2.221E-10	2.897E-10	1.738E-10	2.437E-11
Sr-90	Sr-90	1.000E+00	6.346E-10	6.162E-10	5.812E-10	4.733E-10	2.633E-10	3.382E-11	9.605E-14	1.173E-22

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.130E-01	1.104E-01	1.054E-01	8.966E-02	5.644E-02	1.117E-02	1.092E-04	1.007E-11
Ra-226	Ra-226	1.000E+00	1.633E+00	1.628E+00	1.619E+00	1.588E+00	1.501E+00	1.233E+00	7.035E-01	9.862E-02
Pb-210	Ra-226	1.000E+00	0.000E+00	4.987E-02	1.444E-01	4.265E-01	9.237E-01	1.216E+00	7.303E-01	1.024E-01
Sr-90	Sr-90	1.000E+00	3.310E-01	3.214E-01	3.031E-01	2.469E-01	1.374E-01	1.764E-02	5.010E-05	6.118E-14

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.30 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.034E-11	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.014E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.466E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.864E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.476E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.034E-11	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.014E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.466E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.864E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.476E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.034E-11	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.466E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.864E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.476E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.034E-11	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.466E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.864E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.476E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.010E-11	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.158E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.442E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.608E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.452E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.010E-11	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.158E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.442E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.608E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.452E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.010E-11	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.442E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.608E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.452E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.010E-11	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.442E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.608E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.452E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.642E-12	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.430E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.395E-09	0.9989	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.118E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.405E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.642E-12	0.0011
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.430E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.395E-09	0.9989
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.118E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.405E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.642E-12	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.395E-09	0.9989	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.118E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.405E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.642E-12	0.0011
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.395E-09	0.9989
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.118E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.405E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	8.200E-12	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.237E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.232E-09	0.9990	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.611E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.240E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.200E-12	0.0010
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.237E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.232E-09	0.9990
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.611E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.240E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	8.200E-12	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.232E-09	0.9990	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.611E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.240E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.200E-12	0.0010
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.232E-09	0.9990
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.611E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.240E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.162E-12	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	4.621E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	7.782E-09	0.9993	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.678E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	7.787E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.162E-12	0.0007
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.621E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.782E-09	0.9993
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.678E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.787E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.162E-12	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	7.782E-09	0.9993	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.678E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	7.787E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.162E-12	0.0007
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.782E-09	0.9993
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.678E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.787E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.022E-12	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.168E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.394E-09	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.724E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.395E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.022E-12	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.168E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.394E-09	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.724E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.395E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.022E-12	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.394E-09	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.724E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.395E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.022E-12	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.394E-09	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.724E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.395E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.984E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.057E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.647E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.342E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.647E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.984E-15	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.057E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.647E-09	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.342E-18	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.647E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.984E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.647E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.342E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.647E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.984E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.647E-09	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.342E-18	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.647E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.210E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	4.286E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.113E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.638E-27	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.113E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.210E-22	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.286E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.113E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.638E-27	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.113E-10	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.210E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.113E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.638E-27	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.113E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.210E-22	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.113E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.638E-27	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.113E-10	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	1.130E-01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.633E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	3.310E-01	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	3.500E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	6.000E+00	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	7.000E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	1.130E-01
Thickness:	2.00 meters	Ra-226	1.633E+00
Cover Depth:	0.91 meters	Sr-90	3.310E-01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.784E-04	4.770E-04	4.743E-04	4.650E-04	4.394E-04	3.608E-04	2.058E-04	2.884E-05
M(t):	1.914E-05	1.908E-05	1.897E-05	1.860E-05	1.758E-05	1.443E-05	8.231E-06	1.154E-06

Maximum TDOSE(t): 4.784E-04 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.437E-07	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.776E-04	0.9984	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.346E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.784E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.437E-07	0.0016
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.776E-04	0.9984
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.346E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.784E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.267E-07	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.763E-04	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.162E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.770E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.267E-07	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.763E-04	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.162E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.770E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.938E-07	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.736E-04	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.812E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.743E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.938E-07	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.736E-04	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.812E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.743E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	5.901E-07	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.644E-04	0.9987	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.733E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.650E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.901E-07	0.0013
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.644E-04	0.9987
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.733E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.650E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	3.715E-07	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.391E-04	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.633E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.394E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.715E-07	0.0008
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.391E-04	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.633E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.394E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.352E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.607E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.382E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.608E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.352E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.607E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.382E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.608E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.184E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.058E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.605E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.058E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.184E-10	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.058E-04	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.605E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.058E-04	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.627E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.884E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.173E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.884E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.627E-17	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.884E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.173E-22	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.884E-05	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	1.130E-01	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	1.633E+00	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	3.310E-01	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	7.437E-07	7.267E-07	6.938E-07	5.901E-07	3.715E-07	7.352E-08	7.184E-10	6.627E-17
Ra-226	Ra-226	1.000E+00	4.776E-04	4.763E-04	4.736E-04	4.644E-04	4.391E-04	3.607E-04	2.058E-04	2.884E-05
Pb-210	Ra-226	1.000E+00	5.978E-12	1.765E-11	3.979E-11	1.058E-10	2.221E-10	2.897E-10	1.738E-10	2.437E-11
Sr-90	Sr-90	1.000E+00	6.346E-10	6.162E-10	5.812E-10	4.733E-10	2.633E-10	3.382E-11	9.605E-14	1.173E-22

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.130E-01	1.104E-01	1.054E-01	8.966E-02	5.644E-02	1.117E-02	1.092E-04	1.007E-11
Ra-226	Ra-226	1.000E+00	1.633E+00	1.628E+00	1.619E+00	1.588E+00	1.501E+00	1.233E+00	7.035E-01	9.862E-02
Pb-210	Ra-226	1.000E+00	0.000E+00	4.987E-02	1.444E-01	4.265E-01	9.237E-01	1.216E+00	7.303E-01	1.024E-01
Sr-90	Sr-90	1.000E+00	3.310E-01	3.214E-01	3.031E-01	2.469E-01	1.374E-01	1.764E-02	5.010E-05	6.118E-14

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.29 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.144E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.536E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.170E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.830E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.173E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.144E-12	0.0014
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.536E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.170E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.830E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.173E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.144E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.170E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.830E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.173E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.144E-12	0.0014
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.170E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.830E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.173E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.072E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.022E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.164E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.748E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.167E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.072E-12	0.0014
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.022E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.164E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.748E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.167E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.072E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.164E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.748E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.167E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.072E-12	0.0014
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.164E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.748E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.167E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.933E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.942E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.152E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.592E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.155E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.933E-12	0.0014
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.942E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.152E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.592E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.155E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.933E-12	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.152E-09	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.592E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.155E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.933E-12	0.0014
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.152E-09	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.592E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.155E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.495E-12	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.684E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.110E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.111E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.113E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.495E-12	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.684E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.110E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.111E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.113E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.495E-12	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.110E-09	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.111E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.113E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.495E-12	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.110E-09	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.111E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.113E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.570E-12	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.049E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.995E-09	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.174E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.997E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.570E-12	0.0008
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.049E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.995E-09	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.174E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.997E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.570E-12	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.995E-09	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.174E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.997E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.570E-12	0.0008
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.995E-09	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.174E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.997E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.108E-13	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.311E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.639E-09	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.508E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.639E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.108E-13	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.311E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.639E-09	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.508E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.639E-09	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.108E-13	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.639E-09	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.508E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.639E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.108E-13	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.639E-09	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.508E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.639E-09	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.037E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	7.837E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	9.350E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.284E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.350E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.037E-15	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.837E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.350E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.284E-19	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.350E-10	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.037E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	9.350E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.284E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.350E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.037E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.350E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.284E-19	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.350E-10	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.802E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.099E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.311E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.231E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.311E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.802E-22	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.099E-16	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.311E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.231E-28	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.311E-10	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.802E-22	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.311E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.231E-28	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.311E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.802E-22	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.311E-10	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.231E-28	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.311E-10	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	1.125E+01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.600E+02	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	3.292E+01	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	7.000E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.400E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.500E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	1.125E+01
Thickness:	2.00 meters	Ra-226	1.600E+02
Cover Depth:	0.91 meters	Sr-90	3.292E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.687E-02	4.674E-02	4.648E-02	4.556E-02	4.306E-02	3.535E-02	2.016E-02	2.826E-03
M(t):	1.875E-03	1.870E-03	1.859E-03	1.822E-03	1.722E-03	1.414E-03	8.065E-04	1.130E-04

Maximum TDOSE(t): 4.687E-02 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.405E-05	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.680E-02	0.9984	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.312E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.687E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.405E-05	0.0016
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.680E-02	0.9984
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.312E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.687E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.235E-05	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.667E-02	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.130E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.674E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.235E-05	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.667E-02	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.130E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.674E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.908E-05	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.641E-02	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.781E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.648E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.908E-05	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.641E-02	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.781E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.648E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	5.875E-05	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.550E-02	0.9987	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.708E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.556E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.875E-05	0.0013
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.550E-02	0.9987
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.708E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.556E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	3.698E-05	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.302E-02	0.9991	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.619E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.306E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.698E-05	0.0009
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.302E-02	0.9991
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.619E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.306E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.320E-06	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.535E-02	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.364E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.535E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.320E-06	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.535E-02	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.364E-09	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.535E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.153E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.016E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.554E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.016E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.153E-08	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.016E-02	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.554E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.016E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.599E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.826E-03	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.167E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.826E-03	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.599E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.826E-03	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.167E-20	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.826E-03	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	1.125E+01	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	1.600E+02	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	3.292E+01	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	7.405E-05	7.235E-05	6.908E-05	5.875E-05	3.698E-05	7.320E-06	7.153E-08	6.599E-15
Ra-226	Ra-226	1.000E+00	4.680E-02	4.667E-02	4.641E-02	4.550E-02	4.302E-02	3.535E-02	2.016E-02	2.826E-03
Pb-210	Ra-226	1.000E+00	5.857E-10	1.730E-09	3.899E-09	1.037E-08	2.176E-08	2.839E-08	1.703E-08	2.388E-09
Sr-90	Sr-90	1.000E+00	6.312E-08	6.130E-08	5.781E-08	4.708E-08	2.619E-08	3.364E-09	9.554E-12	1.167E-20

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.125E+01	1.099E+01	1.050E+01	8.927E+00	5.619E+00	1.112E+00	1.087E-02	1.003E-09
Ra-226	Ra-226	1.000E+00	1.600E+02	1.596E+02	1.587E+02	1.556E+02	1.471E+02	1.208E+02	6.893E+01	9.663E+00
Pb-210	Ra-226	1.000E+00	0.000E+00	4.886E+00	1.415E+01	4.179E+01	9.050E+01	1.192E+02	7.156E+01	1.003E+01
Sr-90	Sr-90	1.000E+00	3.292E+01	3.197E+01	3.015E+01	2.456E+01	1.366E+01	1.755E+00	4.984E-03	6.085E-12

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 1.41 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.029E-09	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.974E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.295E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.817E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.305E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.029E-09	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.974E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.295E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.817E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.305E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.029E-09	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.295E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.817E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.305E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.029E-09	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.295E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.817E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.305E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.006E-09	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.115E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.272E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.562E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.282E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.006E-09	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.115E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.272E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.562E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.282E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.006E-09	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.272E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.562E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.282E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.006E-09	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.272E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.562E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.282E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.600E-10	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.381E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.225E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.074E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.235E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.600E-10	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.381E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.225E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.074E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.235E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.600E-10	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.225E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.074E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.235E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.600E-10	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.225E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.074E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.235E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	8.165E-10	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.172E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.065E-07	0.9990	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.576E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.073E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.165E-10	0.0010
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.172E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.065E-07	0.9990
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.576E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.073E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	8.165E-10	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.065E-07	0.9990	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.576E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.073E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.165E-10	0.0010
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.065E-07	0.9990
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.576E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.073E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.140E-10	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	4.527E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	7.625E-07	0.9993	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.659E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	7.630E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.140E-10	0.0007
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.527E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.625E-07	0.9993
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.659E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.630E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.140E-10	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	7.625E-07	0.9993	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.659E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	7.630E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.140E-10	0.0007
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.625E-07	0.9993
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.659E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.630E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.017E-10	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.063E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.265E-07	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.699E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.266E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.017E-10	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.063E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.265E-07	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.699E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.266E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.017E-10	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.265E-07	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.699E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.266E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.017E-10	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.265E-07	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.699E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.266E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.941E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.995E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.574E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.335E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.574E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.941E-13	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.995E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.574E-07	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.335E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.574E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.941E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.574E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.335E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.574E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.941E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.574E-07	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.335E-16	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.574E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.170E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	4.199E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.009E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.630E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.009E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.170E-20	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.199E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.009E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-25	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.009E-08	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	9.170E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.009E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.630E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.009E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.170E-20	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.009E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-25	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.009E-08	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	1.125E+01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.600E+02	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	3.292E+01	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	3.500E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	6.000E+00	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	7.000E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	1.125E+01
Thickness:	2.00 meters	Ra-226	1.600E+02
Cover Depth:	0.91 meters	Sr-90	3.292E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	4.687E-02	4.674E-02	4.648E-02	4.556E-02	4.306E-02	3.535E-02	2.016E-02	2.826E-03
M(t):	1.875E-03	1.870E-03	1.859E-03	1.822E-03	1.722E-03	1.414E-03	8.065E-04	1.130E-04

Maximum TDOSE(t): 4.687E-02 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.405E-05	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.680E-02	0.9984	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.312E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.687E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.405E-05	0.0016
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.680E-02	0.9984
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.312E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.687E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.235E-05	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.667E-02	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.130E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.674E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.235E-05	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.667E-02	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.130E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.674E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.908E-05	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.641E-02	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.781E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.648E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.908E-05	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.641E-02	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.781E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.648E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	5.875E-05	0.0013	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.550E-02	0.9987	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.708E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.556E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.875E-05	0.0013
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.550E-02	0.9987
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.708E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.556E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	3.698E-05	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.302E-02	0.9991	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.619E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.306E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.698E-05	0.0009
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.302E-02	0.9991
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.619E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.306E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.320E-06	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.535E-02	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.364E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.535E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.320E-06	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.535E-02	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.364E-09	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.535E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.153E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.016E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.554E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.016E-02	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.153E-08	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.016E-02	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.554E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.016E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	6.599E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.826E-03	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.167E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.826E-03	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.599E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.826E-03	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.167E-20	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.826E-03	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	1.125E+01	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	1.600E+02	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	3.292E+01	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	7.405E-05	7.235E-05	6.908E-05	5.875E-05	3.698E-05	7.320E-06	7.153E-08	6.599E-15
Ra-226	Ra-226	1.000E+00	4.680E-02	4.667E-02	4.641E-02	4.550E-02	4.302E-02	3.535E-02	2.016E-02	2.826E-03
Pb-210	Ra-226	1.000E+00	5.857E-10	1.730E-09	3.899E-09	1.037E-08	2.176E-08	2.839E-08	1.703E-08	2.388E-09
Sr-90	Sr-90	1.000E+00	6.312E-08	6.130E-08	5.781E-08	4.708E-08	2.619E-08	3.364E-09	9.554E-12	1.167E-20

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.125E+01	1.099E+01	1.050E+01	8.927E+00	5.619E+00	1.112E+00	1.087E-02	1.003E-09
Ra-226	Ra-226	1.000E+00	1.600E+02	1.596E+02	1.587E+02	1.556E+02	1.471E+02	1.208E+02	6.893E+01	9.663E+00
Pb-210	Ra-226	1.000E+00	0.000E+00	4.886E+00	1.415E+01	4.179E+01	9.050E+01	1.192E+02	7.156E+01	1.003E+01
Sr-90	Sr-90	1.000E+00	3.292E+01	3.197E+01	3.015E+01	2.456E+01	1.366E+01	1.755E+00	4.984E-03	6.085E-12

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.28 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.130E-10	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.505E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.126E-07	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.815E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.130E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.130E-10	0.0015
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.505E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.126E-07	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.815E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.130E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.130E-10	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.126E-07	0.9985	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.815E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.130E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.130E-10	0.0015
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.126E-07	0.9985
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.815E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.130E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.059E-10	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.981E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.120E-07	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.734E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.123E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.059E-10	0.0014
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.981E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.120E-07	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.734E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.123E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.059E-10	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.120E-07	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.734E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.123E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.059E-10	0.0014
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.120E-07	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.734E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.123E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.920E-10	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.883E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.109E-07	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.578E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.111E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.920E-10	0.0014
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.883E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.109E-07	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.578E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.111E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.920E-10	0.0014	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.109E-07	0.9986	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.578E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.111E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.920E-10	0.0014
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.109E-07	0.9986
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.578E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.111E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.484E-10	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.569E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.068E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.100E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.070E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.484E-10	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.569E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.068E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.100E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.070E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.484E-10	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.068E-07	0.9988	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.100E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.070E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.484E-10	0.0012
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.068E-07	0.9988
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.100E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.070E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.564E-10	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.028E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.955E-07	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.168E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.956E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.564E-10	0.0008
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.028E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.955E-07	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.168E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.956E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.564E-10	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.955E-07	0.9992	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.168E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.956E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.564E-10	0.0008
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.955E-07	0.9992
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.168E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.956E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.095E-11	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.285E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.606E-07	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.500E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.606E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.095E-11	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.285E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.606E-07	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.500E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.606E-07	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.095E-11	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.606E-07	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.500E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.606E-07	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.095E-11	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.606E-07	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.500E-14	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.606E-07	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.024E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	7.678E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	9.161E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.261E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.161E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.024E-13	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.678E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.161E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.261E-17	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.161E-08	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.024E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	9.161E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.261E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.161E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.024E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.161E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.261E-17	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.161E-08	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.790E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.076E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.284E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.203E-26	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.284E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.790E-20	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.076E-14	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.284E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.203E-26	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.284E-08	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.790E-20	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.284E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.203E-26	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.284E-08	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.790E-20	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.284E-08	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.203E-26	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.284E-08	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	2.300E+02	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	2.100E+04	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	8.500E+02	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	7.000E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2.400E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.500E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	2.300E+02
Thickness:	2.00 meters	Ra-226	2.100E+04
Cover Depth:	0.91 meters	Sr-90	8.500E+02

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	6.144E+00	6.127E+00	6.092E+00	5.973E+00	5.647E+00	4.639E+00	2.646E+00	3.709E-01
M(t):	2.458E-01	2.451E-01	2.437E-01	2.389E-01	2.259E-01	1.856E-01	1.058E-01	1.484E-02

Maximum TDOSE(t): 6.144E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.514E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.142E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.630E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.144E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.514E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.142E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.144E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.479E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.125E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.583E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.127E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.479E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.125E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.583E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.127E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.412E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.091E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.492E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.092E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.412E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.091E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.492E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.092E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.201E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.972E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.215E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.973E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.201E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.972E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.215E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.973E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.560E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.646E+00	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.762E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.647E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.560E-04	0.0001
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.646E+00	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.762E-07	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.647E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.496E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.639E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.685E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.639E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.496E-04	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.639E+00	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.685E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.639E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.462E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.646E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.467E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.646E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.462E-06	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.646E+00	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.467E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.646E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.349E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.709E-01	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.012E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.709E-01	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.349E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.709E-01	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.012E-19	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.709E-01	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	2.300E+02	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	2.100E+04	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	8.500E+02	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.514E-03	1.479E-03	1.412E-03	1.201E-03	7.560E-04	1.496E-04	1.462E-06	1.349E-13
Ra-226	Ra-226	1.000E+00	6.142E+00	6.125E+00	6.091E+00	5.972E+00	5.646E+00	4.639E+00	2.646E+00	3.709E-01
Pb-210	Ra-226	1.000E+00	7.688E-08	2.270E-07	5.117E-07	1.361E-06	2.856E-06	3.726E-06	2.235E-06	3.134E-07
Sr-90	Sr-90	1.000E+00	1.630E-06	1.583E-06	1.492E-06	1.215E-06	6.762E-07	8.685E-08	2.467E-10	3.012E-19

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	2.300E+02	2.247E+02	2.146E+02	1.825E+02	1.149E+02	2.274E+01	2.222E-01	2.050E-08
Ra-226	Ra-226	1.000E+00	2.100E+04	2.094E+04	2.082E+04	2.042E+04	1.930E+04	1.586E+04	9.047E+03	1.268E+03
Pb-210	Ra-226	1.000E+00	0.000E+00	6.413E+02	1.857E+03	5.485E+03	1.188E+04	1.564E+04	9.392E+03	1.317E+03
Sr-90	Sr-90	1.000E+00	8.500E+02	8.254E+02	7.784E+02	6.340E+02	3.527E+02	4.530E+01	1.287E-01	1.571E-10

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.33 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.104E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.590E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.089E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.276E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.089E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.104E-08	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.590E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.089E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.276E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.089E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.104E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.089E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.276E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.089E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.104E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.089E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.276E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.089E-04	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.056E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.775E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.086E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.210E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.086E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.056E-08	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.775E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.086E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.210E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.086E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.056E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.086E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.210E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.086E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.056E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.086E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.210E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.086E-04	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.963E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.125E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.080E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.085E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.080E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.963E-08	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.125E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.085E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.963E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.080E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.085E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.080E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.963E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.085E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E-04	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.669E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	4.163E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.059E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.698E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.059E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.669E-08	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.163E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.059E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.698E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.059E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.669E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.059E-04	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.698E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.059E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.669E-08	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.059E-04	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.698E-11	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.059E-04	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.051E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.942E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.001E-04	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.445E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.001E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.051E-08	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.942E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.001E-04	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.445E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.001E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.051E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.001E-04	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	9.445E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.001E-04	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.051E-08	0.0001
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.001E-04	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.445E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.001E-04	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.080E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	6.646E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.223E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.213E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.223E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.080E-09	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.646E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.223E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.213E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.223E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.080E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	8.223E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.213E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	8.223E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.080E-09	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.223E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.213E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.223E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.032E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.931E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.690E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.445E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.690E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.032E-11	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.931E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.690E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.445E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.690E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	2.032E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.690E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.445E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.690E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.032E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.690E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.445E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.690E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.875E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	5.511E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.575E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.207E-24	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.575E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.875E-18	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.511E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.575E-06	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.207E-24	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.575E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	1.875E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.575E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	4.207E-24	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.575E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.875E-18	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.575E-06	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.207E-24	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.575E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Summary : Residential Child 3 Ft Cover
File : N:\PROJECTS\2005 PROJECTS\25-049_NAVY_HPS_E-2_RI-FS\F_CALCULATIONS\RAD\CT3B.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 4
Summary of Pathway Selections 8
Contaminated Zone and Total Dose Summary 9
Total Dose Components
Time = 0.000E+00 10
Time = 1.000E+00 11
Time = 3.000E+00 12
Time = 1.000E+01 13
Time = 3.000E+01 14
Time = 1.000E+02 15
Time = 3.000E+02 16
Time = 1.000E+03 17
Dose/Source Ratios Summed Over All Pathways 18
Single Radionuclide Soil Guidelines 18
Dose Per Nuclide Summed Over All Pathways 19
Soil Concentration Per Nuclide 19

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Ba-137m (Source: FGR 12)	3.606E+00	3.606E+00	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(4)
A-1	Cs-137 (Source: FGR 12)	7.510E-04	7.510E-04	DCF1(5)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(6)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(7)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(8)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(9)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(10)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(11)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(12)
A-1	Sr-90 (Source: FGR 12)	7.043E-04	7.043E-04	DCF1(13)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(14)
A-1	Y-90 (Source: FGR 12)	2.391E-02	2.391E-02	DCF1(15)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(1)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(2)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(3)
B-1	Sr-90+D	1.308E-03	1.300E-03	DCF2(4)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(1)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(2)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(3)
D-1	Sr-90+D	1.528E-04	1.420E-04	DCF3(4)
D-34	Food transfer factors:			
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(1,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(1,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(2,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(3,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(3,3)
D-34				
D-34	Sr-90+D , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(4,1)
D-34	Sr-90+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-03	8.000E-03	RTF(4,2)
D-34	Sr-90+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(1,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(2,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(2,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(3,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(3,2)
D-5				
D-5	Sr-90+D , fish	6.000E+01	6.000E+01	BIOFAC(4,1)
D-5	Sr-90+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Cs-137	2.300E+02	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	2.100E+04	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Sr-90	8.500E+02	0.000E+00	---	S1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Sr-90	not used	0.000E+00	---	W1(4)
R013	Cover depth (m)	9.144E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	0.000E+00	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	4.600E+03	4.600E+03	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	4.600E+03	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	4.600E+03	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.623E-05	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.374E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Sr-90				
R016	Contaminated zone (cm**3/g)	3.000E+01	3.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	3.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	3.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	5.516E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.663E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	3.500E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	6.000E+00	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	0.000E+00	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	9.590E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	7.000E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	2000.00 square meters	Cs-137	2.300E+02
Thickness:	2.00 meters	Ra-226	2.100E+04
Cover Depth:	0.91 meters	Sr-90	8.500E+02

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	6.144E+00	6.127E+00	6.092E+00	5.973E+00	5.647E+00	4.639E+00	2.646E+00	3.709E-01
M(t):	2.458E-01	2.451E-01	2.437E-01	2.389E-01	2.259E-01	1.856E-01	1.058E-01	1.484E-02

Maximum TDOSE(t): 6.144E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.514E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.142E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.630E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.144E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.514E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.142E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.144E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.479E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.125E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.583E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.127E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.479E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.125E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.583E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.127E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.412E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	6.091E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.492E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	6.092E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.412E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.091E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.492E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.092E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.201E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.972E+00	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.215E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.973E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.201E-03	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.972E+00	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.215E-06	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.973E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	7.560E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	5.646E+00	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.762E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	5.647E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.560E-04	0.0001
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.646E+00	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.762E-07	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.647E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.496E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	4.639E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	8.685E-08	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	4.639E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.496E-04	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.639E+00	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.685E-08	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.639E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.462E-06	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.646E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	2.467E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.646E+00	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.462E-06	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.646E+00	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.467E-10	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.646E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	1.349E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	3.709E-01	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.012E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.709E-01	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.349E-13	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.709E-01	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.012E-19	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.709E-01	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137+D	Cs-137+D	1.000E+00	6.581E-06	6.431E-06	6.140E-06	5.222E-06	3.287E-06	6.506E-07	6.358E-09	5.865E-16
Ra-226+D	Ra-226+D	1.000E+00	2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Ra-226+D	Pb-210+D	1.000E+00	3.661E-12	1.081E-11	2.437E-11	6.481E-11	1.360E-10	1.774E-10	1.064E-10	1.492E-11
Ra-226+D	∑DSR(j)		2.925E-04	2.917E-04	2.900E-04	2.844E-04	2.689E-04	2.209E-04	1.260E-04	1.766E-05
Sr-90+D	Sr-90+D	1.000E+00	1.917E-09	1.862E-09	1.756E-09	1.430E-09	7.955E-10	1.022E-10	2.902E-13	3.543E-22

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	3.799E+06	3.887E+06	4.072E+06	4.788E+06	7.605E+06	3.843E+07	3.932E+09	*8.704E+13
Ra-226	8.547E+04	8.571E+04	8.620E+04	8.791E+04	9.298E+04	1.132E+05	1.984E+05	1.415E+06
Sr-90	1.304E+10	1.343E+10	1.424E+10	1.748E+10	3.143E+10	2.447E+11	8.615E+13	*1.365E+14

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Cs-137	2.300E+02	0.000E+00	6.581E-06	3.799E+06	6.581E-06	3.799E+06
Ra-226	2.100E+04	0.000E+00	2.925E-04	8.547E+04	2.925E-04	8.547E+04
Sr-90	8.500E+02	0.000E+00	1.917E-09	1.304E+10	1.917E-09	1.304E+10

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	1.514E-03	1.479E-03	1.412E-03	1.201E-03	7.560E-04	1.496E-04	1.462E-06	1.349E-13
Ra-226	Ra-226	1.000E+00	6.142E+00	6.125E+00	6.091E+00	5.972E+00	5.646E+00	4.639E+00	2.646E+00	3.709E-01
Pb-210	Ra-226	1.000E+00	7.688E-08	2.270E-07	5.117E-07	1.361E-06	2.856E-06	3.726E-06	2.235E-06	3.134E-07
Sr-90	Sr-90	1.000E+00	1.630E-06	1.583E-06	1.492E-06	1.215E-06	6.762E-07	8.685E-08	2.467E-10	3.012E-19

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Cs-137	Cs-137	1.000E+00	2.300E+02	2.247E+02	2.146E+02	1.825E+02	1.149E+02	2.274E+01	2.222E-01	2.050E-08
Ra-226	Ra-226	1.000E+00	2.100E+04	2.094E+04	2.082E+04	2.042E+04	1.930E+04	1.586E+04	9.047E+03	1.268E+03
Pb-210	Ra-226	1.000E+00	0.000E+00	6.413E+02	1.857E+03	5.485E+03	1.188E+04	1.564E+04	9.392E+03	1.317E+03
Sr-90	Sr-90	1.000E+00	8.500E+02	8.254E+02	7.784E+02	6.340E+02	3.527E+02	4.530E+01	1.287E-01	1.571E-10

THF(i) is the thread fraction of the parent nuclide.

RESCALC.EXE execution time = 0.30 seconds

Table of Contents

Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors 2
Risk Slope and ETFG for the Ground Pathway 3
Amount of Intake Quantities and Excess Cancer Risks
Time= 0.000E+00 4
Time= 1.000E+00 7
Time= 3.000E+00 10
Time= 1.000E+01 13
Time= 3.000E+01 16
Time= 1.000E+02 19
Time= 3.000E+02 22
Time= 1.000E+03 25

Cancer Risk Slope Factors Summary Table
Risk Library: FGR 13 Morbidity

Menu	Parameter	Current Value	Base Case*	Parameter Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):			
Sf-1	Cs-137+D	2.55E-06	5.32E-10	SLPF(1,1)
Sf-1	Pb-210+D	4.21E-09	1.41E-09	SLPF(2,1)
Sf-1	Ra-226+D	8.49E-06	2.29E-08	SLPF(3,1)
Sf-1	Sr-90+D	1.96E-08	4.82E-10	SLPF(4,1)
Sf-2	Inhalation, slope factors, 1/(pCi):			
Sf-2	Cs-137+D	1.12E-10	1.12E-10	SLPF(1,2)
Sf-2	Pb-210+D	3.08E-08	1.58E-08	SLPF(2,2)
Sf-2	Ra-226+D	2.83E-08	2.82E-08	SLPF(3,2)
Sf-2	Sr-90+D	4.33E-10	4.25E-10	SLPF(4,2)
Sf-3	Food ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,3)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,3)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,3)
Sf-3	Water ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.04E-11	3.04E-11	SLPF(1,4)
Sf-3	Pb-210+D	2.66E-09	8.81E-10	SLPF(2,4)
Sf-3	Ra-226+D	3.86E-10	3.85E-10	SLPF(3,4)
Sf-3	Sr-90+D	7.40E-11	5.59E-11	SLPF(4,4)
Sf-3	Soil ingestion, slope factors, 1/(pCi):			
Sf-3	Cs-137+D	3.74E-11	3.74E-11	SLPF(1,5)
Sf-3	Pb-210+D	3.44E-09	1.18E-09	SLPF(2,5)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF(3,5)
Sf-3	Sr-90+D	9.53E-11	6.88E-11	SLPF(4,5)
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):			
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
Sf-Rn	Radon K factors, (mrem/WLM):			
Sf-Rn	Rn-222 Indoor	7.60E+02	7.60E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	5.70E+02	5.70E+02	KFACTR(1,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Risk Slope and Environmental Transport Factors for the Ground Pathway

Nuclide (i)	Slope(i)*	ETFG(i,t) At Time in Years (dimensionless) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
At-218	3.570E-09	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23	6.206E-23
Ba-137m	2.690E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06	1.952E-06
Bi-210	2.760E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09	9.950E-09
Bi-214	7.480E-06	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05	2.983E-05
Cs-137	5.320E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10	3.615E-10
Pb-210	1.410E-09	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30	3.312E-30
Pb-214	9.820E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07	2.158E-07
Po-210	3.950E-11	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06	3.871E-06
Po-214	3.860E-10	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06	5.032E-06
Po-218	4.260E-11	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06	5.043E-06
Ra-226	2.290E-08	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09	8.120E-09
Rn-222	1.740E-09	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06	1.285E-06
Sr-90	4.820E-10	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11	6.077E-11
Tl-210	0.000E+00	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01	9.590E-01
Y-90	1.910E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08	8.136E-08

* - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 0.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.399E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.976E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.791E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	7.268E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.792E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.399E-09	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.976E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.791E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.268E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.792E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.399E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.791E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	7.268E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.792E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.399E-09	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.791E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.268E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.792E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.253E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	2.600E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.783E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	7.058E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.784E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.253E-09	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.600E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.783E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.058E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.784E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.253E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.783E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	7.058E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.784E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.253E-09	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.783E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.058E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.784E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+00 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.970E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	3.784E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.767E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.656E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.768E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.970E-09	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.784E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.767E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.656E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.768E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.970E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.767E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	6.656E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.768E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.970E-09	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.767E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.656E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.768E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.077E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	7.309E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.714E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.421E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.714E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.077E-09	0.0002
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.309E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.714E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.421E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.714E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.077E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.714E-05	0.9998	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	5.421E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.714E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.077E-09	0.0002
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.714E-05	0.9998
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.421E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.714E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+01 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.196E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.349E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.566E-05	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.016E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.566E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.196E-09	0.0001
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.349E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.566E-05	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.016E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.566E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+01 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	3.196E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.566E-05	0.9999	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.016E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.566E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.196E-09	0.0001
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.566E-05	0.9999
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.016E-12	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.566E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.326E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.686E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.108E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.873E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.108E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.326E-10	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.686E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.108E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.873E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.108E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.326E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	2.108E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	3.873E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.108E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.326E-10	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.108E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.873E-13	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.108E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 3.000E+02 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.182E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.008E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.202E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.100E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.202E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.182E-12	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.008E-11	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.100E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 3.000E+02 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	6.182E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.202E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.100E-15	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.202E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.182E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-05	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.100E-15	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-05	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As pCi/yr at t= 1.000E+03 years

Radio-	Water Independent Pathways (Inhalation w/o radon)					Water Dependent Pathways					Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Cs-137	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Pb-210	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ra-226	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Sr-90	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

* Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil
and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of
Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.703E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	1.413E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.685E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.343E-24	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.685E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.703E-19	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.413E-12	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.685E-06	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.343E-24	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.685E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	5.703E-19	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	1.685E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Sr-90	1.343E-24	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.685E-06	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All pathways	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Cs-137	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.703E-19	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.685E-06	1.0000
Sr-90	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.343E-24	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.685E-06	1.0000

***CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Appendix E. Geotechnical Analyses Report

REPORT

GEOTECHNICAL ANALYSES REPORT

(60% COMPLETION DRAFT)

Remedial Design for Parcel E-2
Hunters Point Naval Shipyard

Submitted To: Engineering/Remediation Resources Group, Inc.
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Distribution: ERRG (electronic copy)

June 2013

Project No. 123-97583

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Table of Contents

1.0 INTRODUCTION 1
2.0 BACKGROUND 2
2.1 Site Description 2
2.2 Geology 2
2.3 Previous Geotechnical Studies 3
2.3.1 TtEMI Study, 2004 3
2.3.2 ERRG Study, 2011 and 2012 4
2.3.3 Historical Subsurface Investigation 5
2.4 Remedial Design 5
3.0 SEISMIC HAZARD ANALYSIS 7
3.1 Peak Ground Acceleration 7
3.2 Selection of Time Histories 8
4.0 ANALYSIS OF LIQUEFACTION POTENTIAL 9
4.1 Free-Field PGA 9
4.2 Liquefaction Analysis Using Soil Boring Data 9
4.2.1 Analysis Methodology 9
4.2.2 Reanalysis of 2002 Soil Boring Data 9
4.2.3 Analysis of 2011 and 2012 Soil Boring Data 10
4.3 Liquefaction Analysis Using CPT Data 10
4.3.1 Analysis Methodology 10
4.3.2 Reanalysis of 2002 CPT Data 10
4.3.3 Analysis of 2011 and 2012 CPT Data 10
4.4 Consequences of Liquefaction 11
5.0 ANALYSIS OF CYCLIC SOFTENING POTENTIAL OF BAY MUD 12
6.0 SLOPE STABILITY UNDER STATIC CONDITIONS 13
6.1 General 13
6.1.1 Design Methodology 13
6.1.2 Design Criteria 13
6.2 Selection of Shear Strength Parameters 13
6.3 Analysis of Critical Cross Section 14
6.3.1 Analysis of Cross Section A-A 14
6.3.1.1 Short-Term Static Stability 14
6.3.1.2 Long-Term Static Stability 16
6.3.1.3 Impact of Slurry Wall on Slope Stability 16
7.0 SLOPE STABILITY UNDER SEISMIC CONDITIONS 17
7.1 General 17
7.1.1 Design Methodology 17

7.1.2 Design Criteria 17
7.2 Selection of Bay Mud Shear Strength for Seismic Analysis 17
7.3 Yield Acceleration Values 17
7.4 Seismic Response Analysis 18
7.5 Permanent Displacement Analysis 19
7.6 Post-Liquefaction Slope Stability 19
8.0 CONCLUSIONS AND RECOMMENDATIONS 21
8.1 Liquefaction Potential 21
8.2 Cyclic Softening Potential 21
8.3 Slope Stability 21
9.0 REFERENCES 23

List of Tables

Table 1 Summary of Liquefaction Potential Analysis Results for the 2002 Soil Boring and CPT Locations
Table 2 Summary of Liquefaction Potential Analysis Results for the 2011–2012 Soil Boring and CPT Locations

List of Figures

Figure 1 Parcel E-2 Location
Figure 2 Parcel E-2 Areas
Figure 3 Previous Geotechnical Investigations and Locations of Slope Stability Cross-Sections
Figure 4 OCR and S_u Profiles based on Gregg Drilling Data for CPT Locations along the Shoreline
Figure 5 Consolidation Analysis, Cross Section A-A′, Excess Pore Pressure After Soil Fill Placement
Figure 6 Slope Stability Analysis, Cross Section A-A′, Short-Term Factor of Safety After Soil Fill Placement
Figure 7 Consolidation Analysis, Cross Section A-A′, Excess Pore Pressure After Placement of Revetment
Figure 8 Slope Stability Analysis, Cross Section A-A′, Short-Term Factor of Safety After Placement of Revetment without Geogrids
Figure 9 Slope Stability Analysis, Cross Section A-A′, Short-Term Factor of Safety After Placement of Filter and Revetment with Two Layers of Miragrid 22XT
Figure 10 Consolidation Analysis, Cross Section A-A′, Excess Pore Pressure 5 Years After Placement of Revetment
Figure 11 Slope Stability Analysis, Cross Section A-A′, Factor of Safety 5 Years After Placement of Revetment with Two Layers of Miragrid 22XT
Figure 12 Slope Stability Analysis, Long-Term Static, Cross Section A-A′ with Two Layers of Miragrid 22XT
Figure 13 Slope Stability Analysis, Long-Term Static, Cross Section A-A′, Large Trial Surface through the Landfill
Figure 14 Slope Stability Analysis, Yield Acceleration, Cross Section A-A′ with Two Layers of Miragrid 22XT
Figure 15 Seismic Slope Stability, Cross Section A-A′, Permanent Displacement Analysis for MCE Time History = Chy029

Figure 16 Seismic Slope Stability, Cross Section A-A′, Permanent Displacement Analysis for MCE Time History = TCU076
Figure 17 Seismic Slope Stability, Cross Section A-A′, Permanent Displacement Analysis for MCE Time History = TCU052
Figure 18 Seismic Slope Stability, Cross Section A-A′, Permanent Displacement Analysis for MCE Time History = Izmit
Figure 19 Post-Liquefaction Slope Stability Analysis, Cross Section A-A′

List of Attachments

Attachment E1 Geologic Cross Sections and Historic Boring Logs
Attachment E2 Seismic Hazard Analysis
Attachment E3 Analysis Liquefaction Potential using SPT Data
Attachment E4 Analysis Liquefaction Potential using CPT Data
Attachment E5 Analysis of Cyclic Softening Potential
Attachment E6 Slope Stability Analyses
Attachment E7 SHAKE Analyses Results
Attachment E8 Newmark Analyses Results

List of Abbreviations and Acronyms

1-D	one-dimensional
2-D	two-dimensional
bgs	below ground surface
CPTs	cone penetration tests
CSRs	cyclic stress ratios
DISPLMT	name of the computer program used for Newmark analysis
EERI	Earthquake Engineering Research Institute
EPP	excess pore pressure
ERRG	Engineering/Remediation Resources Group, Inc.
FS	factor of safety
f_s	Cone skin friction
g	acceleration due to gravity
Golder	Golder Associates Inc.
HEA	horizontal equivalent acceleration
GMPEs	ground motion prediction equations
HPNS	Hunters Point Naval Shipyard
LI	liquidity index
LL	liquid limit
MCE	maximum credible earthquake
M_w	Earthquake moment magnitude
NC	normally consolidated
NGA	New Generation Attenuation
OCR	over consolidation ratio
PGA	peak ground acceleration
PL	plastic limit
q_t	cone tip resistance
QUAD4M	a computer program for 2-D seismic response analysis
RD	remedial design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SHAKE and SHAKE91	name of the computer program used for seismic response analysis
Shaw	Shaw Environmental, Inc.
SIGMA/W	name of the computer program used for pore pressure analysis
SLOPE/W	name of the computer program used for slope stability analysis
SPT	standard penetration test
S_u	undrained shear strength
TtEMI	Tetra Tech EM Inc.
w_n	natural moisture content
σ'_v or σ'_{vc}	effective vertical stress

1.0 INTRODUCTION

This report presents the results of geotechnical analyses performed as part of the remedial design (RD) for Parcel E-2 Landfill at the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California. Golder Associates Inc. (Golder) performed the geotechnical analyses under a contract with Engineering/Remediation Resources Group, Inc. (ERRG).

This draft report corresponds to the 60 percent design level and includes the following:

- A deterministic seismic hazard analysis to estimate the peak ground acceleration (PGA) corresponding to the maximum credible earthquake (MCE) along the San Andreas Fault and to develop spectrally matched acceleration time histories for seismic response analysis.
- A reanalysis of the liquefaction potential using data collected during a previous geotechnical investigation from soil borings and cone penetration tests (CPTs) (Tetra Tech EM Inc. [TtEMI], 2004).
- Analysis of liquefaction potential using data collected during a previous geotechnical investigation from soil borings and CPTs (ERRG, 2013).
- Analysis of the potential for cyclic softening of Bay Mud using data collected during a previous geotechnical investigation from CPTs (ERRG, 2013).
- Analysis of the slope stability of the most critical cross section of the Parcel E-2 Landfill (where the landfill is closest to San Francisco Bay) under both static and seismic conditions.

The draft final version of this report will correspond to the 90 percent design level and will include the following additional elements:

- Analysis of the slope stability of additional cross sections of the Parcel E-2 Landfill under both static and seismic conditions.
- Analysis of the slope stability of the landfill final cover under static and seismic conditions.
- Analysis of waste and underlying Bay Mud settlement to estimate its impact on final cover grades.

2.0 BACKGROUND

2.1 Site Description

HPNS is located in the City and County of San Francisco, California (see Figure 1). HPNS includes 866 acres (420 acres on land and 446 acres under water in the San Francisco Bay) in southeastern San Francisco on a peninsula that extends east into San Francisco Bay and is bounded by non-Navy property to the west. HPNS property was placed on the National Priorities List in 1989, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act, because past shipyard operations left hazardous substances on site. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure at HPNS involves conducting environmental remediation and making the property available for non-defense use.

Parcel E-2 consists of about 47 acres of shoreline and lowland coast along the southwestern portion of HPNS. Parcel E-2 contains four distinct areas, which were designated as follows (see Figure 2):

- The “Parcel E-2 Landfill,” located in the north-central part of Parcel E-2
- The “Panhandle Area,” located west and southwest of the Parcel E-2 Landfill
- The “East Adjacent Area,” located to the east of the Parcel E-2 Landfill
- The “Shoreline Area,” located at the edge of San Francisco Bay

Parcel E-2 is part of an area created in the 1940s, 1950s, and 1960s by filling the bay margin with various materials, including soil, crushed bedrock, dredged sediments, and debris. The landfill has a heterogeneous composition and includes solid waste intermixed with soil fill. The physical extent of the solid waste covers approximately 22 acres. Shortly after landfill operations ceased in 1974, the Navy implemented several preliminary landfill closure measures, including placing a minimum of 2 feet of compacted, imported soil on top of the Parcel E-2 Landfill.

2.2 Geology

The peninsula forming HPNS is within a northwest-trending belt of the Franciscan Complex bedrock known as the Hunters Point Shear zone. The natural geology at HPNS consists of unconsolidated Holocene sediments of estuarine and alluvial origin (Quaternary age) deposited on an uneven, eroded bedrock surface composed primarily of serpentinite (Jurassic-Cretaceous age). Artificial Fill was deposited extensively over the natural sediments and bedrock during expansion of the shipyard in the early 1940s. Six individual geologic units have been identified at HPNS. Representative geologic cross sections from the Remedial Investigation/Feasibility Study (RI/FS) Report are provided in the Design Basis Report to which this report is appended. In general, the stratigraphic sequence of the geologic units, from youngest (shallowest) to oldest (deepest), is as follows: (1) Artificial Fill; (2) Slope Debris and

Ravine Fill; (3) Undifferentiated Upper Sand Deposits; (4) Bay Mud; (5) Undifferentiated Sedimentary Deposits; and (6) Franciscan Complex Bedrock (ERRG and Shaw Environmental, Inc., 2011).

The geologic conditions along the Parcel E-2 shoreline, where the most critical cross section is located, were identified during a series of previous investigations (ERRG and Shaw, 2011; ERRG, 2013). Past investigations show that the Artificial Fill ranges from 7 feet to 30.5 feet thick along the Parcel E-2 shoreline and consists primarily of soil and construction debris used for land reclamation. The soil portion of the fill varies in composition from fine-grained clay deposits to coarse-grained gravel and larger boulders and has an irregular contact depth with the underlying Bay Mud. The irregular contact may be attributed to both natural causes (such as former stream channels) and manmade causes (such as dredging or placement of heavier bedrock-derived fill and debris on softer Bay Mud and sand deposits). The underlying Bay Mud ranges from 16 feet thick to greater than 30 feet thick along the Parcel E-2 shoreline, and consists of grayish-green sediments that are almost exclusively composed of silt and clay. The Undifferentiated Sedimentary Deposits consist of interbedded clay, silt, and sand and range from 115 feet thick to greater than 235 feet thick along the Parcel E-2 shoreline. Franciscan Complex/Great Valley Complex Bedrock, which consists predominantly of serpentinite of Jurassic Age, is present at depths ranging from 150 feet below ground surface (bgs) to greater than 280 feet bgs along the Parcel E-2 shoreline (ERRG, 2013).

2.3 Previous Geotechnical Studies

The following previous studies specifically addressed geotechnical issues at Parcel E-2:

- "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Liquefaction Potential" by TtEMI (2004). This report is included in Appendix C of the RI/FS Report (ERRG and Shaw, 2011).
- "Technical Memorandum for the Geotechnical Investigation at Parcel E-2 (Installation Restoration Site 01/21)" by ERRG (2013).

2.3.1 TtEMI Study, 2004

In 2002, TtEMI collected data from 5 soil borings and 20 CPTs, the locations of which are shown in Figure 3 and included in TtEMI (2004). The soil borings were advanced using rotary-wash drilling to perform standard penetration tests (SPTs) and to collect soil samples for geotechnical laboratory tests (such as, shear strength tests). The soil borings were designated as S-01 through S-05 and their depths ranged between 61.5 and 76.5 feet. In the CPTs, tip resistance, sleeve friction, and pore pressures were measured and recorded as the cone penetrometer probe was pushed under pressure into the subsurface. The CPTs were designated as CPT-01 through CPT-04, CPT-06 through CPT-16, CPT-22 through CPT-26A, and CPT-26B and their depths ranged from 60 to 100 feet except at CPT-26A and CPT-26-B, which were less than 20 feet deep. CPT-08, CPT-14, CPT-16, CPT-23, and CPT-06 were collocated with soil

borings S-01 through S-05, respectively. The interpreted stratigraphy from these CPT borings was correlated with the visual observations from the collocated soil borings.

Based on the liquefaction analyses using the soil boring and CPT data, TtEMI concluded that sandy soil below and along the perimeter of the landfill is potentially liquefiable. TtEMI also concluded that, because the thickness and types of soil varied at each location, liquefaction was likely to be non-uniform (or discontinuous) across the site, which would be less damaging than liquefaction over a large continuous areal extent.

2.3.2 ERRG Study, 2011 and 2012

In 2011 and 2012, ERRG collected geotechnical data from 3 soil borings and 18 CPT locations, which are shown in Figure 3. The soil borings were designated as IR01B500, IR01B501, and IR01B502, and their depths ranged between 40.5 and 44.5 feet. The borings were advanced using a mud rotary drill rig to collect relatively undisturbed samples of Bay Mud for laboratory testing. The CPTs were designated as IR01CPT52 through IR01CPT69 and their depths ranged between 13.1 and 43.3 feet except at IR01CPT52, which was 80.4 feet deep.

ERRG transported 17 relatively undisturbed Bay Mud samples collected from the soil borings to the geotechnical testing laboratory at University of California, Berkeley. The following tests were performed on the Bay Mud samples:

- **Index tests** (including specific gravity, unit weight, natural moisture content (w_n), grain-size distribution, and Atterberg limits; eight samples tested). The tests showed a moist unit weight ranging from 97.0 to 109.9 pounds per cubic feet, moisture content ranging from 43 to 72 percent, liquid limit (LL) ranging from 40 to 82, and plastic limit (PL) ranging from 17 to 30 for the Bay Mud. The liquidity index (LI)[1] of the Bay Mud was estimated to be between 0.75 and 0.975, which indicated that the Bay Mud is sensitive (i.e., the material loses shear strength at large strains).
- **Laboratory vane shear test** (one sample tested). The test estimated the sensitivity (which is the ratio of the peak to residual undrained shear strength) of the Bay Mud to be around 4.6.
- **Constant rate of strain consolidation tests** (three samples tested). The consolidation tests estimated that the over-consolidation ratios (OCRs[2]) at depths of approximately 10, 20, and 40 feet bgs were approximately 2, 1.5, and 1, respectively. These estimates indicate that Bay Mud within the upper 10 to 15 feet is over-consolidated[3].

[1] $LI = (w_n - PL)/PI$

[2] $OCR = \sigma'_{vm}/\sigma'_{v0}$

where σ'_{vm} = maximum past effective vertical stress estimated from consolidation testing

σ'_{v0} = current effective vertical stress

[3] This means the upper 10 to 15 feet of Bay Mud has experienced a higher effective vertical stress in the past (σ'_{vm}) compared to the current effective vertical stress (σ'_{v0}), likely due to desiccation. In other words, the upper 10 to 15 feet of Bay Mud has an OCR greater than 1.

- **Static triaxial shear strength using consolidated undrained test conditions** (three samples tested). The test samples were normally consolidated (NC) before shearing by applying effective confining pressures higher than that in the field for each sample. The undrained shear strength (S_u) to effective confining stress (σ'_{vc}) ratios (i.e., S_u/σ'_{vc} ratio) from the three tests were estimated to be 0.29, 0.36, and 0.39 for NC Bay Mud.
- **Cyclic triaxial shear strength tests** (three series of tests on three samples): Each series involved four different cyclic stress ratios (CSRs) ranging from 0.05 to 0.43. These tests were also performed after the samples were NC before the test. The test results indicate the following:
  - Six of the tests performed with a CSR of less than 0.17 experienced very small cumulative strains (<1 percent) after 30 cycles.
  - A sample tested at a CSR of 0.3 experienced cumulative strain of less than 5 percent after 30 cycles.
  - A sample tested at a CSR of 0.31 experienced cumulative strain of 5 percent in 8 cycles.
  - A sample tested at a CSR of 0.32 experienced cumulative strain of 5 percent in 12 cycles.
  - A sample tested at a CSR of 0.35 experienced cumulative strain of 5 percent in 5 cycles.
  - A sample tested at a CSR of 0.36 experienced cumulative strain of 5 percent in 6 cycles.
  - A sample tested at a CSR of 0.43 experienced cumulative strain of 5 percent in 1 cycle.

  The above results indicate that the NC Bay Mud could withstand 20 cycles of loading at a CSR of close to 0.3, with less than 5 percent cumulative strain.
- **Post-cyclic triaxial shear strength tests** (four samples tested, each of which was used in the cyclic triaxial shear strength tests). These tests were performed immediately after the cyclic triaxial tests. The post-cyclic S_u/σ'_{vc} ratios from the four tests were 0.31, 0.35, 0.37, and 0.44 at large axial strains of 12 percent. These S_u/σ'_{vc} ratios are similar to those from the static triaxial tests listed above, which suggest that Bay Mud did not experience strength loss under post-cyclic conditions.

2.3.3 Historical Subsurface Investigation

In addition to the geotechnical investigations described above, additional borings were drilled at Parcel E-2 as part of previous environmental investigations. Data from these previous investigations provide stratigraphic information (such as depth of Bay Mud) that informs the geotechnical analyses in this report. The boring logs from these investigations are included in Appendix J of the RI/FS Report (ERRG and Shaw, 2011). Figure 3 shows the locations of the historical borings used in the geotechnical analyses. Logs from the previous borings used in the geotechnical analyses (i.e., to construct to cross sections requiring quantitative evaluation) are provided in Attachment E1.

2.4 Remedial Design

According to the Record of Decision (ROD) (Department of the Navy, 2012), the selected remedy for Parcel E-2 consists of the following actions:

- Remove and dispose of contaminated soil in selected areas.
- Separate and dispose of material and soil with radiological contamination.
- Install a protective liner and soil cover over Parcel E-2.
- Install below-ground barriers to limit groundwater flow from the landfill to San Francisco Bay.
- Remove and treat landfill gas to prevent it from moving across the Parcel E-2 boundary.
- Build a shoreline revetment.
- Monitor and maintain the different parts of the preferred alternative (i.e., soil cover, shoreline revetment, wetlands, etc.) to ensure they are working properly.
- Use institutional controls to restrict specific land use and activities on Parcel E-2.

Constructing the shoreline revetment will require the placement of additional soil fill along the landfill perimeter next to the shoreline. The weight of the new soil fill and the weight of the revetment will impose additional loading on the relatively soft Bay Mud present under the southern parts of the Parcel E-2 Landfill. The Bay Mud has relatively low shear strength, particularly along and beyond the landfill perimeter next to the shoreline. Therefore, slope stability of the landfill along the southern perimeter is very critical. Similarly, relatively loose sands are present along parts of the southern perimeter of the landfill. Data collected during TtEMI's 2002 investigation indicate that these sands are potentially liquefiable during an earthquake (TtEMI, 2004). Therefore, post-liquefaction slope stability of the southern perimeter of the landfill is also very critical.

Soil will also be removed from selected areas outside the Parcel E-2 Landfill (primarily to construct the shoreline revetment and new wetlands) and will be consolidated near the northwest corner of the landfill, which will raise the elevation of the landfill by about 5 feet. Regrading of the landfill may impact both the slope stability and settlement of the landfill.

HPNS is located only 12 kilometers (7.5 miles) from the San Andreas Fault. Therefore, liquefaction potential of sandy/silty soil, cyclic softening potential of Bay Mud, and seismic slope stability are critical considerations for the RD for Parcel E-2.

The analyses presented in this report address the above considerations.

3.0 SEISMIC HAZARD ANALYSIS

As part of this study, Golder performed a seismic hazard analysis for Parcel E-2 RD. Attachment E2 presents the results of Golder's seismic hazard analysis. The following sections briefly summarize the estimation of the PGA corresponding to the MCE and development of four spectrally matched acceleration time histories for use in the seismic response analysis.

3.1 Peak Ground Acceleration

The Parcel E-2 Landfill final cover is designed to withstand the MCE, which is the design requirement under Title 22 of California Code of Regulations Section 66264.310(a)(5). The MCE is defined as "the maximum earthquake that appears capable of occurring under the presently known geologic framework." Because the site is located 12 kilometers (7.5 miles) from the San Andres Fault, the MCE would be a repeat of the 1906 San Francisco Earthquake, which was a moment magnitude (M_w) 7.9 earthquake. To be conservative, the M_w was assumed to be 8 in this study. The promulgated design requirements for seismic slope stability do not specify the method of estimating the ground motion for the MCE event. Accordingly, ground motion for the MCE event was estimated based on the current state of practice for seismic design. The estimated ground motion (referred to as the "PGA") was used in the geotechnical analyses of liquefaction potential and slope stability.

Published regional empirical ground motion prediction equations (GMPEs) were used to estimate the 5 percent damped MCE acceleration response spectra. The GMPEs used for crustal earthquakes are based on Next Generation Attenuation (NGA) relationships developed by Abrahamson and Silva (2008), Boore and Atkinson (2008), Chiou and Youngs (2008), and Campbell and Bozorgnia (2008). The four GMPEs for crustal earthquakes were equally weighted (0.25 each) to estimate spectral accelerations as a function of magnitude, source-to-site distance, and fault geometry and for an average shear wave velocity in the upper 30 meters (100 feet) of the soil column (V_{s30}) equal to 760 meters per second (2,500 feet per second). The spectral accelerations are shown in Attachment E2.

Based on the four GMPEs, the median PGA for the Parcel E-2 Landfill is estimated to be 0.29 times the acceleration due to gravity (0.29 g). The final cover for the Parcel E-2 Landfill has been designed to withstand this estimated ground motion from the MCE. The PGA used in this RD is less than the PGA used in the TtEMI (2004) report (0.5g) because the NGA relationships, which were not available at the time of the previous analysis, more accurately predict PGA for sites close to the epicenter of a large earthquake. The accuracy of the PGA estimates is improved because the NGA models incorporate a large number of recordings within 20 kilometers (12.4 miles) of earthquakes having a M_W greater than 7 as compared with previous models. The additional data included in the NGA models showed that the previous models over-predicted the ground motion for sites close to the epicenter of a large earthquake.

As a result, the NGA models provide significantly lower estimates of PGA for sites close to the epicenter of large strike-slip earthquakes as compared with previous models.

The reduction of approximately 40 percent in the estimated PGA (from 0.5g to 0.29g) was consistent with other landfill closure projects in the San Francisco Bay Area. For example, the seismic hazard analysis performed by Dr. Norman Abrahamson for the Ox Mountain Landfill (Abrahamson, 2007), which is located 6 kilometers (3.7 miles) from the San Andreas Fault near Half Moon Bay, resulting in a similar estimated PGA based on the NGA models, which was significantly lower than the estimated PGA using previous models.

3.2 Selection of Time Histories

Golder reviewed available acceleration time history records that met the magnitude-distance criteria for the San Andreas Fault. The table below shows the four "seed" acceleration time history records selected for the MCE at this site.

Motion No.	Earthquake Name (date)	Magnitude (M_W)	Station	Component of Motion	Duration (seconds)
1	Chi Chi Taiwan (1999)	7.6	CHY029	Vertical	30.25
2	Chi Chi Taiwan (1999)	7.6	TCU076	East-West	30.84
3	Chi Chi Taiwan No. 4 (1999)	7.6	TCU051	East-West	26.78
4	Kocaeli Turkey (1999)	7.5	Izmit	Fault Normal	18.09

The table lists the earthquake, date of the earthquake, earthquake moment magnitude, station name, component of motion, and duration. The acceleration time histories were spectrally matched to the 5 percent damped acceleration response spectrum for the MCE event, as discussed in Attachment E2. The plots of spectrally matched acceleration time histories are shown in Attachment E2. The spectrally matched acceleration time histories were used in the seismic response analysis discussed in Section 7. The four motions are subsequently referred to using their station identification (i.e., Chy029, TCU076, TCU051, and Izmit).

4.0 ANALYSIS OF LIQUEFACTION POTENTIAL

4.1 Free-Field PGA

The PGA (and acceleration time histories) discussed in Section 3 corresponds to the bedrock surface at the Parcel E-2 Landfill, which is present at depths ranging from 150 feet bgs to greater than 280 feet bgs along the Parcel E-2 shoreline (see Section 2.2). The overburden soil above the bedrock modifies the PGA as shear waves travel up to the ground surface. In other words, the acceleration at the ground surface would be different from the estimated PGA in the underlying bedrock. The overburden can either attenuate or amplify the PGA at the ground surface depending on the natural frequency of the overburden. Traditional methods for analyzing liquefaction potential require the use of the PGA at the ground surface (referred to as the "free-field PGA") to compute the seismically induced shear stresses at various depths. The free-field PGA is typically estimated using a seismic response analysis program, such as "SHAKE" (Schnabel et al., 1972; Idriss et al., 1992). Golder has not performed SHAKE analysis specifically to estimate the free-field PGA. However, based on the SHAKE analyses performed as part of the seismic slope stability discussed subsequently in Section 7.4, we concluded that the free-field PGA would be lower than the bedrock PGA. However, to be conservative, Golder has assumed a free-field PGA equal to the bedrock PGA (0.29g) for the liquefaction analysis discussed in Sections 4.2 and 4.3.

4.2 Liquefaction Analysis Using Soil Boring Data

4.2.1 Analysis Methodology

The blow counts (N values) measured from the standard penetration tests (SPTs) conducted during drilling of soil borings were used to analyze the liquefaction potential of loose cohesionless soil (sands and silts). The liquefaction analysis was performed using the empirical procedure outlined in the Earthquake Engineering Research Institute's (EERI) monograph MNO-12 (Idriss and Boulanger, 2008). This monograph is an update of the original EERI monograph entitled "Ground Motions and Soil Liquefaction During Earthquakes" (Seed and Idriss, 1982).

4.2.2 Reanalysis of 2002 Soil Boring Data

TtEMI analyzed liquefaction potential using the N values measured in the five soil borings (S-01 through S-05) based on the Youd et al. (2001) procedure. Golder reanalyzed the liquefaction potential at borings S-01 through S-05 based on the Idriss and Boulanger (2008) procedure and using a PGA of 0.29g. Attachment E3 presents the results of Golder's analysis. Table 1 summarizes the liquefaction analysis for soil borings S-01 through S-05 (next to the liquefaction analyses results for the corresponding CPTs). In Table 1, the zones shaded in orange under each location represent the potentially liquefiable depths.

4.2.3 Analysis of 2011 and 2012 Soil Boring Data

Golder analyzed the liquefaction potential using the SPT N values recorded in borings IR01B501 and IR01B502. Attachment E3 presents the results of the liquefaction analysis using the N values. Table 2 summarizes the results (next to the results of corresponding CPT borings from 2011 and 2012). In Table 2, the zones shaded in orange under each location represent the potentially liquefiable depths.

4.3 Liquefaction Analysis Using CPT Data

4.3.1 Analysis Methodology

The EERI monograph MNO-12 (Idriss and Boulanger, 2008) presents a CPT-based empirical liquefaction analysis procedure. Similar to other procedures available (e.g., Robertson and Wride, 1997), the procedure uses the cone tip resistance (q_t) and sleeve friction (f_s) recorded from the cone penetrometer probe in the analysis of liquefaction potential.

4.3.2 Reanalysis of 2002 CPT Data

TtEMI analyzed liquefaction potential at CPT-01 through CPT-04, CPT-06 through CPT-16, CPT-22 through CPT-26A, and CPT-26B based on the Youd et al. (2001) procedure after converting the CPT data to obtain equivalent N values (TtEMI, 2004). Golder reanalyzed the liquefaction potential at the CPTs by directly using the CPT data (i.e., the q_t and f_s data). The analysis was performed using the CPT-based empirical procedure outlined in Idriss and Boulanger (2008). Attachment E4 presents the results of Golder's analysis.

Table 1 summarizes the liquefaction potential at the 2002 CPT locations. As noted in Section 4.2.2, this table also shows the liquefaction potential at the 2002 soil borings S-01, S-02, S-03, S-04, and S-05, which are located next to CPT-08, CPT-14, CPT-16, CPT-23, and CPT-06, respectively. As noted previously, the zones shaded in orange under each location represent the potentially liquefiable depths. The estimated liquefaction potential for adjacent soil borings and CPTs in Table 1 correlate reasonably well, particularly at S-02/CPT-14 and S-03/CPT-16. Results of the reanalysis (as summarized in Table 1) are generally similar to the 2002 results (TtEMI, 2004); however, the PGA value used in the reanalysis (0.29g) is lower than that used in the 2002 analysis (TtEMI, 2004). These results suggest the loose sandy soil underlying the southern perimeter of the landfill could liquefy during the MCE. However, as noted in the 2002 liquefaction report (TtEMI, 2004), the loose sandy soil is not present in continuous layers and the surrounding soil (that would not liquefy during the MCE) would limit lateral movement of soil.

4.3.3 Analysis of 2011 and 2012 CPT Data

Golder analyzed the liquefaction potential at the 2011 and 2012 CPT borings (IR01CPT52 through IR01CPT69) using the procedure discussed in Section 4.3.2. It should be noted that these CPTs are

located along the shoreline south of the landfill. Results of the analyses are presented in Attachment E4 and are summarized in Table 2. Table 2 also shows the results for the 2012 soil borings IR01B501 and IR01B502, which are located next to CPT borings IR01CPT60 and IR01CPT63, respectively. The results identified isolated liquefiable zones from CPT-52 through CPT-62, which are located along the southern part of the landfill. The liquefiable zones appear to be more prominent at CPT-63 through CPT-69, which are located along the shoreline next to the Panhandle Area.

4.4 Consequences of Liquefaction

The potential consequences of liquefaction include (1) instability due to low residual shear strength of the liquefied soil, (2) lateral spreading, and (3) post-liquefaction settlement. TtEMI concluded that, although liquefaction potential exists, uniform (or continuous) liquefaction under the site is unlikely (TtEMI, 2004). Results of Golder's reanalyses corroborated the 2004 finding. TtEMI conservatively estimated lateral displacements of 4 to 5 feet. The lateral spreading is likely to be localized, and therefore unlikely to be critical to the overall stability of the landfill, because only discrete zones are identified as potentially liquefiable. Similarly, post-liquefaction settlement is unlikely to be critical to the overall stability of the landfill because it is estimated to be less than 10 inches.

However, Golder's reanalysis indicated a potential concern regarding the post-liquefaction stability of the critical slope where the Parcel E-2 Landfill is adjacent to the shoreline. A qualitative analysis in Appendix Q of the RI/FS Report identified that geogrid reinforcement would be required to stabilize the revetment during liquefaction (ERRG and Shaw, 2011). Section 7.6 summarizes the quantitative analysis of post-liquefaction slope stability, which includes geogrid reinforcement. It should be noted the geogrid reinforcement also addresses slope stability concerns associated with low shear strength of Bay Mud, as discussed in Section 6.3.

Because of its greater depth (more than 30 feet), liquefaction of the alluvium underlying the Bay Mud is unlikely to have significant impact on the overall stability of the landfill considering the relatively small height of the landfill (less than 25 feet at the critical cross section A-A′, as discussed in Section 6).

5.0 ANALYSIS OF CYCLIC SOFTENING POTENTIAL OF BAY MUD

Cyclic softening, if it were to occur, is of concern for sensitive clays. Boulanger and Idriss (2007) and the EERI monograph MNO-12 (Idriss and Boulanger, 2008) present an empirical procedure, which is similar to the liquefaction analysis procedures, to analyze the liquefaction potential of clays and plastic silts. The procedure was used to estimate the liquefaction potential of Bay Mud located under the shoreline. CPT-15 (from 2002) and CPT-58 through CPT-61 (from 2011 and 2012) were selected for the analysis because of their location at or near the cross section where the Parcel E-2 Landfill is closest to San Francisco Bay (which, as described further in Section 6, is the most critical area requiring a slope stability analysis). The analysis was performed using an undrained shear strength to effective confining stress ratio (S_u/σ'_{vc}) of 0.3 for the Bay Mud estimated from the CPT data (see Section 6.2). A free-field PGA of 0.29g was used in the analysis.

Attachment E5 presents the analysis of potential cyclic softening. The analysis showed that Bay Mud at the Parcel E-2 Landfill may potentially undergo strain softening when subjected to cyclic loading from the MCE. The Bay Mud is sensitive clay with a liquidity index of close to 1 and a sensitivity ranging from 5 to 8 (Bonaparte and Mitchell, 1979); therefore, cyclic softening may be a concern. However, the laboratory's post-cyclic triaxial tests showed very little or no cyclic softening, thus it is likely that the results using the Idriss and Boulanger procedure are conservative.

The M_w 8 MCE along the San Andreas Fault is likely to generate approximately 20 equivalent cycles of loading. Although not conclusive, the cyclic triaxial tests noted in Section 2.3.2 and discussed in the ERRG (2013) report indicated that the NC Bay Mud could withstand 30 cycles of loading with a CSR of 0.25 to 0.3, with less than 5 percent cumulative strain. It should be noted that the seismic response analysis discussed in Section 7.4 estimated a maximum CSR of less than 0.3 within the Bay Mud, which suggests that the Bay Mud may not undergo cyclic softening.

More importantly, the post-cyclic triaxial tests on samples used in the cyclic triaxial tests showed very little reduction in the post-cyclic shear strength although some of the samples had undergone more than 5 percent cumulative strain during the cyclic triaxial tests. The four post-cyclic triaxial tests were carried to total axial strains of 12 percent. The post-cyclic S_u/σ'_{vc} ratios ranged from 0.31 to 0.44, which is similar to static conditions. Therefore, it appears that the Bay Mud suffered very little strength loss or cyclic softening in the laboratory. This finding is consistent with the findings of a geotechnical characterization performed in support of the new eastern span of the San Francisco-Oakland Bay Bridge (Fugro-Earth Mechanics, 2001).

6.0 SLOPE STABILITY UNDER STATIC CONDITIONS

6.1 General

6.1.1 Design Methodology

The slope stability analyses have been performed using the SLOPE/W computer program developed by GEO-SLOPE International Ltd. (2012a). SLOPE/W performs two-dimensional limit equilibrium analysis using slices to compute factors of safety (FSs) against slope instability. The analysis was performed using the Morgenstern-Price method of slices (Morgenstern and Price, 1965), which satisfies both force and moment equilibrium.

6.1.2 Design Criteria

Traditional geotechnical practice recommends a minimum static FS of 1.3 for short-term (end-of-construction) conditions and a minimum static FS of 1.5 for long-term (permanent) conditions. Accordingly, minimum FSs of 1.3 and 1.5 have been used as the design criteria for short-term and long-term conditions, respectively.

6.2 Selection of Shear Strength Parameters

Because the NC Bay Mud is relatively soft and is present over a relatively thick layer (as compared to the over-consolidated Bay Mud closer to the ground surface), its shear strength has the most significant influence on the computed FS against slope instability at the site. As noted in Section 2.3.2, the Bay Mud is over-consolidated (or OCR greater than 1) within the upper 10 to 15 feet, which is typical of Bay Muds in the San Francisco area. However, the over-consolidated Bay Mud, while relatively stronger than the NC Bay Mud, has less of an impact on slope stability because it is present over a relatively thin layer (as compared to the NC Bay Mud). The test results summarized in Section 2.3.2 show undrained shear strength to effective confining stress ratios (S_u/σ'_{vc}) ratios of 0.29, 0.36, and 0.37 for the three consolidated undrained triaxial tests performed under NC conditions.

To estimate the S_u profile of the Bay Mud with depth, Golder plotted the OCR and S_u values estimated by Gregg Drilling (electronic data provided by Gregg Drilling to ERRG) for the CPTs advanced along the shoreline in 2011 and 2012. Figure 4 shows the plots; the left side of the plot shows the OCR profile with depth and the right side shows the S_u profile with depth. The OCRs estimated from the three laboratory consolidation tests are also plotted on the left side of the figure.

The estimated OCRs varied considerably between the different CPT borings; however, the data showed general trend that the upper 10 feet of the Bay Mud is over-consolidated, with an OCR of greater than 1. Also, the OCRs computed from the laboratory consolidation tests at depths of approximately 10 feet and 15 feet are higher than those estimated empirically by Gregg Drilling.

Unlike the OCR, the estimated S_u values typically fell within a narrow band, as seen on the right side of Figure 4. The dark red line on this plot shows Golder's fit for the lower-bound S_u profile with depth. As shown on the figure, the lower-bound S_u profile corresponds to a constant S_u of 115 pounds per square feet within the over-consolidated upper 10-foot depth and a S_u/σ'_v ratio of 0.3 below 10 feet. The S_u/σ'_v ratio of 0.3 is within the lower end of the 0.29 to 0.39 range estimated from the three triaxial tests. Therefore, Golder's fit for the S_u/σ'_v profile shown in Figure 4 appears to be reasonable.

Based on the above discussion, the Bay Mud profile defined by a constant S_u of 115 pounds per square feet within the upper 10-foot depth and a S_u/σ'_v ratio of 0.3 below the 10-foot depth was used in the slope stability analysis. For other materials (i.e., landfill debris), typical shear strength parameters were assigned, based on Golder's past experience and professional judgment

6.3 Analysis of Critical Cross Section

Three critical cross sections (A-A′, B-B′, and C-C′) were identified for slope stability analysis. Figure 3 shows the locations of the three cross sections. Cross section A-A' was identified as the most critical based on a review of the subsurface conditions, in conjunction with the landfill final grading plan, and is the focus of this draft report. Cross sections B-B′ and C-C′ will be analyzed in the draft final version of this report; these two cross sections intersect the northwest portion of the Parcel E-2 Landfill, where additional geotechnical data are being collected in summer 2013 (in conjunction with a landfill gas investigation).

6.3.1 Analysis of Cross Section A-A

Cross section A-A′, which was prepared by ERRG in support of this report, is presented in Attachment E1 (along with the associated boring logs). This cross section shows additional proposed filling for the shoreline revetment adjacent to the Parcel E-2 Landfill: (1) rip rap (i.e., large armor stone), (2) filter stone (i.e., smaller-diameter rock), and (3) soil fill behind the filter stone. This filling will result in additional loading on the Bay Mud. Typically, short-term (end-of-filling) conditions are critical for fill slopes on soft cohesive soil, such as Bay Mud, because excess pore pressure (EPP) is generated within soft clays due to the added loading. The end-of-filling conditions typically result in the lowest FS against slope instability. Therefore, the static slope stability was analyzed for both short-term and long-term (permanent) conditions as discussed below.

6.3.1.1 Short-Term Static Stability

It is normal practice to analyze short-term static slope stability by assigning initial (or existing) S_u to the soft cohesive soil without accounting for pore pressure effects (i.e., an undrained analysis). However, most of the Bay Mud at cross section A-A′ has gained shear strength from the existing landfill debris and

fill. Therefore, to account for the spatial variation of the excess pore pressure generated only by the new fill (i.e., rip rap, filter stone, and soil fill) and to model its dissipation with time, Golder performed a pore pressures analysis. The analysis was performed using the finite element method-based SIGMA/W (GEO-SLOPE International Ltd., 2012b) computer program. A fully coupled stress-deformation and pore pressure analysis was performed. Golder used the Modified Cam Clay stress-strain model for the Bay Mud. The finite element mesh used had 7,819 nodes and 7,946 elements. The pore pressures estimated by SIGMA/W were directly imported to the SLOPE/W to compute short-term FS at various stages.

As noted in Section 6.2, the shear strength profile shown in Figure 4 was used for Bay Mud in the slope stability analysis.

The SIGMA/W and SLOPE/W analyses were performed in three stages as listed below.

1. The first stage was used to estimate the EPP and compute the corresponding FS after placement of the soil fill and prior to placement of the rip rap and filter stone. Figure 5 shows the contours of the computed EPP when the placement of the soil fill is complete. Figure 6 shows the corresponding short-term FS from the slope stability analysis. The computed FS of 1.3 is acceptable because the modeled scenario is a temporary condition.

2. The second stage was used to estimate the EPP after placement of the filter stone and rip rap. Figure 7 shows the contours of the computed EPP when the placement of filter stone and rip rap is complete. Figure 8 shows the corresponding short-term FS from the slope stability analysis. The computed FS is 0.81, indicating that the slope will be unstable without adequate stabilization measures. As a result, it was decided to use high-tensile geogrids to reinforce and stabilize the slope. The presence of a proposed slurry cut-off wall immediately behind the revetment will preclude the use of horizontal geogrids of adequate pullout length. Therefore, the geogrids are proposed to be placed on an inclined plane immediately below the filter layer and extended horizontally over the top of the slurry wall (see Figure 9). Installation of the geogrids will require excavation and backfilling of existing debris. Results of the slope stability analysis showed that two layers of Tencate Miragird 22XT geogrid layers, placed one over the other (or equivalent reinforcement with a combined long-term design strength of 20,500 pounds per foot), will be required to improve the FS to 1.5. The required total length of each geogrid layer is approximately 82 feet. Figure 9 shows the results of the slope stability analysis.

3. The third stage was a 30-year dissipation analysis with 100 time steps to estimate the EPPs at several intermediate time periods after placement of the filter stone and rip rap. A slope stability analysis was performed at different stages to estimate the time required to reach a FS of 1.5. Figure 10 shows the EPP after approximately 5 years; the corresponding FS was computed to be

1.5, as shown in Figure 11. Also, the long-term FS after 30 years is computed to be approximately 1.7, which is the same as the long-term FS discussed in Section 6.3.2.

Attachment E6 presents the detailed results of SIGMA/W and SLOPE/W analyses for the above three stages.

Based on the results described in item 2 above, the slope would undergo failure if a geogrid is not provided before placement of the filter stone and rip rap. Also, to prevent slope failure during construction, it is extremely important that the filter stone and rip rap are placed only after the upper horizontal portion of the geogrids are installed and fully anchored by placing the overlying fill to the final grades.

6.3.1.2 Long-Term Static Stability

The long-term static slope stability was analyzed assuming full consolidation of the Bay Mud. Figure 12 shows the results of this analysis, with the geogrid reinforcement noted in Section 6.3.1. The computed FS was 1.74, which is greater than the minimum acceptable value of 1.5. Attachment E6 presents the detailed SLOPE/W result for this analysis.

It should be noted that the global slope stability of the Parcel E-2 Landfill, with a trial slip surface[4] extending toward the center of the landfill, was determined to be significantly less critical than the slope stability scenario shown in Figure 12. For example, a large circular trial slip surface through the Bay Mud terminating near the right end of cross section A-A′ has a FS of 1.88 (see Figure 13) and larger surfaces will have even higher FS.

6.3.1.3 Impact of Slurry Wall on Slope Stability

To minimize the impact of the slurry wall on slope stability, the design shear strength of the slurry wall will be equal to or greater than the shear strength of the existing soil (i.e., greater than the equivalent shear strength corresponding to a friction angle of 32 degrees for the silty debris and 36 degrees for the gravelly debris). A soil-cement-bentonite backfill with a minimum unconfined compressive strength of 30 pounds per square inch based on a 30-day curing time will be used to satisfy this design requirement. The technical specification for the slurry wall will require the construction contractor to perform pilot testing before construction to determine required cement and bentonite fractions to achieve the required strength.

[4] Trial slip surfaces are the potential slope failure surfaces that are searched for by the slope stability analysis program.

7.0 SLOPE STABILITY UNDER SEISMIC CONDITIONS

7.1 General

7.1.1 Design Methodology

The seismic slope stability analysis of the Parcel E-2 Landfill was performed consistent with standard practice [as identified in Title 27 California Code of Regulations Section 21750(f)(5)(D)]. The analysis included the following evaluations:

- A site-specific deterministic seismic hazard analysis to estimate the PGA associated with the MCE along San Andreas Fault, as discussed in Section 3.
- Pseudo-static slope stability analysis to estimate the yield acceleration for the critical cross section (A-A′) analyzed; yield acceleration is the horizontal acceleration that results in a pseudo-static FS of 1.
- Seismic response analysis using the SHAKE91 computer program (Idriss and Sun, 1992) to estimate the time history of average horizontal equivalent acceleration (HEA) for the critical surface associated with the yield acceleration, using all four acceleration time histories listed in Section 3.2.
- Newmark displacement analysis (Newmark, 1965) using the DISPLMT computer program (Houston et al., 1987), which involved the double-integration of the average HEA in excess of the yield acceleration. This analysis estimated the likely magnitude of permanent displacement resulting from the MCE event, using all four acceleration time histories listed in Section 3.2.

7.1.2 Design Criteria

Typically, a maximum seismically induced permanent displacement of 3 feet is considered the maximum allowable limit for earthen slopes (Makdisi and Seed, 1978). However, because Bay Mud at the Parcel E-2 Landfill is sensitive (i.e., the material may lose shear strength at large strains), the 3-foot maximum allowable limit may not be adequately conservative. To increase the conservatism of this analysis, Golder has used a maximum allowable permanent displacement of 1 foot as the seismic design criterion in this report.

7.2 Selection of Bay Mud Shear Strength for Seismic Analysis

As noted in Sections 2.3.2 and 5.2, the post-cyclic triaxial tests in the laboratory showed the post-cyclic S_u/σ'_v ratio to be similar to the static strengths. However, to be conservative, the shear strength of the Bay Mud was reduced by 10 percent in the slope stability analysis to estimate the yield acceleration. In other words, a S_u/σ'_v ratio of 0.27 was used for the NC Bay Mud below the upper 10 feet. The shear strength of the over-consolidated upper 10 feet of Bay Mud was not reduced.

7.3 Yield Acceleration Values

The yield acceleration, which is the horizontal acceleration that reduces the FS to 1, was estimated using an iterative pseudo-static slope stability analysis using SLOPE/W. Figure 14 shows the graphical result of

the final iteration of the pseudo-static stability analysis for cross section A-A′ with geogrid reinforcement, as discussed in Section 6.3.1. The yield acceleration is estimated to be 0.077g. Attachment E6 presents the detailed SLOPE/W results.

7.4 Seismic Response Analysis

The magnitude of permanent displacement during the MCE along cross section A-A′ will depend on the magnitudes of the induced average accelerations within the critical trial slip surface (associated with the yield acceleration). As described in Section 3, the PGA and acceleration time histories correspond to bedrock at the Parcel E-2 Landfill. The overburden soil will modify both the PGA and the acceleration time histories induced within the critical trial slip surfaces. To estimate the time histories of average accelerations within the critical trial slip surfaces, response analyses were performed using the SHAKE91 computer program (Idriss and Sun, 1992).

SHAKE91 uses the one-dimensional (1-D) wave propagation theory to compute the response of a visco-elastic, semi-infinite, horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves. The computer program uses an equivalent linear approximation to model the non-linear behavior of soil and rock.

Because SHAKE91 can analyze only 1-D soil columns, a simplification was used to estimate the average response of the HEA of the potential trial slip surface of a two-dimensional (2-D) slope. It was assumed that the response of a 2-D trial slip surface can be approximated by the response of an average 1-D column located within the critical slip surface identified by the pseudo-static slope stability analysis. It should be noted that the computed HEA time history, based on a single 1-D column, is conservative. In other words, averaging of HEA values from multiple 1-D soil columns, which is more representative of a 2-D response, would result in lower HEA values because of the averaging of the spatial incoherence (i.e., at any instant of time, different points within the trial slip surface have different magnitudes and the averaging results in lower HEA values). Also, HEA values estimated based on SHAKE91 for most conditions are conservative compared with those obtained from a 2-D site-response analysis (e.g., QUAD4M).

An average soil column taken through the center of the critical trail slip surface shown in Figure 14 has been used in the seismic response analysis using SHAKE91 for cross section A-A′. The top of bedrock at this cross section is estimated to be approximately 200 feet bgs based on the bedrock contour maps in the RI/FS Report (ERRG and Shaw, 2011). Therefore, the soil column used assumed approximately 37 feet of Bay Mud and 150 feet of alluvium. For this soil column, the SHAKE91 analysis was repeated using all four time histories listed in Section 3.

The shear wave velocity of the Bay Mud was computed based on its correlation with S_u shown in Seed et al. (1992). The shear wave velocity of the alluvium was estimated based on Holzer et al. (2005).

Attachment E7 includes the SHAKE91 analyses results. The output files for the time histories of shear stress from the SHAKE91 analyses were used to compute the HEA time history within the trial surfaces using the following equation (Bray et al., 1998):

$$\text{HEA (t)} = \left[\frac{\tau(t)}{\sigma_v}\right] g$$

where, $\tau(t)$ = shear stress at the elevation (base) of the trial surface at time t

σ_v = total vertical stress at the elevation of the trial slip surface

g = acceleration due to gravity

7.5 Permanent Displacement Analysis

The magnitude of seismically induced permanent displacement along the critical trial slip surface was estimated by numerically double integrating the average HEA values that exceeded the yield acceleration. As noted previously, the numerical double integration was performed using the computer program DISPLMT developed by Houston et al. (1987).

Figures 15 through 20 graphically present the results of the DISPLMT analyses for acceleration time histories Chy029, TCU076, TCU052, and Izmit, respectively. Attachment E8 presents the printouts of output files from DISPLMT.

As shown on Figures 15 through 18, the maximum computed permanent displacement is 0.22 feet resulting from the Chy029 acceleration time history record. These results are acceptable because the computed displacement is significantly less than the maximum allowable limit of 1 foot.

7.6 Post-Liquefaction Slope Stability

The slope stability of the revetment and the landfill slope next to the shoreline for post-liquefaction conditions was analyzed using cross section A-A′ with the geogrid reinforcement discussed in Section 6.3.1.1. It should be noted that the standard practice for a post-liquefaction analysis is to not include the inertial forces from the earthquake because liquefaction is observed to fully mobilize after the strong shaking stops. Because it is a temporary condition lasting only a few seconds, a FS of greater than 1.05 to 1.1 is typically considered acceptable for post-liquefaction stability.

In this analysis, it was assumed that both sandy and gravelly debris within the landfill will fully liquefy. For the sandy debris, the residual shear strength to effective vertical stress ratio (S_{ur}/σ'_v) was estimated to be

approximately 0.2 based on Stark and Mesri (1992). A conservative S_{ur}/σ'_v ratio of 0.25 was assigned to the gravelly debris. In addition, the S_{ur}/σ'_v for the Bay Mud was reduced by 10 percent to be conservative; i.e., a S_{ur}/σ'_v ration of 0.27 was assigned to the NC Bay Mud.

Figure 19 presents the results of the post-liquefaction slope stability analysis. The analysis shows a FS of 1.37, which is greater than the generally acceptable minimum FS of 1.05 to 1.1. Attachment E6 presents the detailed SLOPE/W results.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Liquefaction Potential

The analyses of liquefaction potential show that the sandy debris within the Parcel E-2 Landfill could liquefy during the MCE. The potential impact of this liquefaction would be on the stability of the revetment and landfill slope along the shoreline. The post-liquefaction slope stability analysis discussed in Section 7.6 shows that the geogrid reinforcement (discussed in Section 6.3.1) will adequately stabilize the revetment and the landfill slope even if sandy and gravelly debris were to liquefy during the MCE.

Lateral spreading is unlikely to be critical to the overall slope stability at the Parcel E-2 Landfill because the potentially liquefiable zones appear to be discontinuous and isolated. Also, post-liquefaction settlement is estimated to be small (less than 10 inches) and is unlikely to be critical to the integrity of the landfill.

8.2 Cyclic Softening Potential

The analysis of the potential for cyclic softening using the empirical procedure described in Idriss and Boulanger (2008) shows that the Bay Mud has the potential to undergo cyclic softening during the MCE. However, results of the post-cyclic triaxial shear strength tests on samples subjected to cyclic loading show that the post-cyclic shear strength is similar to the original static shear strength. Therefore, strength reduction of Bay Mud due to cyclic softening is expected to be negligible.

8.3 Slope Stability

The stability of the landfill slope and revetment next to the shoreline was determined to be most critical because of the presence of relatively soft Bay Mud and additional loading from the revetment material and new fill below the revetment. Results of the slope stability analysis of cross section A-A′ show that two layers of Tencate Miragrid 22XT geogrid layers, placed one over the other (or equivalent reinforcement with a combined long-term design strength of 20,500 pounds per foot), will be required to achieve a minimum short-term FS of 1.3.

The geogrid layers will be placed on an inclined plane immediately below the revetment (see Figure 9). The geogrid layers will extend horizontally beyond the top of the revetment and pass over the top of the slurry wall. Installation of the geogrid layers will require excavation and backfilling of existing debris. The required total length of each geogrid layer is approximately 82 feet. Based on the results of the short-term slope stability analyses (discussed in Section 6.3.1), the slope would undergo failure if a geogrid is not installed before placement of the revetment material (including filter stone and rip rap). Also, to prevent slope failure during construction, it is extremely important that the revetment material be placed only after the upper horizontal portion of the geogrid layers are installed and fully anchored by placing the overlying fill to the final grades.

The global slope stability of the landfill at cross section A-A′, with a trial slip surface extending toward the center of the landfill, was determined to be less critical than the slope stability of the perimeter area, as discussed in Section 6.3.2.

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TABLES

Table 1

Summary of Liquefaction Potential Analysis Results for the 2002 Soil Boring and CPT Locations

Hunters Point Shipyard, Parcel E-2

Depth	Soil Borings (S) and Cone Penetration Tests (CPT)[1, 2]																								
(ft)	CPT-01	CPT-2	CPT-03	CPT-04	S-05	CPT-06	CPT-07	S-01	CPT-08	CPT-09	CPT-10	CPT-11	CPT-12	CPT-13	S-02	CPT-14	CPT-15	S-03	CPT-16	CPT-22	S-04	CPT-23	CPT-24	CPT-25	CPT-26
2.0																									
4.0																									
6.0																									
8.0																									
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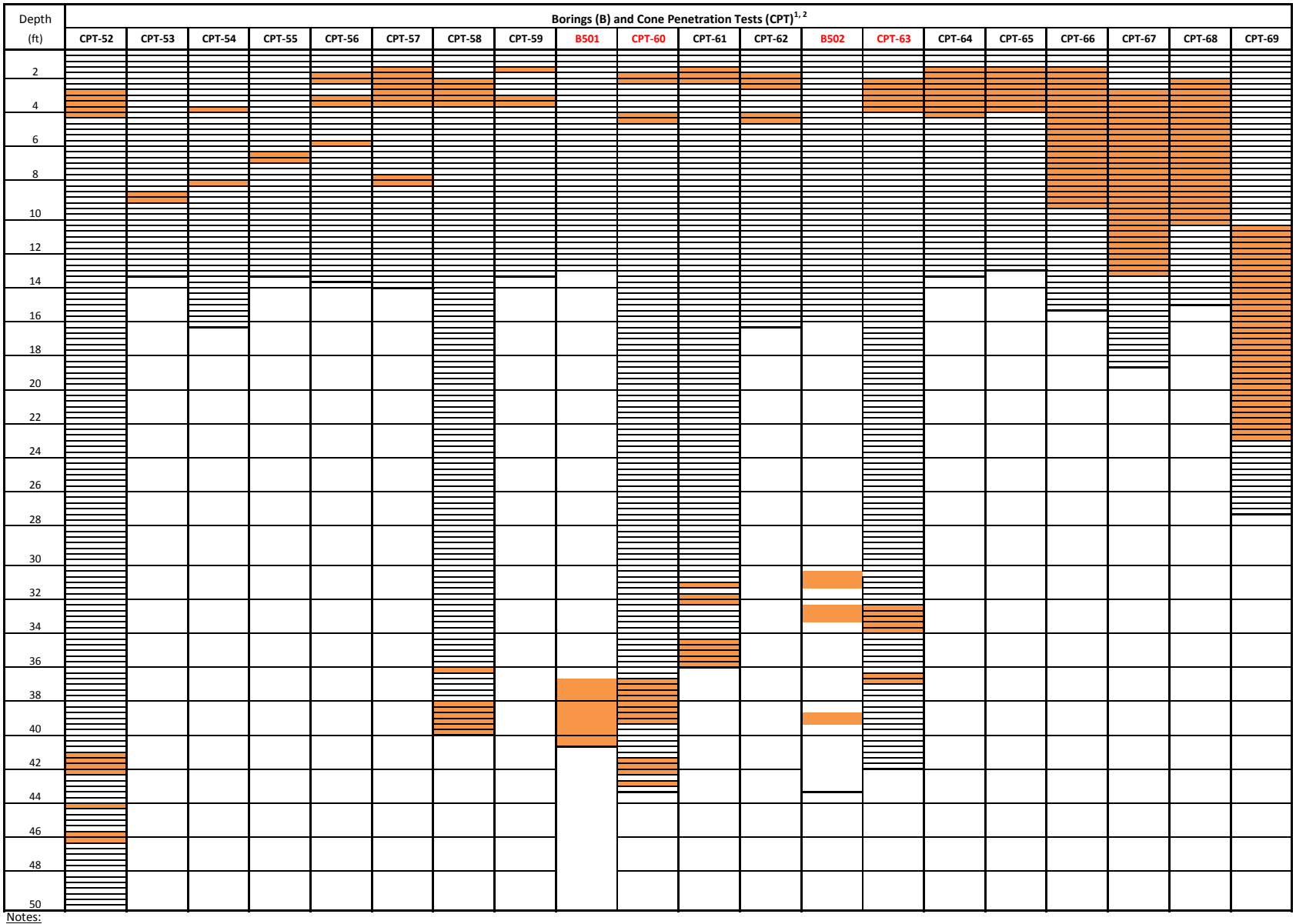
46.0																									
48.0																									
50.0																									
52.0																									
54.0																									
56.0																									
58.0																									
60.0																									

Notes:

1. The depths shaded in orange are potentially liquefiable based on results presented in Attachment E3 for soil borings and Attachment E4 for CPT locations (in 2002)
2. The soil borings and CPT pairs in red are adjacent to each other

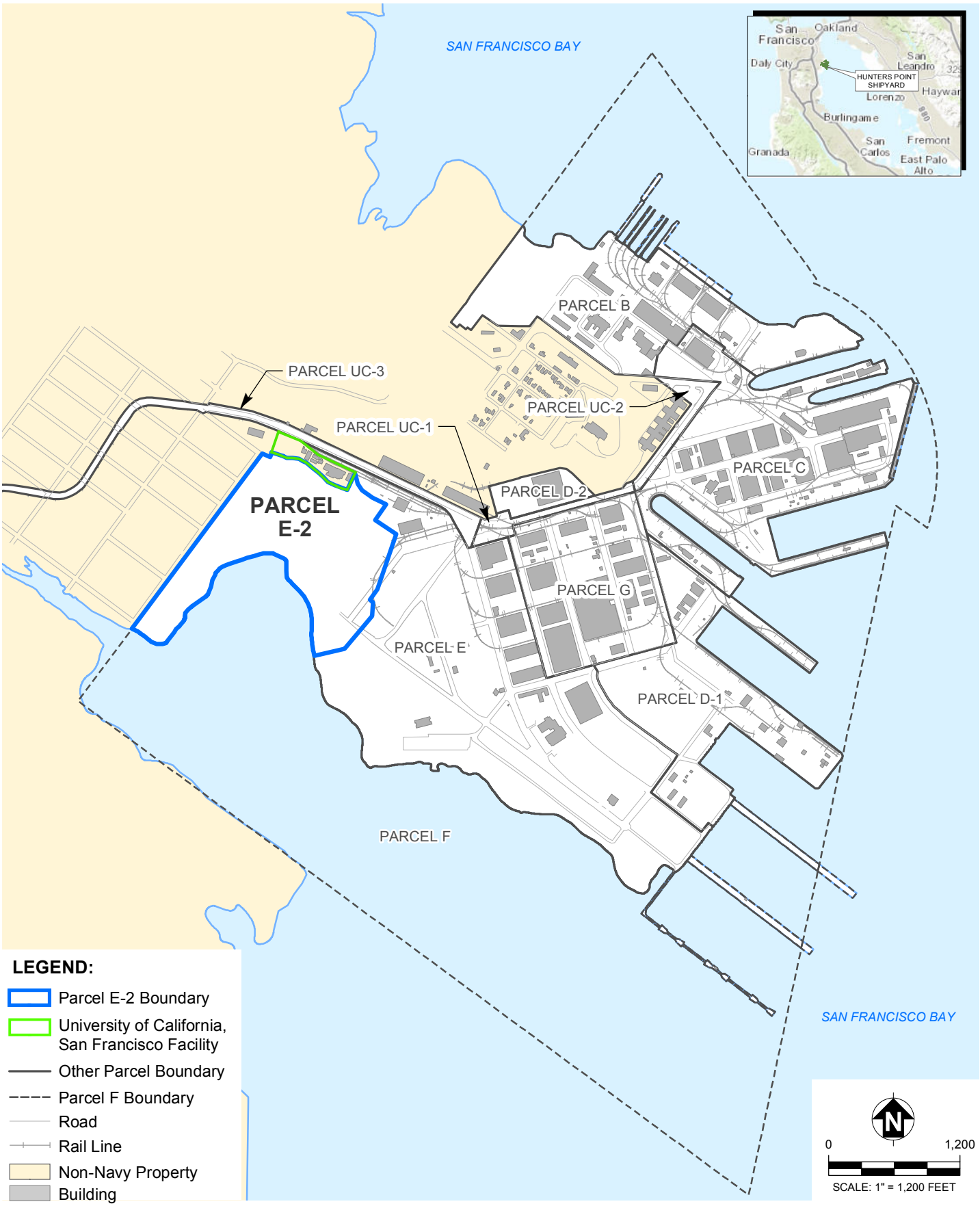
Table 2
Summary of Liquefaction Potential Analysis Results for the 2011-2012 Soil Boring and CPT Locations
Hunter's Point Shipyard, Parcel E-2



Notes:

1. The depths shaded in orange are potentially liquefiable based on results presented in Attachment E3 for soil borings and Attachment E4 for CPT locations (in 2011-12)
2. The soil borings and CPT pairs in red are adjacent to each other

FIGURES



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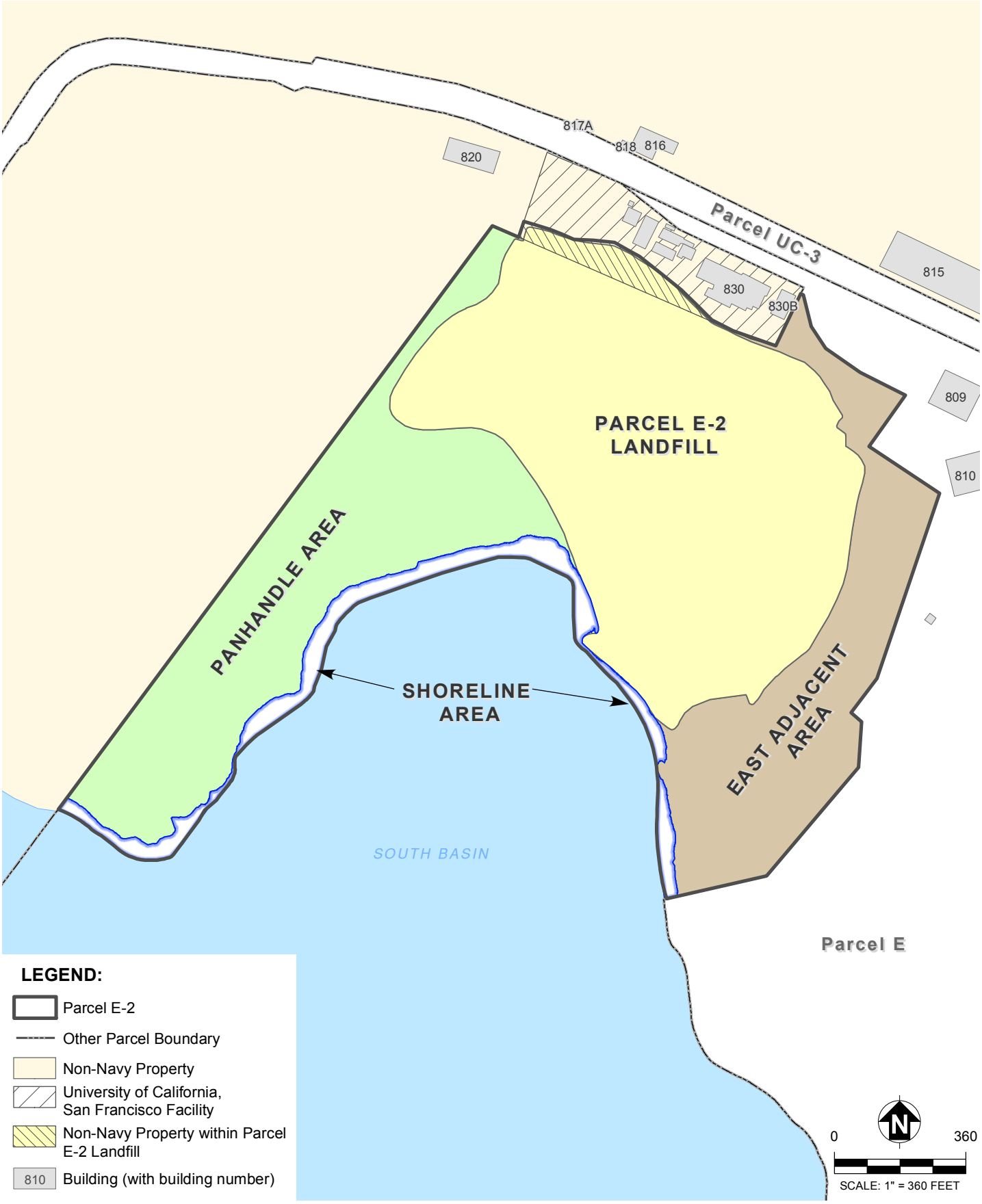
Golder Associates	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	SITE VICINITY MAP			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 06/07/13	CHECKED BY: NK 06/07/13	PROJECT NO. 25-049	FIG NO. 1



N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\App E\Parcel E2 Areas.mxd Last updated: 6/6/2013 at 9:34:11 AM

Golder Associates

CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PARCEL E-2 AREAS			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 06/07/13	CHECKED BY: NK 06/07/13	PROJECT NO. 25-049	FIG NO. 2

Notes:

Cross-section A-A' is based on geologic interpretation detailed in Attachment E1.

Cross-sections B-B' and C-C' will be developed and evaluated in the Draft Final Design Basis Report.

820
Crisp Rd
815
821
S-807
830
830B
808
809
811
810
807
702
CPT-01
CPT-02
CPT-03
CPT-04
CPT-06
S-05
CPT-07
CPT-08
S-01
CPT-09
CPT-10
CPT-11
CPT-12
CPT-14
CPT-15
CPT-16
S-03
S-02
CPT-22
CPT-23
CPT-24
S-04
CPT-25
C26B
CPT-26
CPT-26A
B'
IR01MW17B
IR01B029
C'
IR01B050
IR01MW53B
IR01B049
IR01B035
IR01B028
IR01CPT67
IR01CPT66
IR01CPT65
IR01CPT64
IR01CPT63
IR01CPT69
IR01CPT68
B
IR01B502
C
IR01CPT62
IR01CPT61
IR01MW60A
IR01B275
IR01B040
IR01B024
A'
IR01B501
IR01CPT60
A
IR01CPT59
IR01CPT58
IR01CPT56
IR01CPT57
IR01CPT55
IR01CPT54
IR01B500
IR01CPT53
IR01CPT52
SOUTH BASIN

LEGEND:

- CPT Boring Location from TtEMI (2004) Study
- Soil Boring Location from TtEMI (2004) Study
- CPT Boring Location from ERRG (2013) Study
- Soil Boring Location from ERRG (2013) Study
- Monitoring Well or Soil Boring from Various Projects, 1986-1997 (ERRG and Shaw, 2011)
- Slope Stability Cross-Section
- Freshwater Wetlands
- Tidal Wetlands
- Shoreline Revetment
- Parcel E-2
- Other Parcel Boundary
- Shoreline Area
- 810 Building (with building number)
- Non-Navy Property
- Finish Grade Topographic Contour Line

N

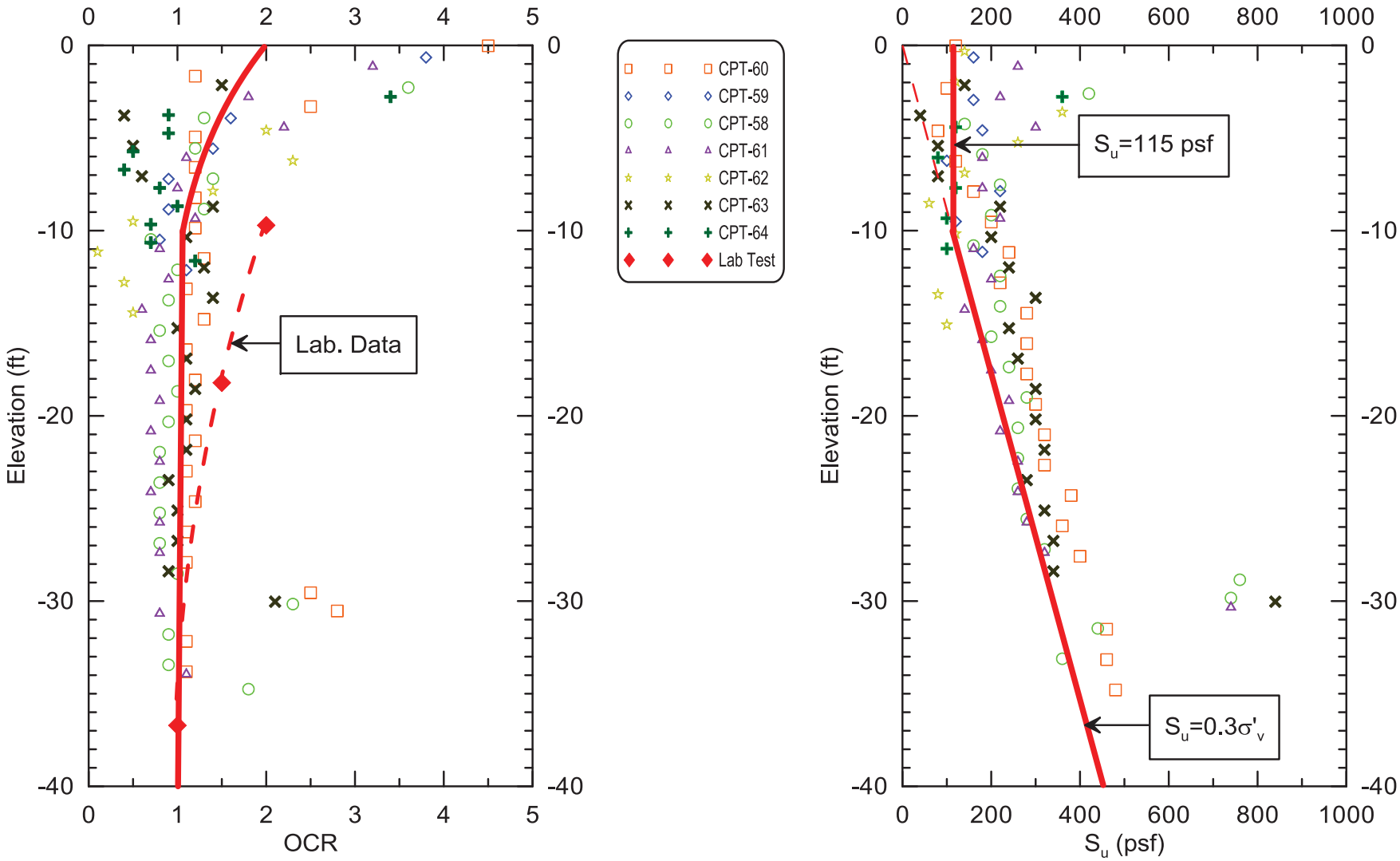
0 240

SCALE: 1" = 240 FEET

Golder Associates

CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PREVIOUS GEOTECHNICAL INVESTIGATIONS AND LOCATIONS OF SLOPE STABILITY CROSS-SECTIONS			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 06/07/13	CHECKED BY: NK 06/07/13	PROJECT NO. 25-049	FIG NO. 3

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\App E\Location of E-2 Cross Sections.mxd Last updated: 6/7/2013 at 4:19:16 PM

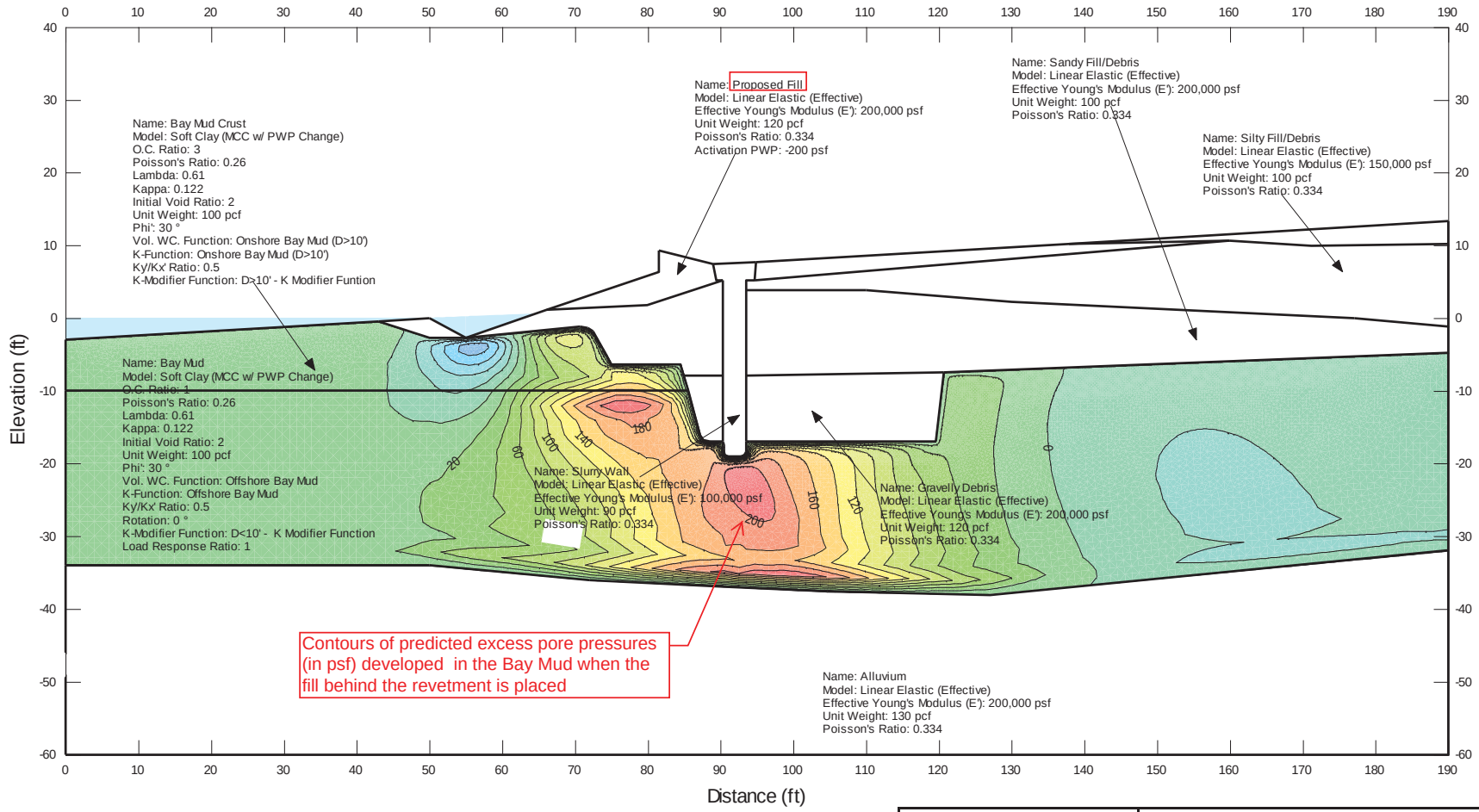


Golder Associates

Hunters Point Naval Shipyard, Parcel E-2, Remedial Design

OCR and S_u Profiles based on Gregg Drilling Data for CPT Locations along the Shoreline

Design: **NK**	Check:	Date: **June 2013**	Figure: **4**



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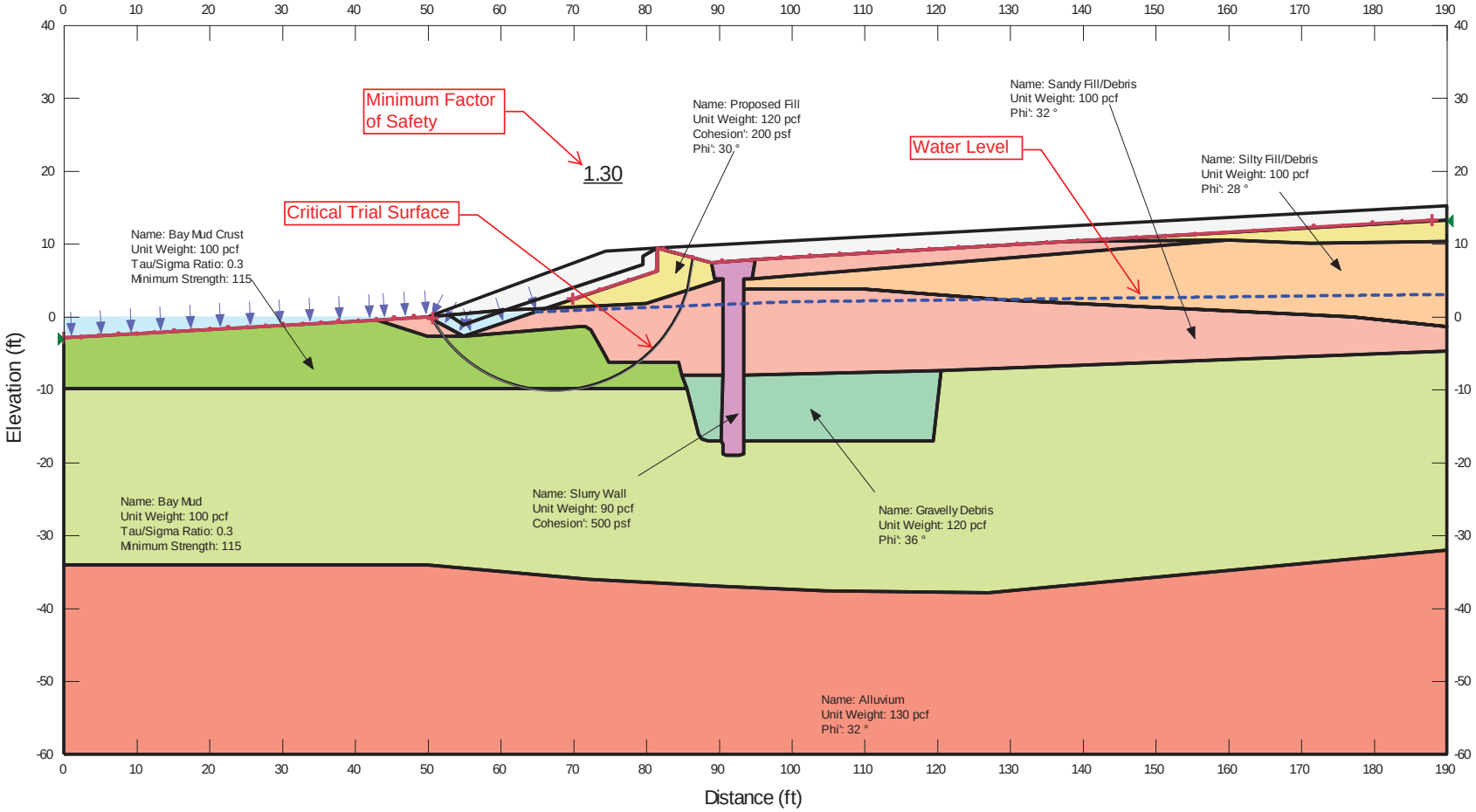
Hunters Point Naval Shipyard
Parcel E-2 Remedial Design
Consolidation Analysis, Cross Section A-A′
Excess Pore Pressure After Soil Fill Placement

Design: **NK**	Check:	Date: **June 2013**	Figure: **5**

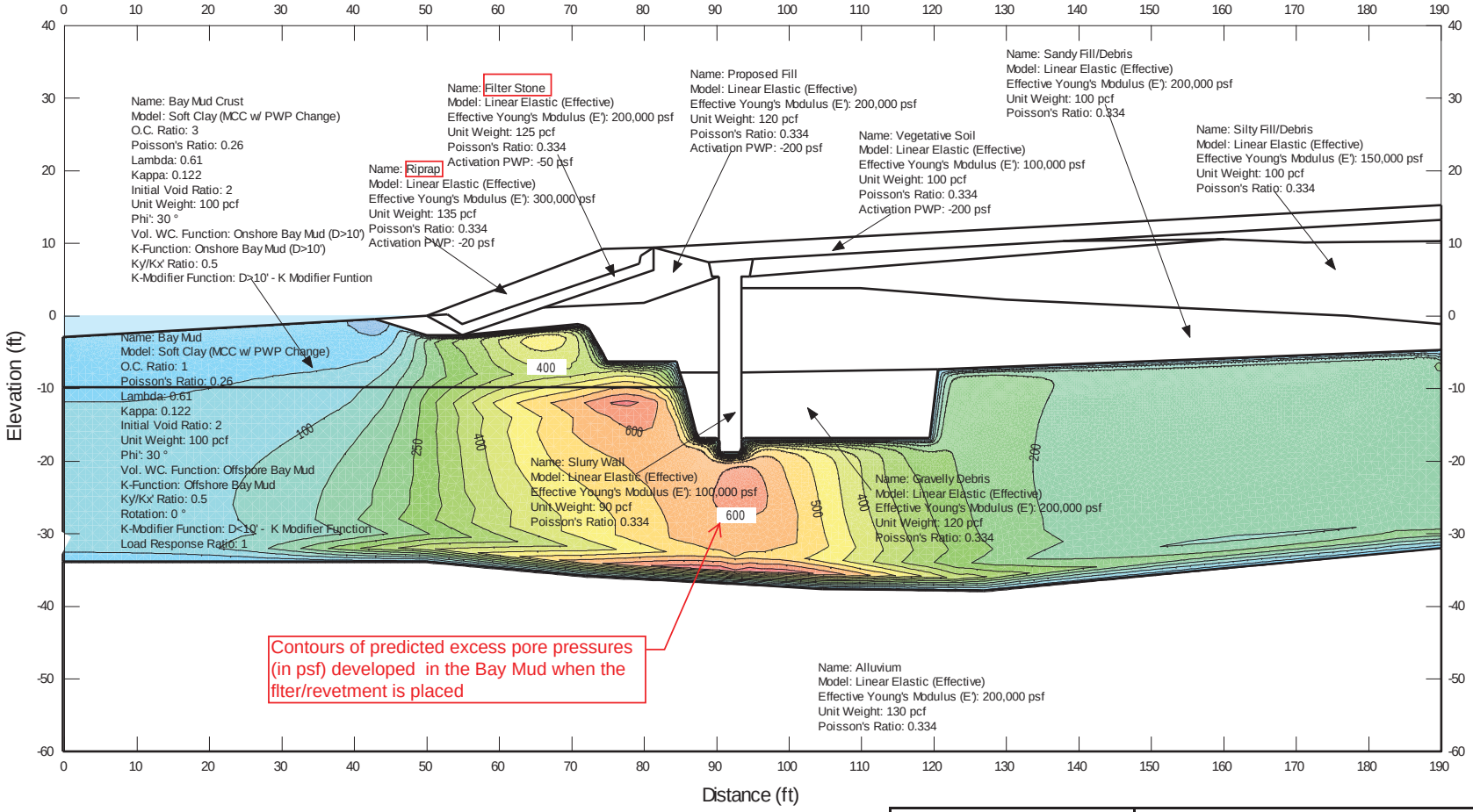


Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

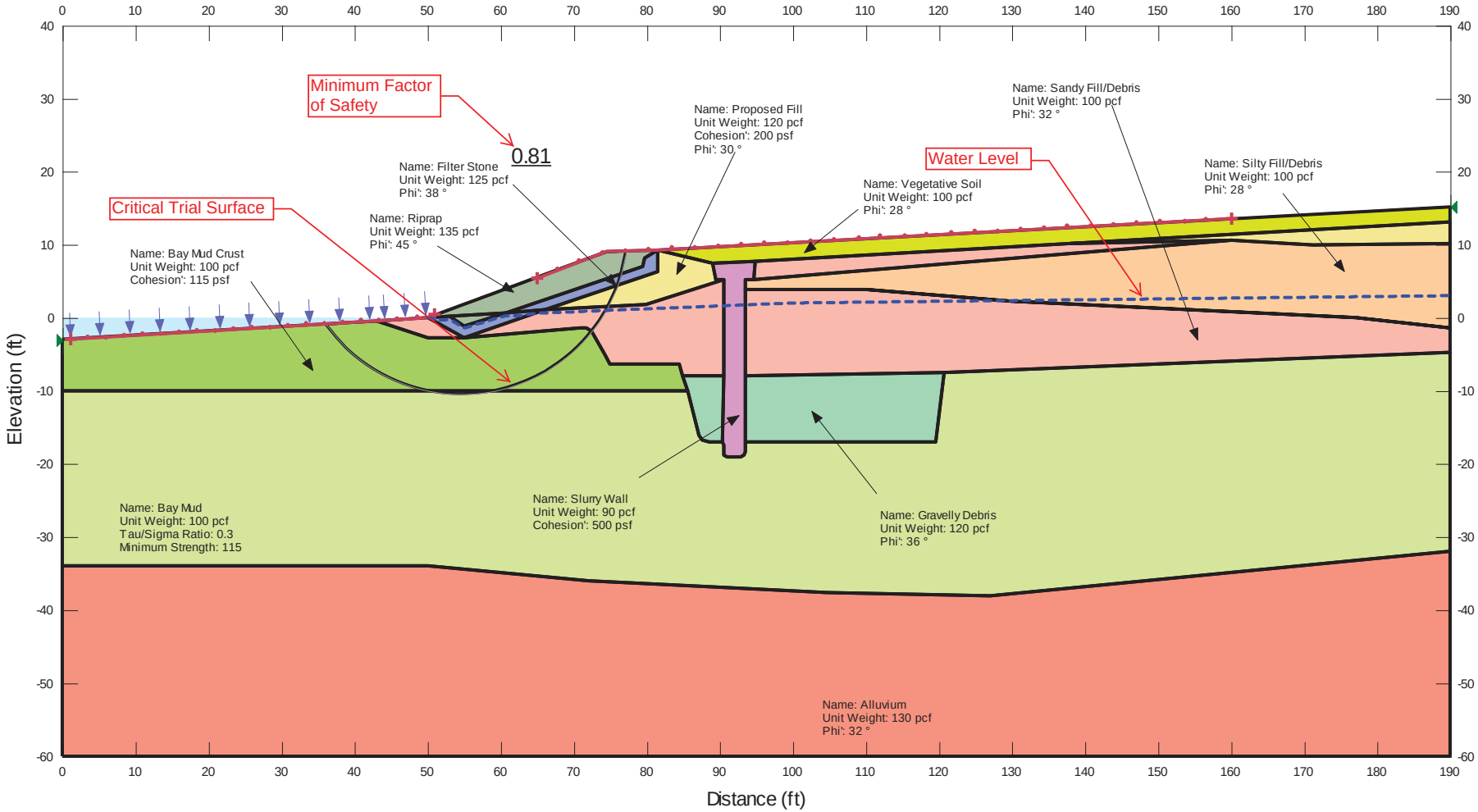
Golder Associates

Hunters Point Naval Shipyard
Parcel E-2 Remedial Design
Slope Stability Analysis, Cross Section A-A'
Short-Term Factor of Safety After Soil Fill Placement

Design: **NK**	Check:	Date: **June 2013**	Figure: **6**

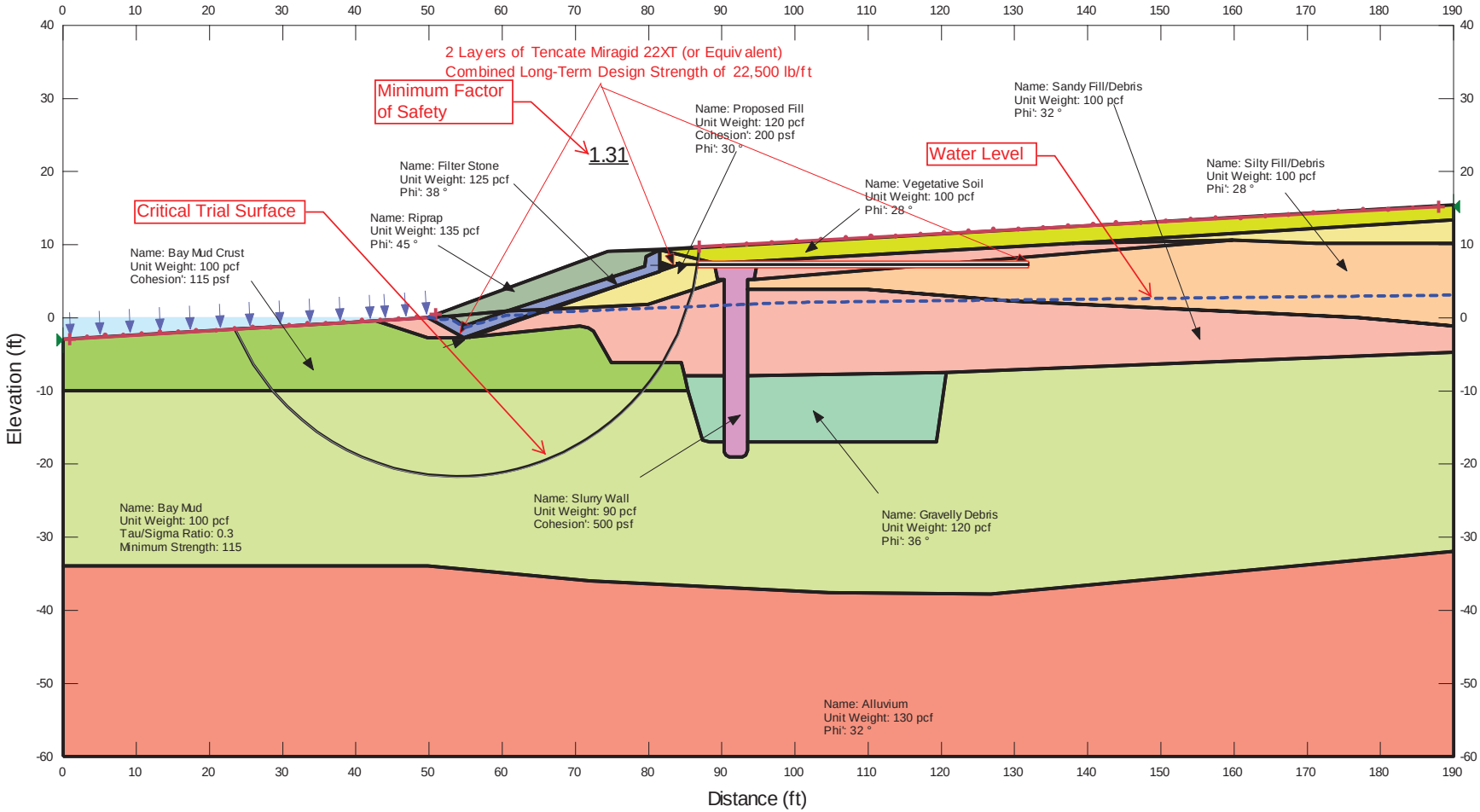


Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Consolidation Analysis, Cross Section A-A′** **Excess Pore Pressure After Placement of Revetment**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **7**



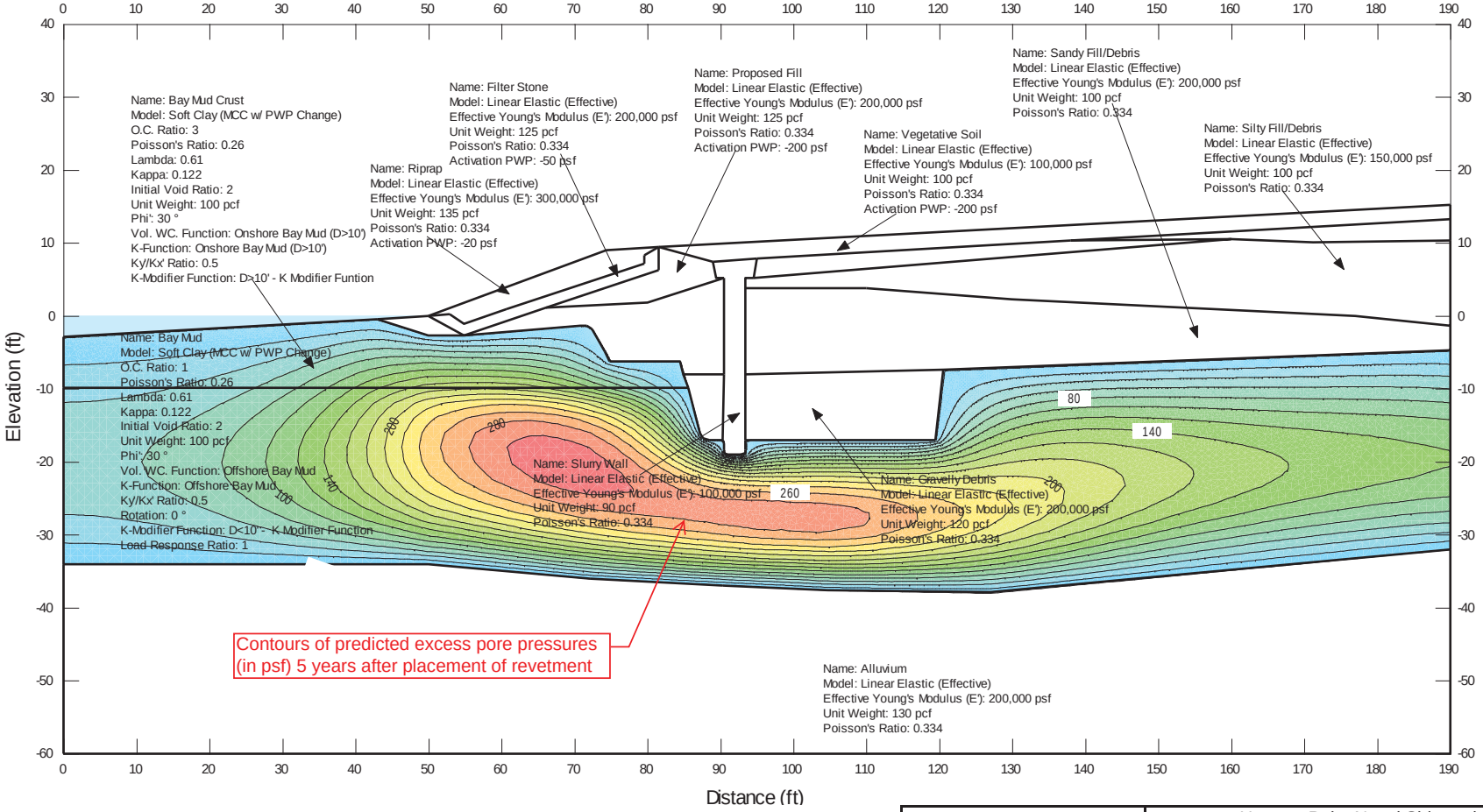
Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Cross Section A-A′** **Short-Term Factor of Safety After Placement of Revetment without Geogrids**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **8**



Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

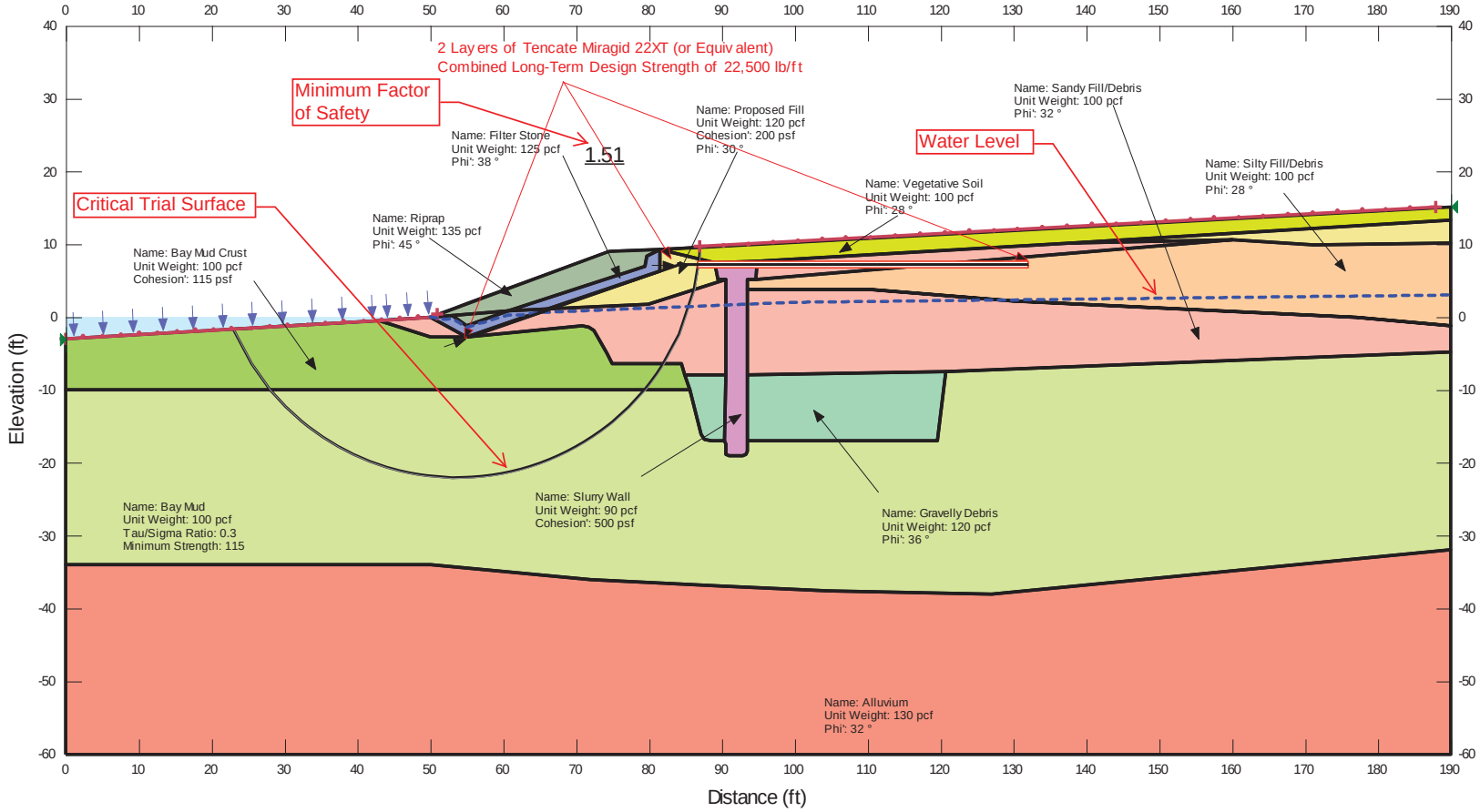
Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Cross Section A-A'** **Short-Term Factor of Safety After Placement of Revetment with Two Layers of Miragrid 22XT**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **9**



Hunters Point Naval Shipyard
Parcel E-2 Remedial Design

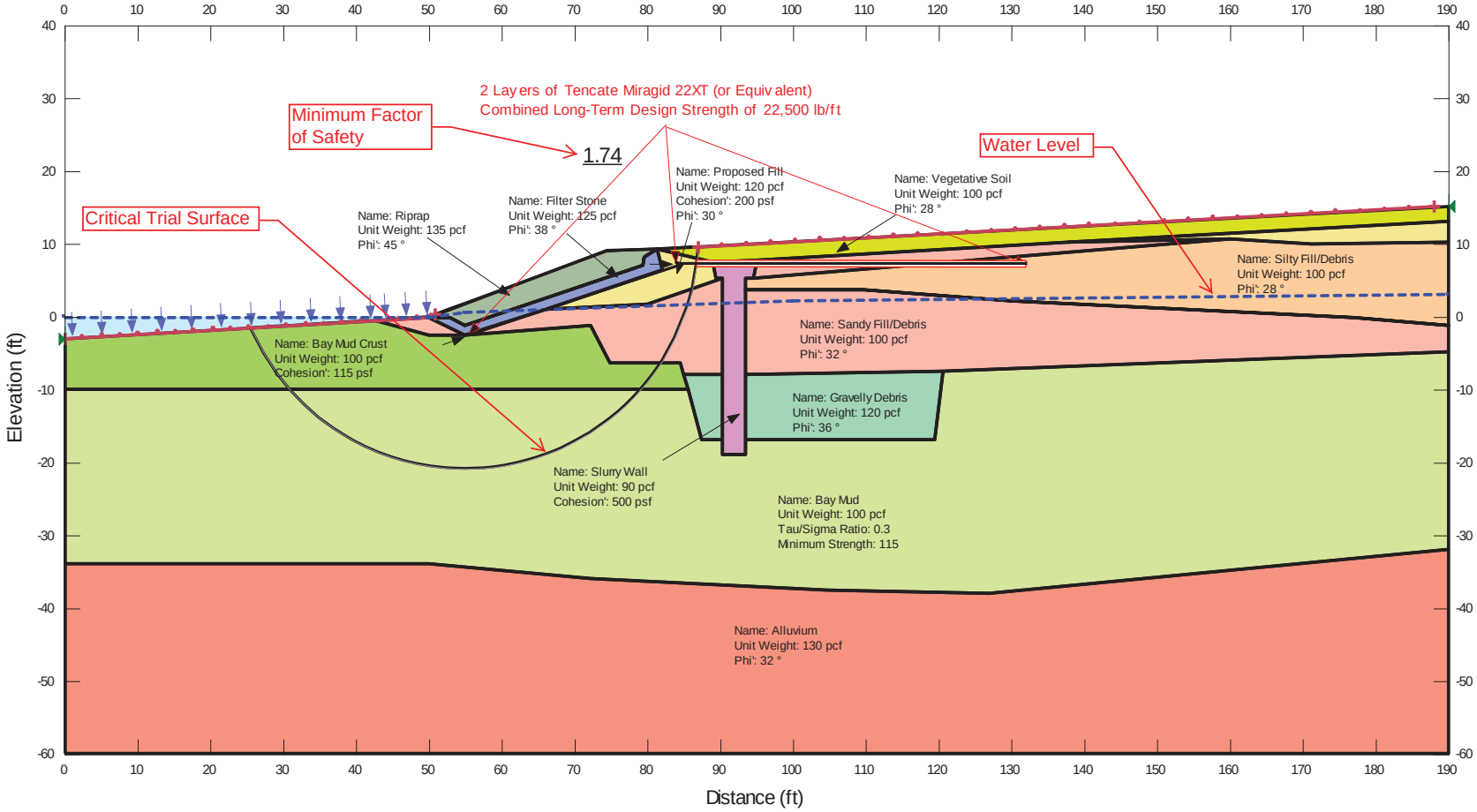
Consolidation Analysis, Cross Section A-A′
Excess Pore Pressure 5 Years After Placement Revetment

Design: **NK**	Check:	Date: **June 2013**	Figure: **10**



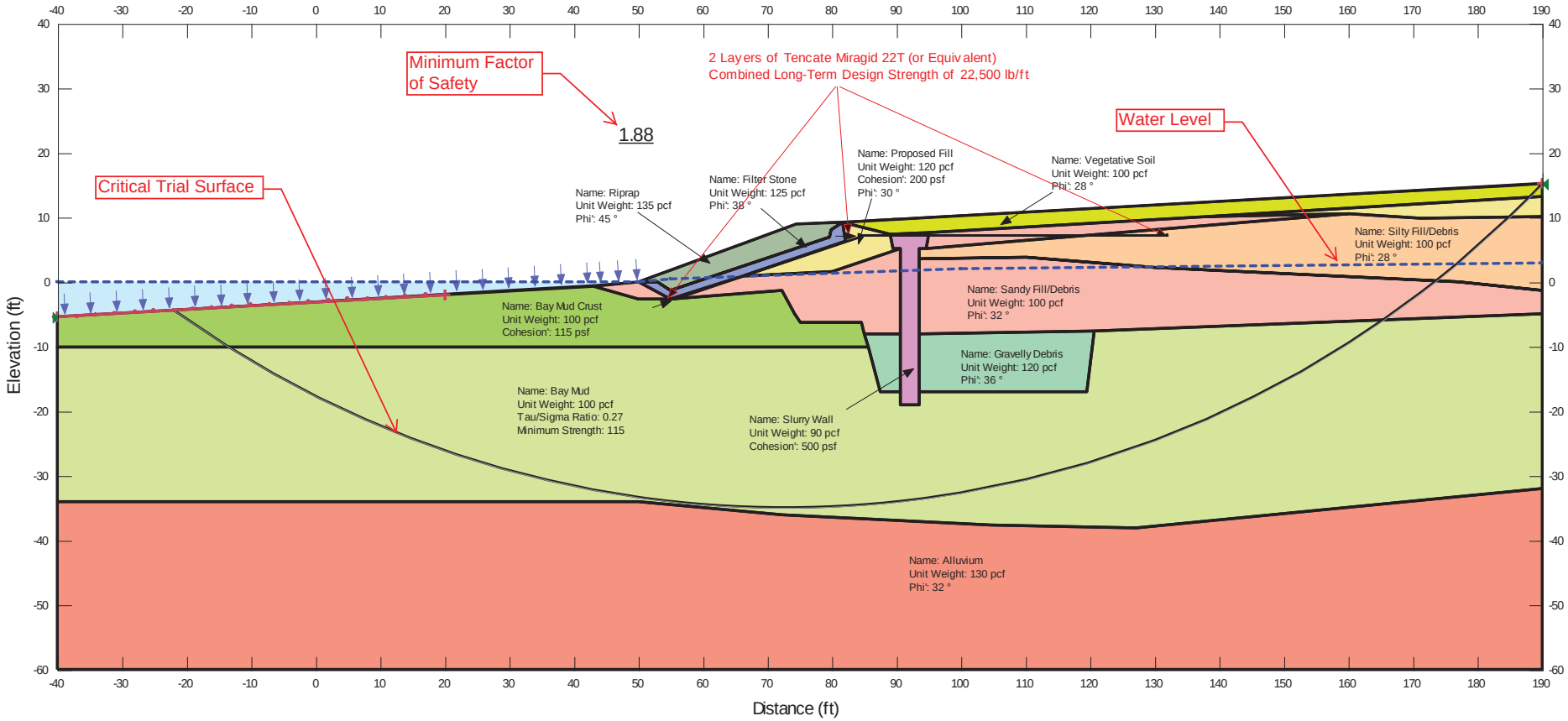
Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Cross Section A-A'** **Factor of Safety 5 Years After Placement of Revetment with Two Layers of Miragrid 22XT**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **11**



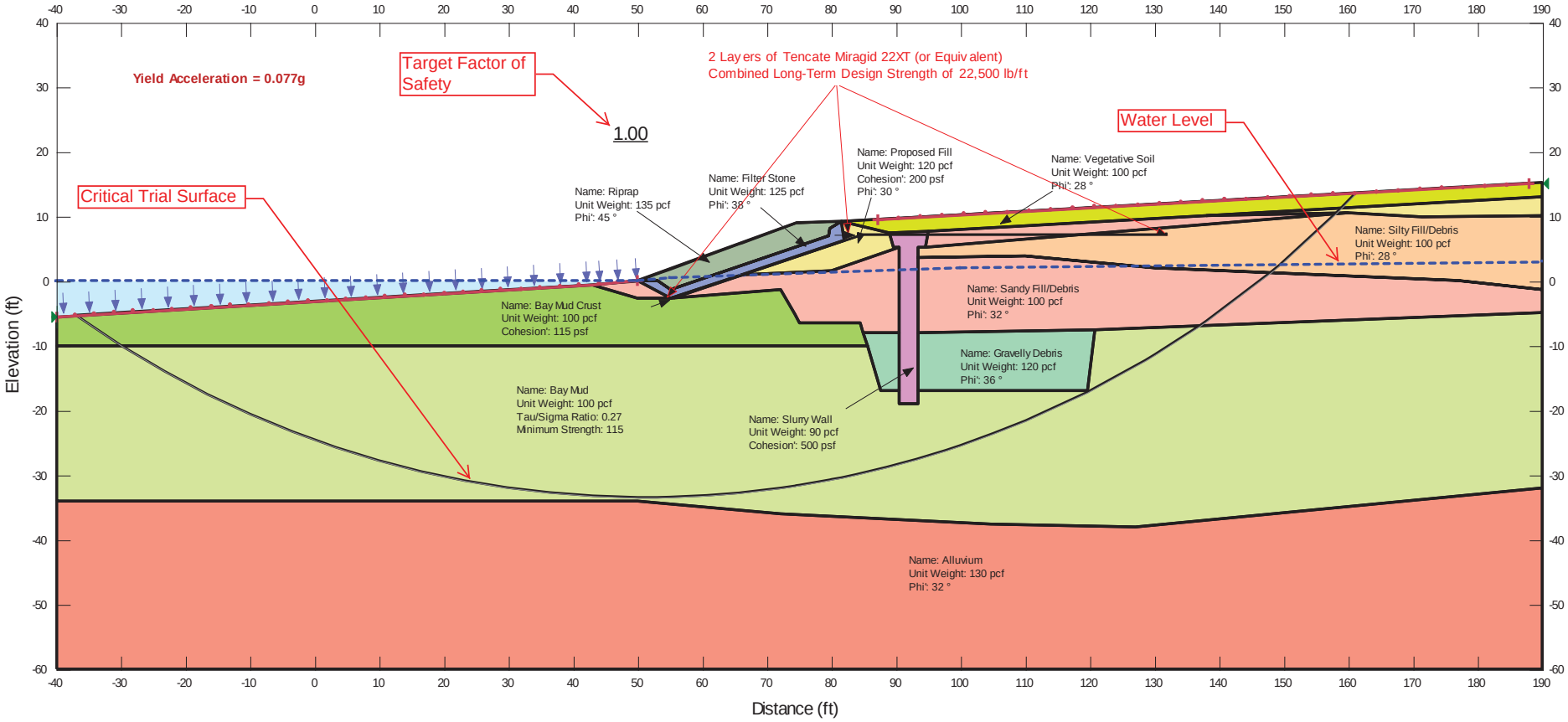
Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Long-Term Static Cross Section A-A' with Two Layers of Miragrid 22XT**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **12**



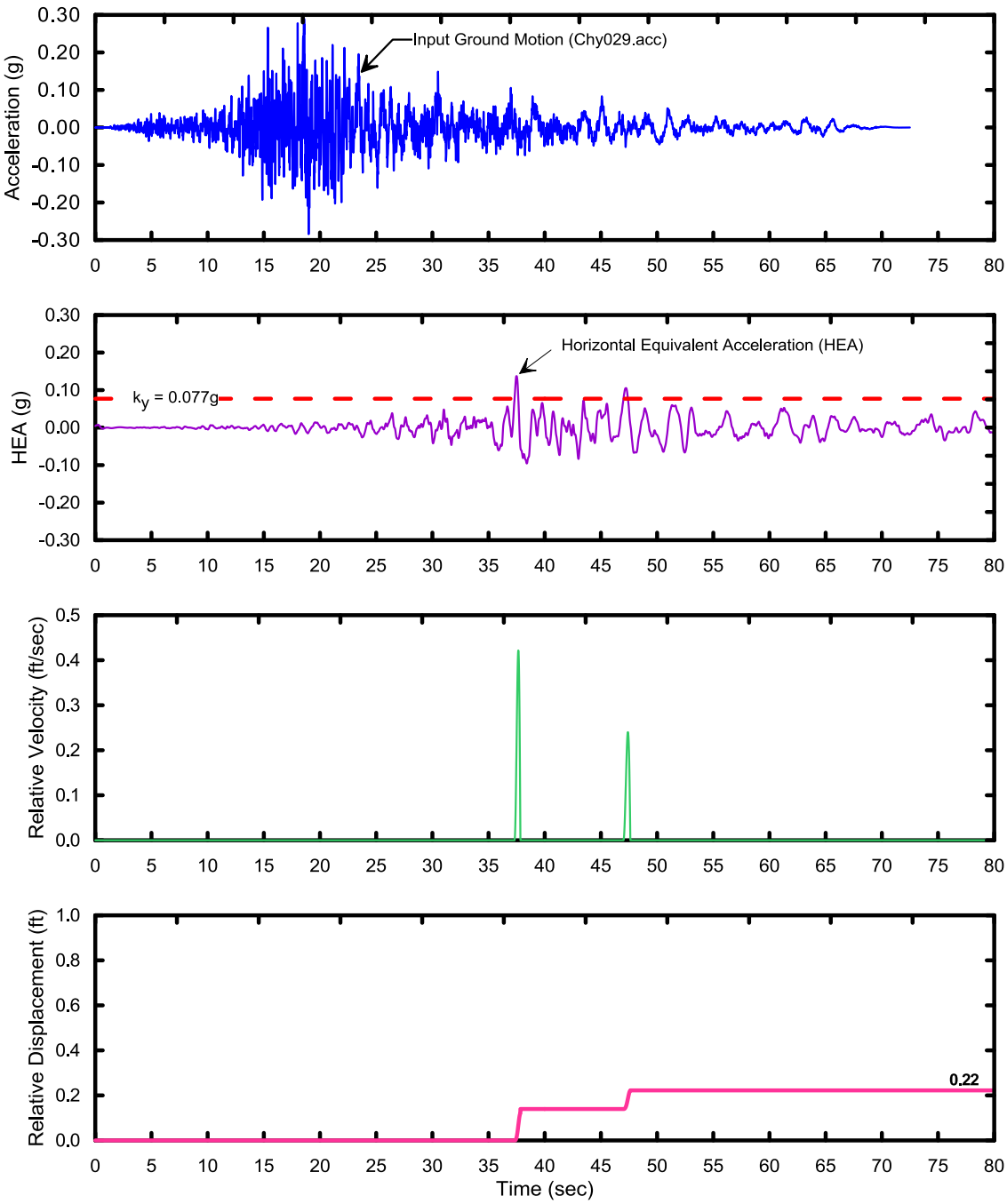
Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Long-Term Static** **Cross Section A-A′ Large Trial Surface Through the Landfill**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **13**



Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

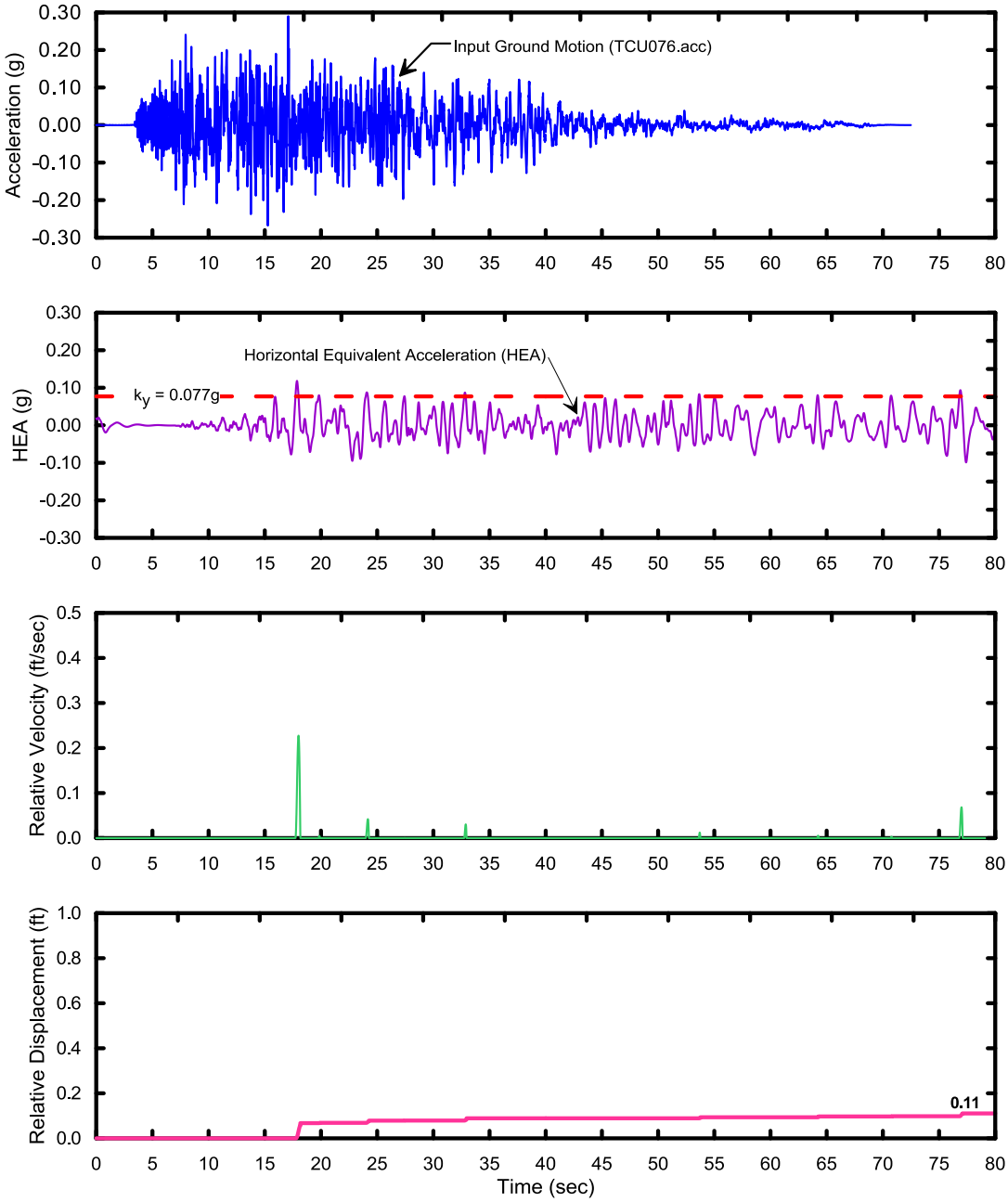
Golder Associates		Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Slope Stability Analysis, Yield Acceleration Cross Section A-A′ with Two Layers of Miragrid 22XT**	
Design: **NK**	Check:	Date: **June 2013**	Figure: **14**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

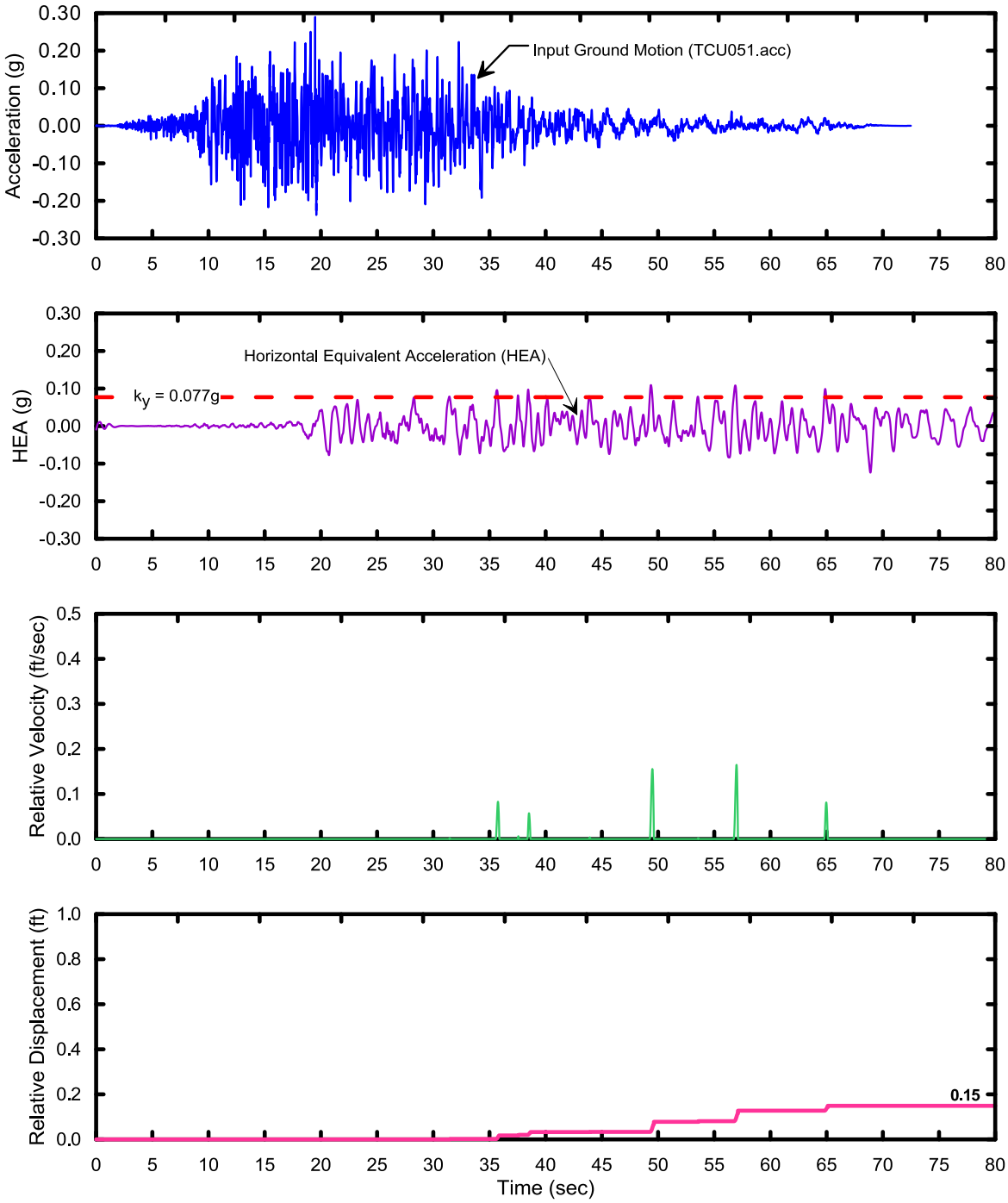
Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement Analysis for MCE** **Time History = Chy029**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **15**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

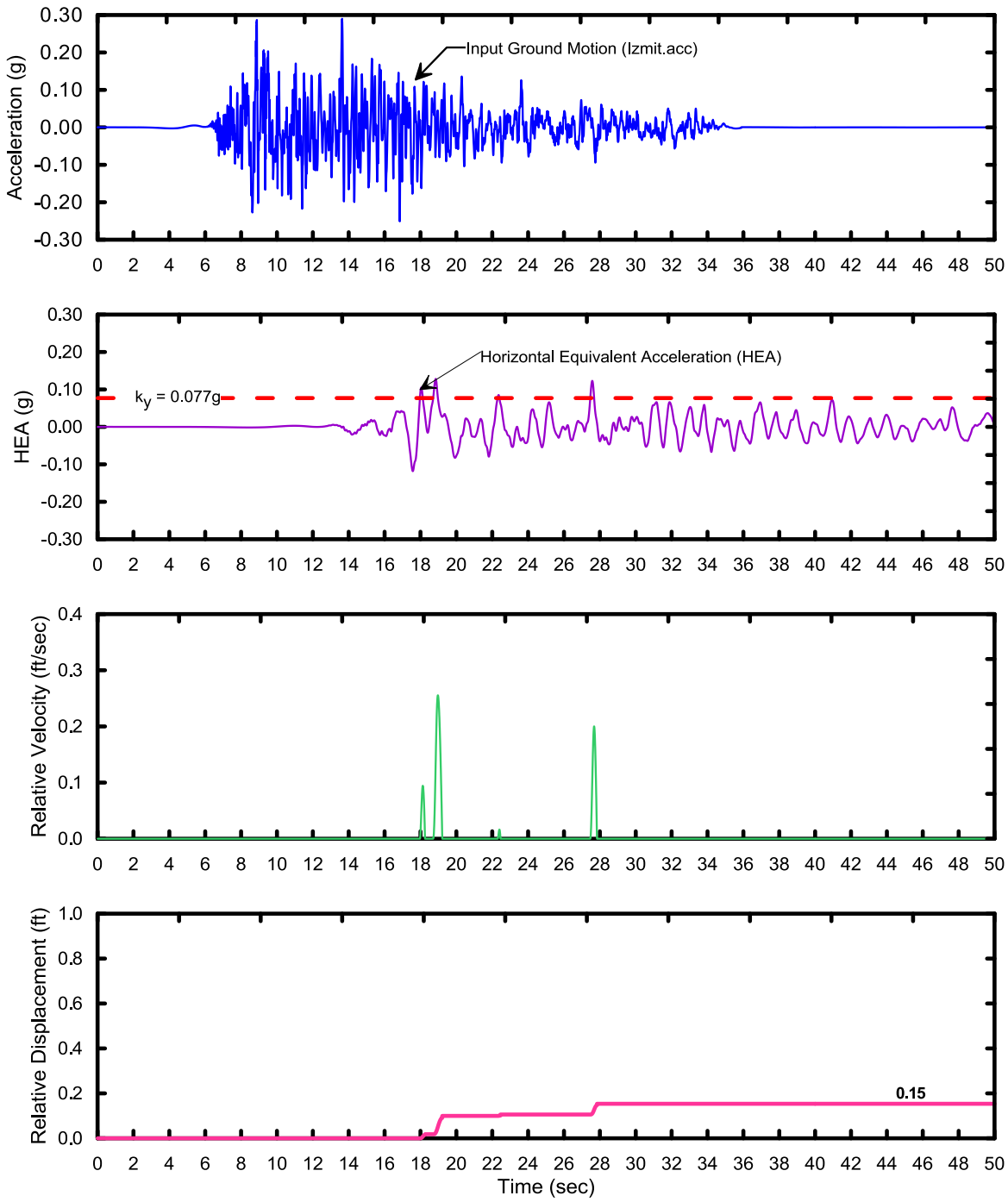
Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement Analysis for MCE** **Time History = TCU076**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **16**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

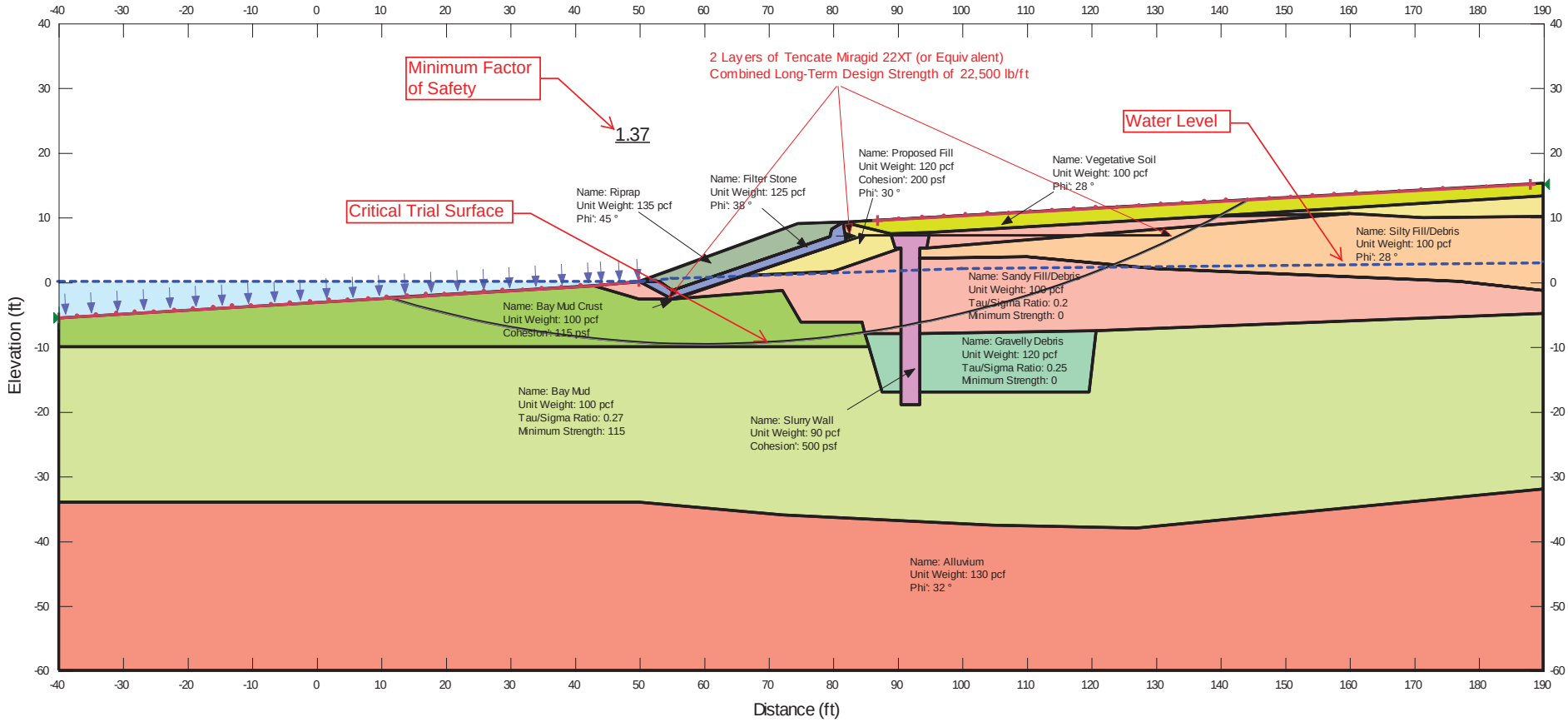
Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement Analysis for MCE** **Time History = TCU051**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **17**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

Golder Associates	Hunters Point Naval Shipyard Parcel E-2 Remedial Design **Seismic Slope Stability, Cross Section A-A′** **Permanent Displacement Analysis for MCE** **Time History = Izmit**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **18**

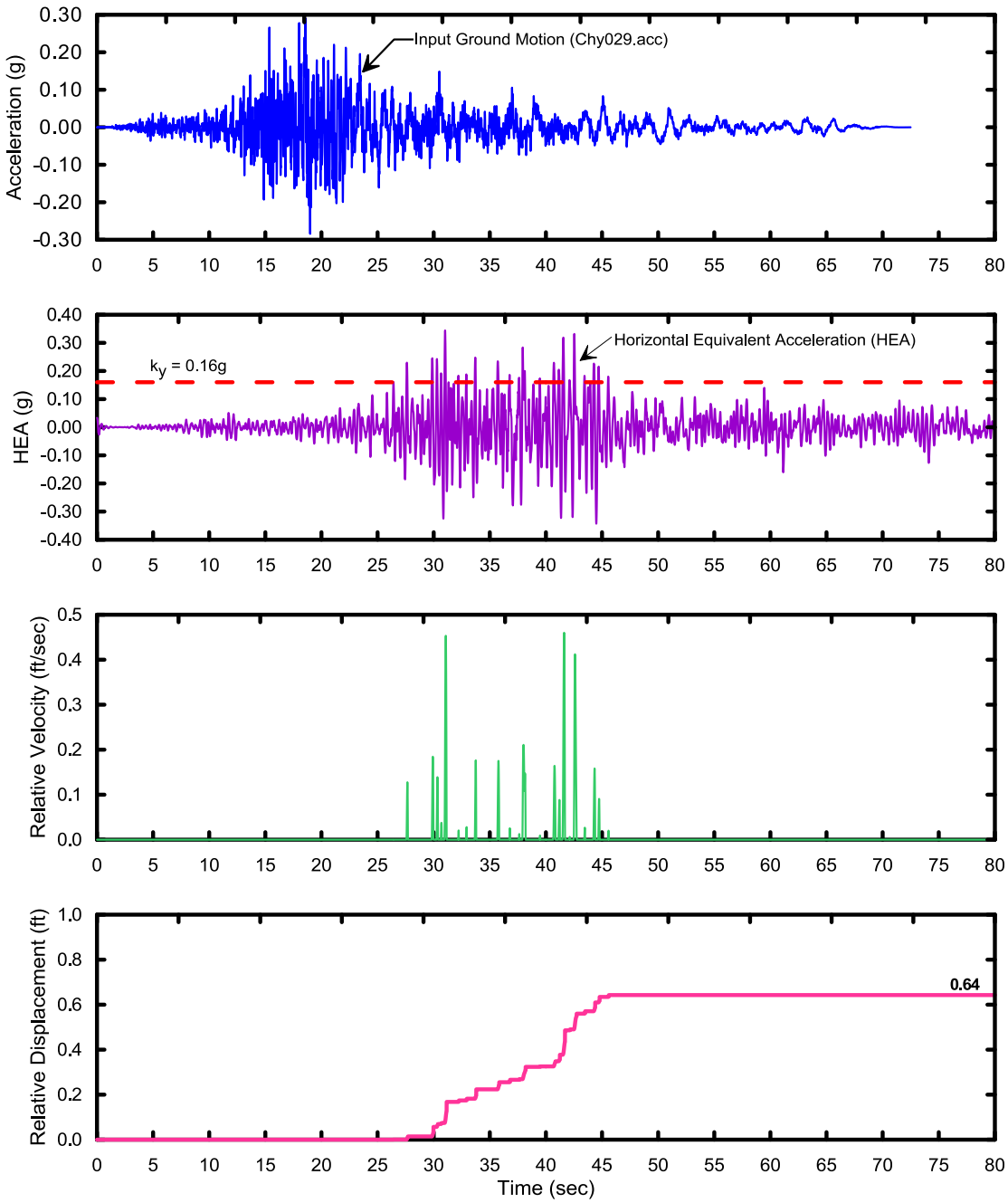


Note: Red lines with + marks along the ground surface indicate trial surface search initiation and termination limits

Golder Associates

Hunters Point Naval Shipyard
Parcel E-2 Remedial Design
Post-Liquefaction Slope Stability Analysis
Cross Section A-A′

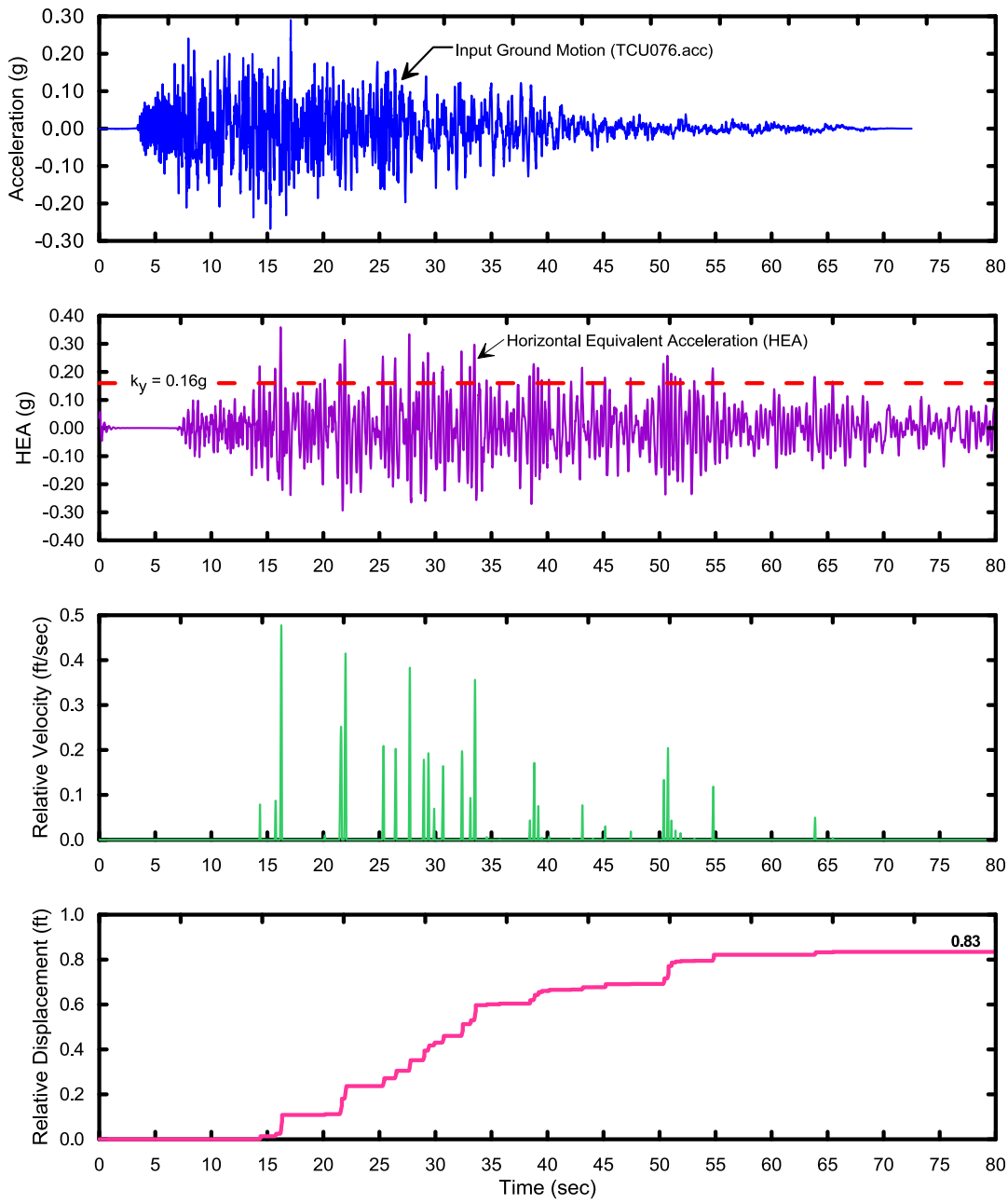
Design: **NK**	Check:	Date: **June 2013**	Figure: **19**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

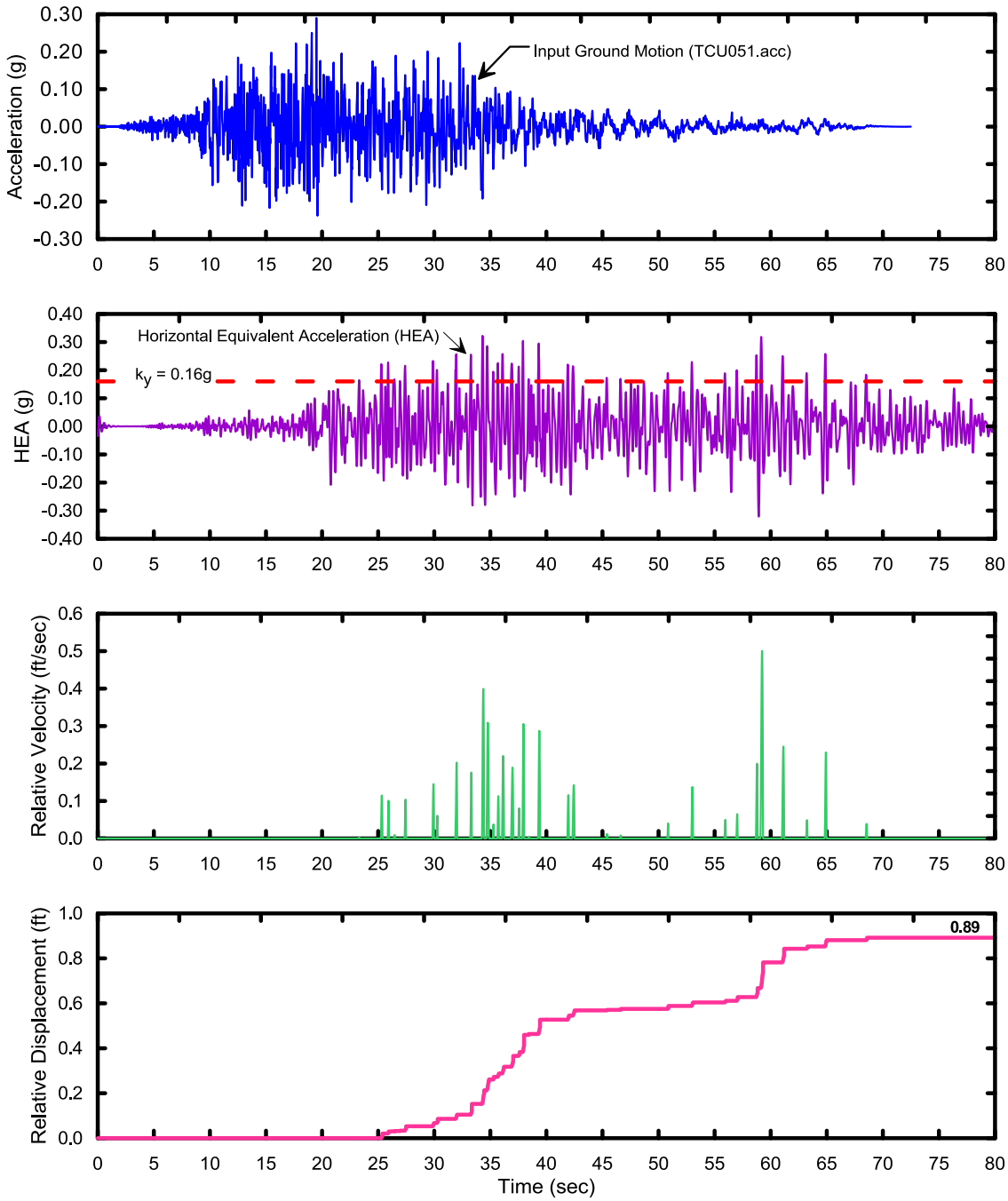
Golder Associates	Hunters Point Naval Shipyard, Parcel E-2 Remedial Design **Final Cover Seismic Slope Stability** **Permanent Displacement Analysis for MCE** **Time History = Chy029**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **20**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

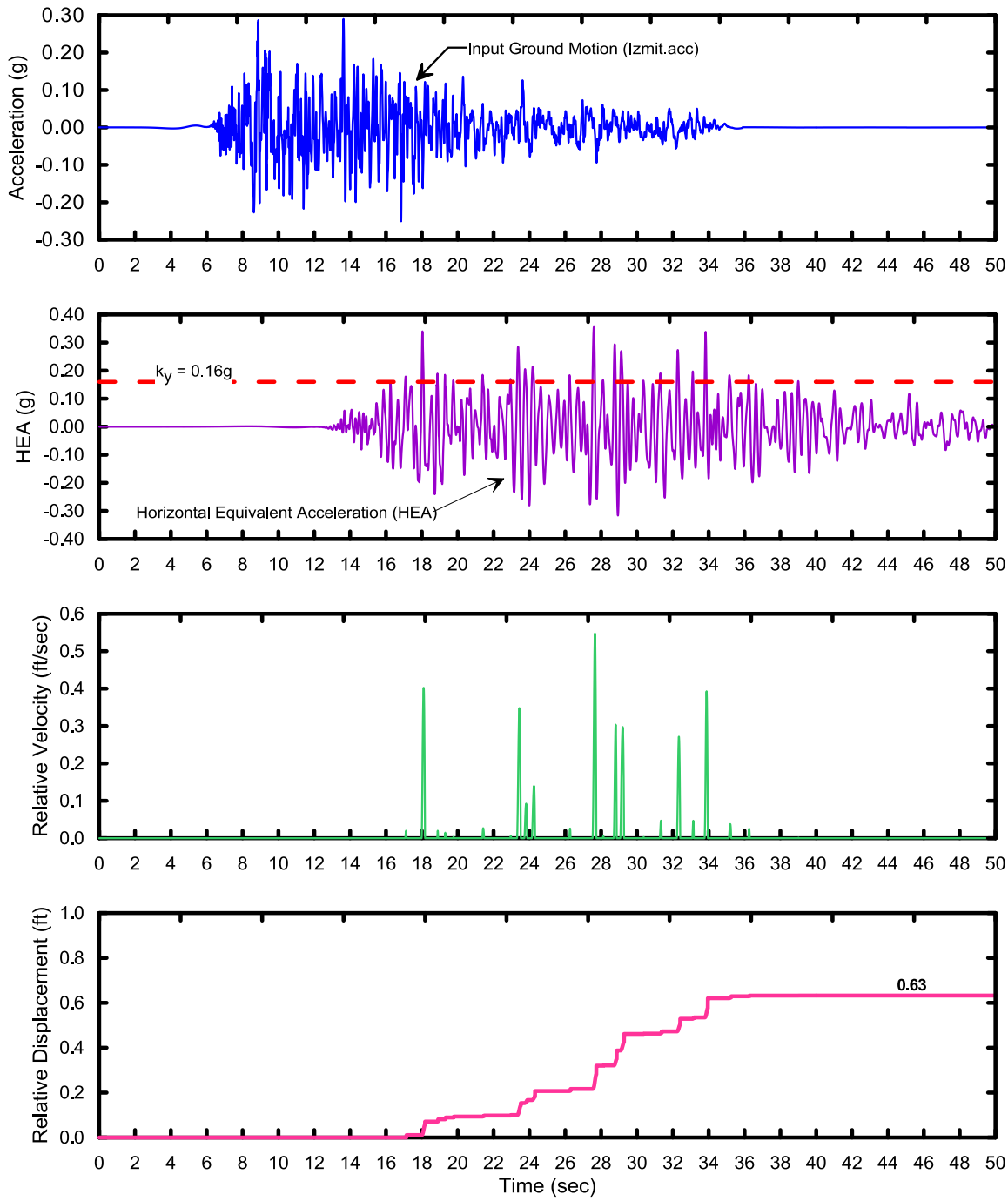
Golder Associates	Hunters Point Naval Shipyard, Parcel E-2 Remedial Design **Final Cover Seismic Slope Stability** **Permanent Displacement Analysis for MCE** **Time History = TCU076**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **21**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., HEA (t) = $[\frac{\tau(t)}{\sigma_v}]$ g
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

Golder Associates	Hunters Point Naval Shipyard, Parcel E-2 Remedial Design **Final Cover Seismic Slope Stability** **Permanent Displacement Analysis for MCE** **Time History = TCU051**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **22**



Note:

1. HEA was computed based on the results of SHAKE91 analysis; i.e., $HEA(t) = [\frac{\tau(t)}{\sigma_v}]\ g$
2. Relative velocity is computed by numerical integration of HEA values exceeding the yield acceleration
3. Relative displacement was computed by numerical integration of the relative velocity

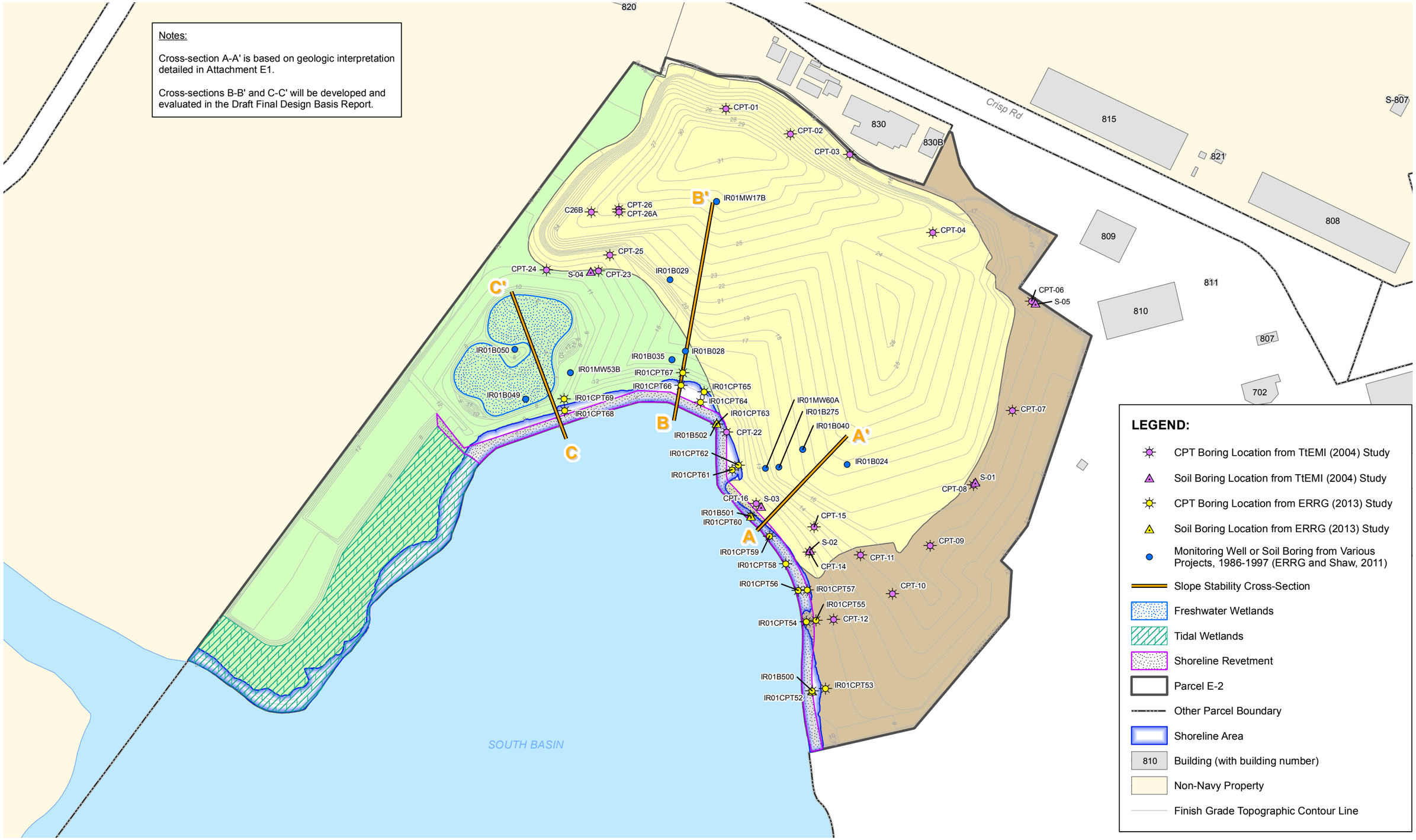
Golder Associates	Hunters Point Naval Shipyard, Parcel E-2 Remedial Design **Final Cover Seismic Slope Stability** **Permanent Displacement Analysis for MCE** **Time History = Izmit**		
Design: **NK**	Check:	Date: **June 2013**	Figure: **23**

ATTACHMENT E1

Notes:

Cross-section A-A' is based on geologic interpretation detailed in Attachment E1.

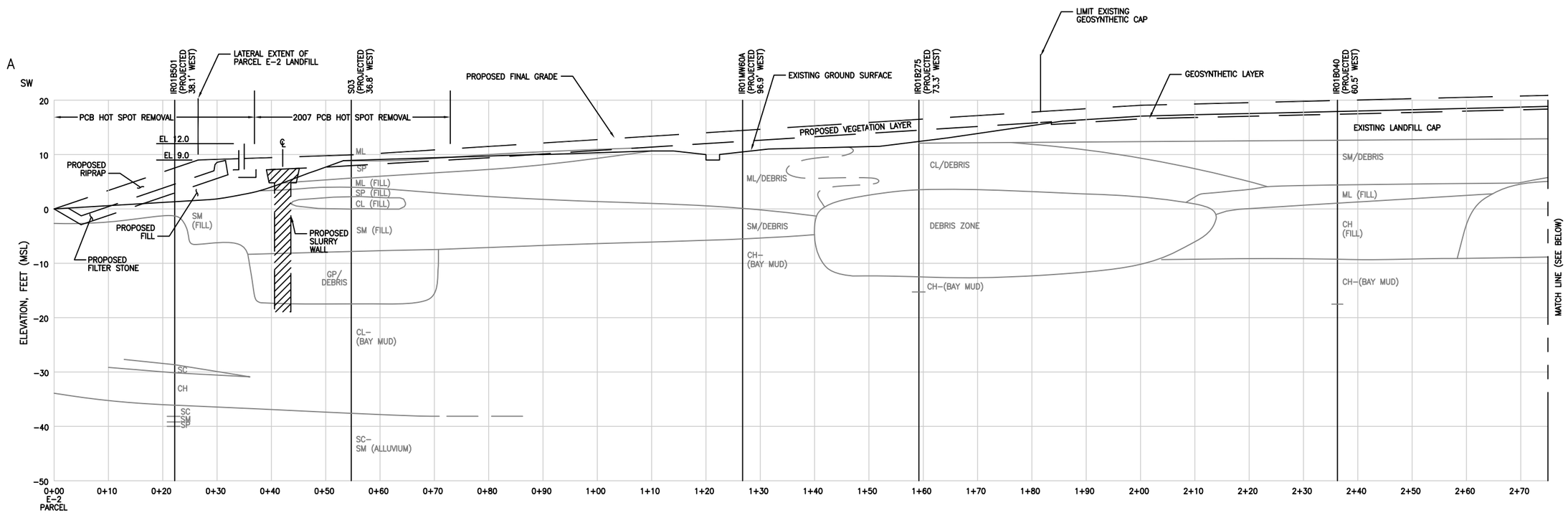
Cross-sections B-B' and C-C' will be developed and evaluated in the Draft Final Design Basis Report.

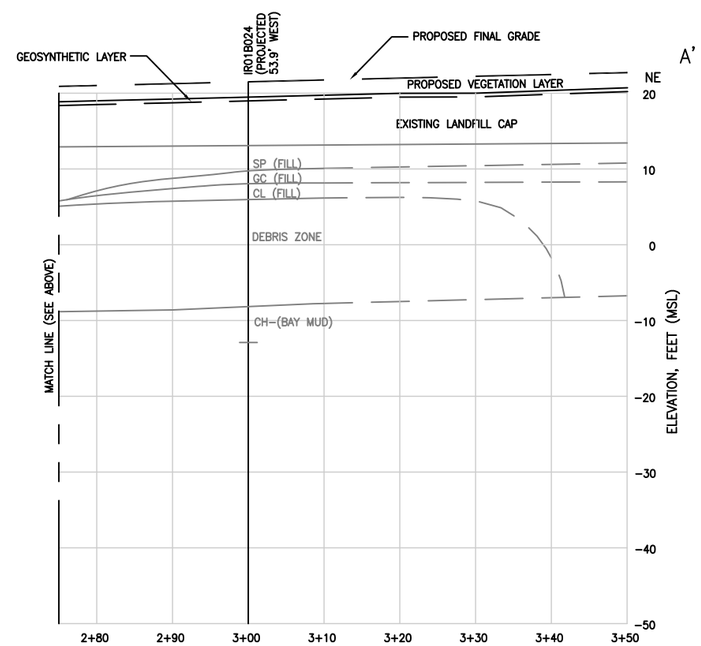


Golder Associates

CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PREVIOUS GEOTECHNICAL INVESTIGATIONS AND LOCATIONS OF SLOPE STABILITY CROSS-SECTIONS			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 06/07/13	CHECKED BY: NK 06/07/13	PROJECT NO. 25-049	FIG NO. E1-1

N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\RD\GIS\DBR\App E\Location of E-2 Cross Sections Attach E.mxd Last updated: 6/7/2013 at 4:20:29 PM





SLOPE STABILITY CROSS SECTION A-A'

SCALE IN FEET
0 10 20

FILE NAME: N:\Graphics\2005\25-049_Navy_HPS_E-2_RI-FS\dwg\Sections D_E_F_G.dwg LAYOUT NAME: SS Section PLOTTED: Wednesday, June 12, 2013 - 7:52am

ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome St., Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY BRAC PMO WEST	SLOPE STABILITY CROSS SECTION A-A'			
	LOCATION: HUNTERS POINT SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: RDB 6/6/13	CHECKED BY: DB 6/6/13	PROJECT NO. 25-049	DWG NO. E1-2

Project: Geotechnical Investigation at Parcel E-2 Project Location: Parcel E-2, Hunters Point Naval Shipyard, San Francisco, CA Project Number: 25-049	**Log of Boring IR01B501** Sheet 1 of 2	ERRG

Date (s) Drilled	4/12/2012	Logged By	E. Binning	Checked By	D. Tang
Drilling Method	Mud Rotary	Drill Bit Size / Type	6"	Total Depth Drilled (feet)	41.5
Drill Rig Type	Track	Drilled By	Gregg Drilling	Hammer Weight / Drop (lb/in)	140 / 30
Groundwater Depth (feet)	0.0	Date Measured	4/12/2012	Approx. Surface Elevation (feet)	1.3
Location	IR01B501			Borehole Backfill	Bentonite Chip

Depth, feet	Sample Name	Sample Type	Sample	Corrected Blows/Foot	Lithology	Soil Classification	MATERIAL DESCRIPTION	Water Content %	Unit Weight, pcf	Lab Tests / Remarks
						SM	**FILL (Af)**; Silty SAND; yellowish-brown; very fine to fine; wet; loose			
4						CH	**BAY MUD (Qhym)**; Fat CLAY; dark gray and black mottled; wet; high plasticity; very soft; pocket penetrometer = 0 TSF			
5	B501A	MC		0						
6	B501B									
7	B501C	SH								Osterberg sampler = 50 psi
10	B501D	SH						65	101	LL = 66, PL = 26, PI = 40; SG = 2.73; Pp = 1,100 psf Osterberg sampler = 100 psi
15	B501E	SPT		0			dark gray to dark green; wet; very soft; pocket penetrometer = 0 TSF			
18	B501F	SH						66	100.8	LL = 74, PL = 30, PI = 44; SG = 2.75 Osterberg sampler = 150 psi

25-049 HPS PARCEL E-2.GPJ 12/11/12

Figure B-2

Project: Geotechnical Investigation at Parcel E-2

Project Location: Parcel E-2, Hunters Point Naval Shipyard, San Francisco, CA

Project Number: 25-049

Log of Boring IR01B501

ERRG

Depth, feet	Sample Name	Sample Type	Sample	Corrected Blows/Foot	Lithology	Soil Classification	MATERIAL DESCRIPTION	Water Content %	Unit Weight, pcf	Lab Tests / Remarks
	B501G	SPT		0			moist; shell fragments; soil appears stiffer than previous strata; pocket penetrometer = 0 TSF			
26										
27	B501H	SH								Osterberg sampler = 175 psi
28										
29										
30	B501I	SPT		2		SC	Clayey SAND; dark gray; fine sand; moist; loose			
31										
32						CH	Fat CLAY; soft			
33	B501J	SH						60	104.6	LL = 69, PL = 26, PI = 43; SG = 2.75 Osterberg sampler = 200 psi with a spike to 400-500 psi; possible sand plug in tube
34										
35							soft material			
36										
37	B501K	SPT		19		SC	**ALLUVIUM**; Clayey SAND; dark gray to dark green; fine sand; medium dense			
38										
39										
40		MC		21		SM	Silty SAND; light brown; wet; fine sand	15.3	114.4	gravel = 0.7%; sand = 85.8%; files = 5.1% SG = 2.71
41	B501L					SP	Poorly graded SAND; dark green; fine sand			
42							Bottom of boring at 41.5 feet			
43										
44										
45										
46										
47										
48										
49										
50										
51										
52										
53										
54										

Figure B-2

Tetra Tech EM Inc.

Log of Boring: S-03

Logged By: S. Delhomme
Logging Consultant: Tetra Tech
Drilling Company: Pitcher

Project: Nonstandard Data Gaps Investigation
Project No: DO 003
Location: IR-01/21 Landfill
Ground Surface Elevation (feet MSL): 12.47

Drilling Method: Rotary Wash
Boring Started: 04/08/02
Completed: 04/08/02
Boring Depth (feet bgs): 61.50
Boring Diameter (inches):

DEPTH (FEET)	DRIVE INTERVAL	RECOVERY (IN)	BLOW COUNTS	SAMPLE ID	OVM (PPM)	WATER LEVEL	GRAPHIC LOG	USCS SOIL TYPE	DESCRIPTION
									Ground Surface
0–1								ML	SILT WITH SAND: brown (FILL)
1–2		2	4/4/7						
2–3		5	7/6/7					ML/CL	CLAYEY SILT: brown, with sand and some rocks (FILL)
3–4		14	3/3/5					SP	POORLY GRADED SAND: tan; clean (FILL)
4–5		5	4/5/4					SM	
5–6								GP	SILTY SAND: tan (FILL)
6–7		7	4/14/13					ML	GRAVEL: black (FILL)
7–8		7	11/16/14					SP	SILT WITH SAND: brown (FILL)
8–9		9	7/9/7					SM	SAND: light gray, with some gravel (FILL)
9–10		8	2/2/2		0			CL	SILTY SAND: black
10–11		5	4/5/5		0				SILTY SAND: gray (FILL)
11–12		5	8/14/12		0			SM	CLAY: gray; wet at 11 feet; with rocks (1/4- to 1-inch diameter); rebar and bolts at 10 feet; steel clamp at 11 feet
12–13		0	9/11/10		0				Some black staining at 12.5 feet
13–14		1	6/5/6						SILTY SAND: dark gray, with rocks (FILL)
14–15		0	7/9/3						SILTY SAND: brown; some sheen in sampler at 15 feet (FILL)
15–16									Threaded nut in end of sampler; no recovery
16–17									SILTY SAND: brown; wet
17–18									Appears to be gravel in drill cuttings
18–19								GP	GRAVEL: 1- to 2-inch diameter; concrete at 21 to 21.5 feet (FILL)
19–20		3	25/19/12						
20–21		0	14/12/11						Pieces of debris (shingles)
21–22		0	19/15/18						Debris too large to go into sampler
22–23									
23–24		0	15/14/9						Concrete at 30 to 30.5 feet
24–25								CL	CLAY: gray, with shells(BAY MUD).
25–26			3/2/3						CLAY: gray (BAY MUD)
26–27									
27–28									
28–29									
29–30									
30–31									
31–32									
32–33									
33–34									
34–35									

Tetra Tech EM Inc.

Log of Boring: S-03

Project: Nonstandard Data Gaps Investigation ***Project No:*** DO 003
Location: IR-01/21 Landfill

DEPTH (FEET)	DRIVE INTERVAL	RECOVERY (IN)	BLOW COUNT	SAMPLE ID	OVM (PPM)	WATER LEVEL	GRAPHIC LOG	USCS SOIL TYPE	DESCRIPTION
36–37		30	100-140PSI						
38–39									
40–41		30	100-160PSI						
42–43								ML/CL	CLAYEY SILT: gray
44–45								CL/ML	CLAY: gray, with silt (BAY MUD)
46–47		30	120-160PSI						
48									CLAYEY SILT: gray, with some sand
49		16	7/10/6					ML	
50								CL	SANDY SILT: gray, with some clay
51		16	5/7/10					CL/ML	SANDY CLAY: gray; stiff
52								SC	SILTY CLAY: gray; stiff
53		16	20/25/39					SM	SILTY CLAY: reddish brown, with gray mottling
54									CLAYEY SAND: dark gray
55									SILTY SAND: dark gray
56		14	13/15/20					SM	SANDY CLAY: light gray
57		16	14/25/29						SILTY SAND: gray
58–59									SILTY SAND: reddish brown
60–61		12	23/28/27						
62								ML	SANDY SILT: tan to light brown
63–70									Total Depth of Boring = 61.5 Feet

Well ID: IR01MW60A

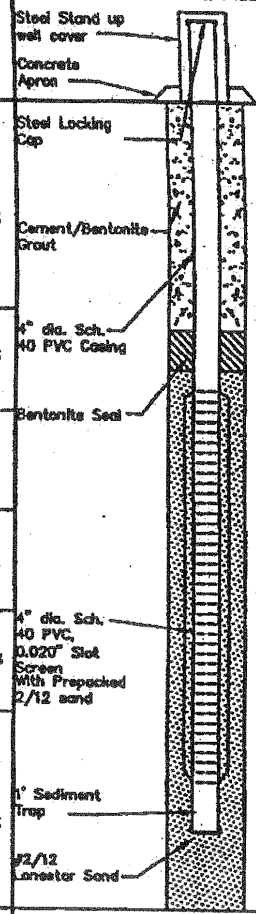
BORING NO. MW-60-1

COORDINATES: N. 450982.5
E. 1457653.0

FIELD GEOLOGIST W. Akiyama — DATE BEGAN 12/18/97
CHECKED BY C. Carlton — DATE FINISHED 12/18/97
APPROVED BY J. Baur — SURFACE ELEV. 12.1 feet MSL
TOTAL DEPTH 20 ft. — T.O.C. ELEV. 14.69 ft MSL

DEPTH IN FEET	SAMPLE NUMBER	BLOWS ON SAMPLER (in)	RECOVERY	USCS	DESCRIPTION
0					Gravel Road, Fill, wood debris, asbestos?, fibrous cloth. SILT; 10yr 5/3 brown, coarse gravel wood, cloth, silty debris, wire, metal strapping, shoe parts, paper.
			1%		
5			0%	ml	∇ Groundwater encountered at 7.0'.
			0%		
10			0%		
			33%		13.0' SILTY SAND; 10yr2/1, loose, wet, medium sand, wood debris.
15			10%	sm/sp	At 17': wood, brick.
					19.0'
20				ch	CLAY; 10yr2/1 plastic, wet. (BAY MUD)
					TOTAL DEPTH 20.0 FEET
25					
30					
35					

WELL CONSTRUCTION DETAILS



Field Check 3 Apr 2007
TD = 22.00 ft btoc,
CE2 Corporation

DRILLER : C. St. Pierre
DRILLING CO. : Gregg Drilling Co.
DRILLING METHOD : 8" O.D. Hollow Stem Auger, Reamed to 12" O.D.
SAMPLING METHOD : California Modified Split-spoon Sampler
PROJECT NAME: Site IR-1/21 D.O. 60
LOCATION : Hunters Point Shipyard
PROJECT NO. : 767497.02106000

DRAWN BY	T.R.S.	CHECKED BY	JBL 9-23-98	FILE NAME & DISK NUMBER	HP-MW60I (HP)

INTERNATIONAL TECHNOLOGY CORPORATION

Log of Boring: IR01B275
Equipment: DRILL SYSTEMS 1000 (ACH), 10 in. diam.
Date: 06/26/1992
Elevation: GS 12.49 feet
Total Depth: 28 ft.

Blows / 6"	OVA(ppm)	Sample Number	Depth (ft)	Description
10 18 18 6 17 21	10	9226A322 9226A373	0	LIGHT REDDISH BROWN GRAVELLY LEAN CLAY (CL) 5YR6/6, medium stiff, dry, 60% clay, 30% subangular gravel, 10% medium- to fine-grained sand, fill VERY DARK GRAY SANDY LEAN CLAY (CL) 5YR3/1, soft, dry, 55% clay, 35% medium- to fine-grained sand, 10% gravel, trace wood, plastic and nails, fill
6 17 20	30	9226A374	5	50% wood debris by 5 ft.
10 15 25	30	9226A375		
21 19 23	8	9226A376	10	DEBRIS ZONE wood, cloth, plastic GRAY POORLY GRADED SAND WITH GRAVEL (SP) 5Y6/1, loose, wet, 65% coarse-grained sand, 35% subrounded gravel, fill DEBRIS ZONE
13 11 11			15	wood No recovery at 15 ft.
17 23 19			20	No recovery at 20 ft., black oily odor logged from cuttings
23 4 5 6 2 2	4	9226A378	25	DARK GREENISH GRAY FAT CLAY (CH) 5GY4/1, soft, wet, 75% clay, 20% shell fragments, 5% fine-grained sand, Bay Mud Deposits

Bottom of boring at 28 feet. Boring backfilled with bentonite cement grout (6/26/92). Grab water sample 9226A377 collected.

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring IR01B275

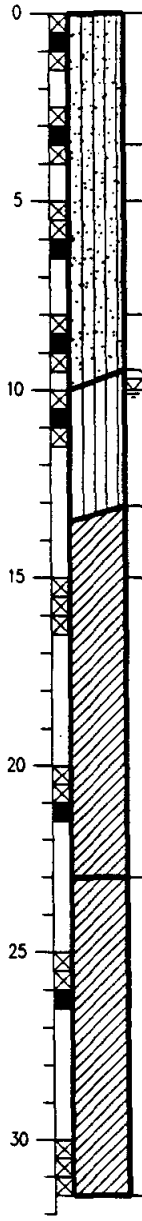
Naval Station, Treasure Island
Hunters Point Annex
San Francisco, California

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
WJF			10/92	

Log of Boring: IR01B040
Equipment: CME 750 (HSA), 8 in. diam.
Date: 11/06/1990
Elevation: GS 13.18 feet
Total Depth: 31.5 ft.

Blows / 6"	OVA(ppm)	Sample Number
3 8 18	0	9045G413
18 28 20	30	9045G414
12 13 28	80	9045G415
5 10 12	150	9045G416
4 12 9		9045G417
0 1 1		
1 1 1	400	9045G418
1 2 2	100	9045G419
2 2 3	120	



YELLOWISH BROWN SILTY SAND WITH GRAVEL (SM)
10YR6/8, loose, moist,
55–60% well-graded sand, 20–25% silt, 15–20% fine to coarse gravel, fill

Color change to very dark gray (2.5YN3/0) at 3.5 ft.

Wood debris and metal from 5 to 10 ft.

Color change to dusky red (2.5YR3/2) at 8 ft., abundant wood fragments

DARK BROWN GRAVELLY SILT WITH SAND (ML)
7.5YR3/2, soft to medium stiff, wet,
45–55% silt, 20–25% fine to coarse gravel, 15–20% sand, trace clay, fill

VERY DARK GRAY FAT CLAY (CH)
7.5YRN3/0, very soft, moist to wet,
80–85% clay, 10–15% silt, fill

No sample recovery at 15 ft.

DARK GREENISH GRAY FAT CLAY (CH)
5GY4/1, soft, moist,
80–85% clay, 10–15% silt, trace shell fragments, bay mud deposits

Bottom of boring at 31.5 feet. Boring backfilled to surface with bentonite cement grout (date boring grouted not available)

Harding Lawson Associates
Engineering and Environmental Services

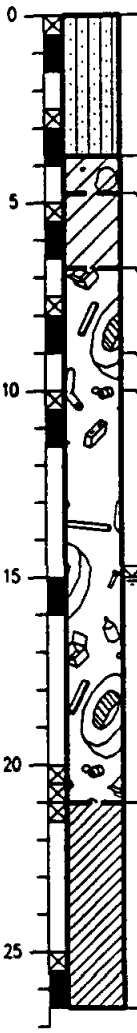
Log of Boring IR01B040
Naval Station Treasure Island
Hunters Point Annex
San Francisco, California

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
			12/93	

Log of Boring: IR01B024
Equipment: DRILL SYSTEMS 1000 (ACH), 10 in. diam.
Date: 05/07/1992
Elevation: GS 13.24 feet
Total Depth: 26.5 ft.

Blows / 6"	OVA(ppm)	Sample Number
14 10 12	0	9219A190
16 12 30	3	9219A191
20 21 21	10	9219A192
34 11 12	250	9219A193
7 11 10	300	9219A194
10 50	30	9219A195
6 9 4	70	
8 4 3	20	9219A196



YELLOWISH BROWN POORLY GRADED SAND WITH SILT (SP-SM)
10YR5/6, loose, dry,
90% fine-grained sand, 10% silt, fill

DARK OLIVE CLAYEY GRAVEL (GC)
5Y3/2, loose, dry,
70% subangular gravel, 30% lean clay, fill

DARK REDDISH BROWN SANDY LEAN CLAY WITH GRAVEL (CL)
5YR3/4,
50% clay, 30% medium- to coarse-grained sand, 20% subangular gravel, fill

DEBRIS ZONE

wood, paper and plastic

High gas readings at 9 ft.

Wood, paper and cardboard debris at 10 ft., high gas readings

Wood, paper, plastic and wash rags at 15 ft.

DARK GREENISH GRAY FAT CLAY (CH)
5GY4/1, soft, wet,
90% clay, 10% shell fragments,
Bay Mud Deposits

Bottom of boring at 26.5 feet. Boring backfilled with bentonite cement grout (5/7/92).

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring IR01B024

Naval Station, Treasure Island
Hunters Point Annex
San Francisco, California

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
mf			11/13/92	

ATTACHMENT E2

TECHNICAL MEMORANDUM

Date: March 13, 2012 **Project No.:** 123-97583
To: Nagesh Koragappa **Company:** Golder Associates Inc.

From: Anthony Augello

RE: **SEISMIC HAZARD ANALYSIS AND DEVELOPMENT OF SPECTRALLY MATCHED ACCELERATION TIME HISTORIES FOR PARCEL E-2 LANDFILL AT THE HUNTERS POINT SHIPYARD**

1.0 DEVELOPMENT OF GROUND MOTIONS FOR SITE RESPONSE ANALYSES

According to Title 27 of the California Code of Regulations (CCR Title 27), Class III Units shall be designed to withstand the maximum probable earthquake (MPE) without damage to the foundation or to the structures which control leachate, surface drainage, or erosion, or gas. The MPE is defined by the State of California as the maximum earthquake that is likely to occur during a 100 year interval. However, the remedial design for the Parcel E-2 Landfill has been performed to withstand the maximum credible earthquake (MCE), which is the design requirement for Class I and Class II units under Title 27. The MCE is in CCR Title 27 as "the maximum earthquake that appears capable of occurring under the presently known geologic framework." Since the site is located 12 km from the San Andres fault, the MCE would be a repeat of the 1906 San Francisco Earthquake, a magnitude 8.0 earthquake located 12 km from the site. CCR Title 27 does not specify the design ground motions for the MPE or MCE events.

2.0 SEISMIC HAZARD ANALYSIS

The MCE event is a deterministic earthquake event. Deterministic seismic hazard analysis (DSHA) uses available historic, instrumental earthquake records, and geologic data to generate discrete, single-valued estimates of ground motion at a site. Typically, one or more earthquakes are specified by magnitude and location with respect to the site. In DSHA, little regard is given to the earthquake recurrence interval, which may vary from less than a hundred years to more than ten thousand years, depending on the geologic environment under consideration.

The seismic source and site location parameters required to estimate ground motions in a DSHA are:

- Fault (source) type;
- Maximum magnitude;
- Closest horizontal distance to the surface projection of the fault rupture plane;
- Closest distance to the rupture plane;

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- Focal depth; and
- Site soil conditions.

These parameters are input into empirical ground motion prediction equations (GMPE) to estimate the earthquake ground motions at a site. The ground motions are usually represented by peak horizontal ground acceleration (PGA) or the acceleration response spectrum for the MCE.

2.1 Empirical Ground Motion Prediction Equations

Published regional empirical GMPE were used to estimate the 5% damped MCE acceleration response spectra. The GMPEs used for crustal earthquakes are based on relations developed by Abrahamson and Silva (2008), Boore and Atkinson (2008), Chiou and Youngs (2008), and Campbell and Bozorgnia (2008). These four GMPEs for crustal earthquakes were equally weighted (0.25 each) estimate spectral accelerations as a function of magnitude, source-to-site distance, fault geometry and for an average shear wave velocity in the upper 30 m of the soil column (V_{s30}) equal to 760 m/s.

Based on these four GMPEs, the median PGA for the Parcel E-2 Landfill is 0.29g. The remedial design for the Parcel E-2 Landfill is being performed to withstand the median ground motions from the MCE.

2.1.1 Target Acceleration Response Spectra

Acceleration time histories are spectrally matched to the 5% damped acceleration response spectrum for the MCE event. Table 1 provides the median 5% damped spectral accelerations from a period of 0.01 to 10 seconds for the MCE. The median uniform hazard acceleration response spectrum was used as the target acceleration response spectrum for spectral matching.

Table 1: MCE Acceleration Response Spectrum at the Hunters Port Site on Weak Rock ($V_{S,30}$ = 760 m/s)

Period (second)	Median Spectral Acceleration (g)
0.01	0.29
0.02	0.30
0.03	0.31
0.05	0.37
0.075	0.46
0.10	0.53
0.15	0.63
0.20	0.64
0.25	0.61
0.30	0.56
0.40	0.48
0.50	0.42

Period (second)	Median Spectral Acceleration (g)
0.75	0.31
1.0	0.25
1.5	0.17
2.0	0.13
3.0	0.09
4.0	0.06
5.0	0.05
7.5	0.03
10.0	0.02

3.0 SPECTRAL MATCHING

3.1 General

Spectral matching is a procedure used to develop an acceleration time history that closely matches a smoothed design response spectrum (target spectrum). Spectral matching is typically performed to reduce the number of acceleration time histories required for dynamic analyses of a structure (Hancock et al. 2006). The spectral matching procedure generally begins with a recorded acceleration time history from an earthquake whose characteristics reasonably represent the earthquake expected at the site. The objective of the spectral matching procedure is to reduce the individual spectral peaks and valleys of the initial acceleration time history while preserving the non-stationary characteristics of the initial time history as much as possible (Abrahamson 1992). The spectrally matched motion is considered an artificial acceleration time history; however, the spectrally matched motion can preserve most of the characteristics of the real earthquake motion (Hancock et al. 2006).

Spectral matching can be undertaken in either the time-domain or frequency domain. Spectral matching in the frequency domain is performed by adjusting the Fourier amplitude spectrum. Adjusting the Fourier amplitude spectrum corrupts the velocity and displacement time histories and can result in motions with a high energy content (Hancock et al. 2006).

In this study, spectral matching was performed in the time-domain. The matching procedure employed adds wavelets to the initial acceleration time history. The wavelets introduce less energy into the acceleration time history and preserve the non-stationary characteristics of the initial time history (Hancock et al. 2006). Each wavelet is applied to the time series so that the time of the maximum spectral response in the adjusted time history occurs at the same time as the maximum spectral response in the unadjusted time history. The fundamental assumption is that the peak response does not change as a result of adding the wavelet adjustment (Hancock et al. 2006). Spectral matching in the time domain

can lead to drift in the velocity and displacement time histories (i.e., non zero velocity and displacement at the end of shaking).

For this study, spectral matching was accomplished using the computer program RSPMATCH which has been incorporated into the EZ-FRISK 7.62 software developed by Risk Engineering Inc. RSPMATCH is based on the time-domain matching method developed by Lilhanand and Tseng (1988) and modified by Abrahamson (1992) and (Hancock et al. 2006). In this study spectral matching was conducted by dividing the target spectrum into a number of subgroups. This decreases the analysis time and generally leads to a mathematically stable solution.

In this study, the duration was defined as the 5-95 Arias duration. This duration is the time that it takes to build up from 5% to 95 % of the normalized Arias intensity. The Arias intensity is calculated as

$$I_a = \frac{\pi}{2g}\int_0^{\infty} [a(t)]^2 \, d$$

The Arias intensity has units of velocity and is considered a measure of the energy content of acceleration time history.

Because the solution is not unique (i.e., there are an infinite number of motions that will produce the target spectrum), the motion was integrated to calculate the velocity and displacement time histories. The acceleration, velocity and displacement time histories were checked to assure that these times histories appear reasonable. This check was made to verify that the spectrally matched motion had a reasonable duration and there was no residual displacement. If necessary, the spectrally matched acceleration time histories were baseline corrected.

Because the target acceleration response spectra were developed for a bedrock site ($V_{S,30}$ = 760 m/sec), the spectrally matched motions can be considered “rock” motions.

3.2 Discussion of Spectral Matching

The seed motions used for spectral matching were actual recorded and synthetic acceleration time histories that are available from readily available worldwide databases. There are a number of parameters that must be considered when selecting recorded acceleration time histories for spectral matching. These include earthquake magnitude, sense of earthquake motions (normal, reverse, and strike-slip), site-to-source distance, shear wave velocity at the recording station, and PGA of the recorded motion. Ideally, recorded time histories that closely match each of these parameters at the site would be selected for spectral matching. However, because of the limited database of world-wide recorded acceleration time histories it may be necessary to relax the criteria for matching some of these parameters. By far, the most import parameter in spectral matching is the earthquake magnitude because the magnitude is directly related to the duration of strong shaking. This is consistent with the

recommendations of Bommer and Acevedo (2004) who show that distance has little influence on spectral shape. They recommend a small window in terms of magnitude but broad limits in terms of distance. Similarly, Watson-Lamprey and Abrahamson (2006) found that spectrally matched acceleration time histories with scale factors of 2.0 on PGA are acceptable. The sense of earthquake movement can affect the peak ground acceleration and the spectral accelerations, but this is accounted for in the attenuation relationships used in the PSHA.

Because the spectral matching solution is not unique, the acceleration, velocity and displacement time histories were checked for the spectrally matched motions to verify that the duration of strong shaking was adequate and that residual displacement was zero. If the duration, displacement or acceleration time history was not adequate the spectrally matched was rejected. For each spectrally matched motion, the target residual displacement was a residual displacement less than 0.1 cm.

3.3 Selection of Seed Acceleration Time Histories

We reviewed available acceleration time history records from normal, strike-slip, reverse and oblique-reverse mechanism earthquakes that met the magnitude-distance criteria listed in Section 1.

Table 2 shows the seed acceleration time histories for the MCE ground motions. This table lists the earthquake, date of the earthquake, earthquake magnitude, station name, component of motion and Arias duration.

Table 2: Selected Time Histories for Spectral Matching

Motion No.	Earthquake Name (date)	Magnitude (M)	Station	Component of Motion	Duration[2] (seconds)
1	Chi Chi Taiwan (1999)	7.6	CHY029	Vertical	30.25
2	Chi Chi Taiwan (1999)	7.6	TCU076	East-West	30.84
3	Chi Chi Taiwan No. 4 (1999)	7.6	TCU051	East-West	26.78
4	Kocaeli Turkey (1999)	7.5	Izmit	Fault Normal[1]	18.09

Notes:
1 Recorded acceleration time history has been rotated to their fault normal and fault parallel components, respectively.
2 Calculated 5-95 Arias duration of the spectrally matched acceleration time history.

3.4 Results of Spectral Matching

This section presents the results of the spectral matching in terms of the acceleration, velocity and displacement time histories. Figures 1 through 4 show the acceleration, velocity and displacement time histories for the four spectrally matched ground motions. The accelerations should be scaled to 0.29g in the seismic response analysis.

4.0 REFERENCES

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Bommer, J. and Acevedo, A.B., 2004, The use of Real Accelerograms as Input to Dynamic Analysis, Journal of Earthquake Engineering, Vol. 8 (Special Issue 1), pp 43-91.

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Hancock, J., Watson-Lamprey, J., Abrahamson, N. A., Bommer, J. J., Markatis, A., McCoy, E., and Mendis, R., 2006, An Improved Method of Matching Response Spectra of Recorded Earthquake Ground Motions Using Wavelets, Journal of Earthquake Engineering, Vol. 10, Special Issue 1, pp 67-89.

Lilhanand, K. and W. S. Tseng. (1988), Development and Application of Realistic Earthquake Time Histories Comparable with Multiple Damping Design Spectra. Proceedings of the Ninth World Conference on Earthquake Engineering, Tokyo-Kyoto, Japan, Vol. 2.

Risk Engineering, Inc. 2012. EZ-FRISK version 7.62, Software for Earthquake Ground Motion Estimation, Denver, Colorado.

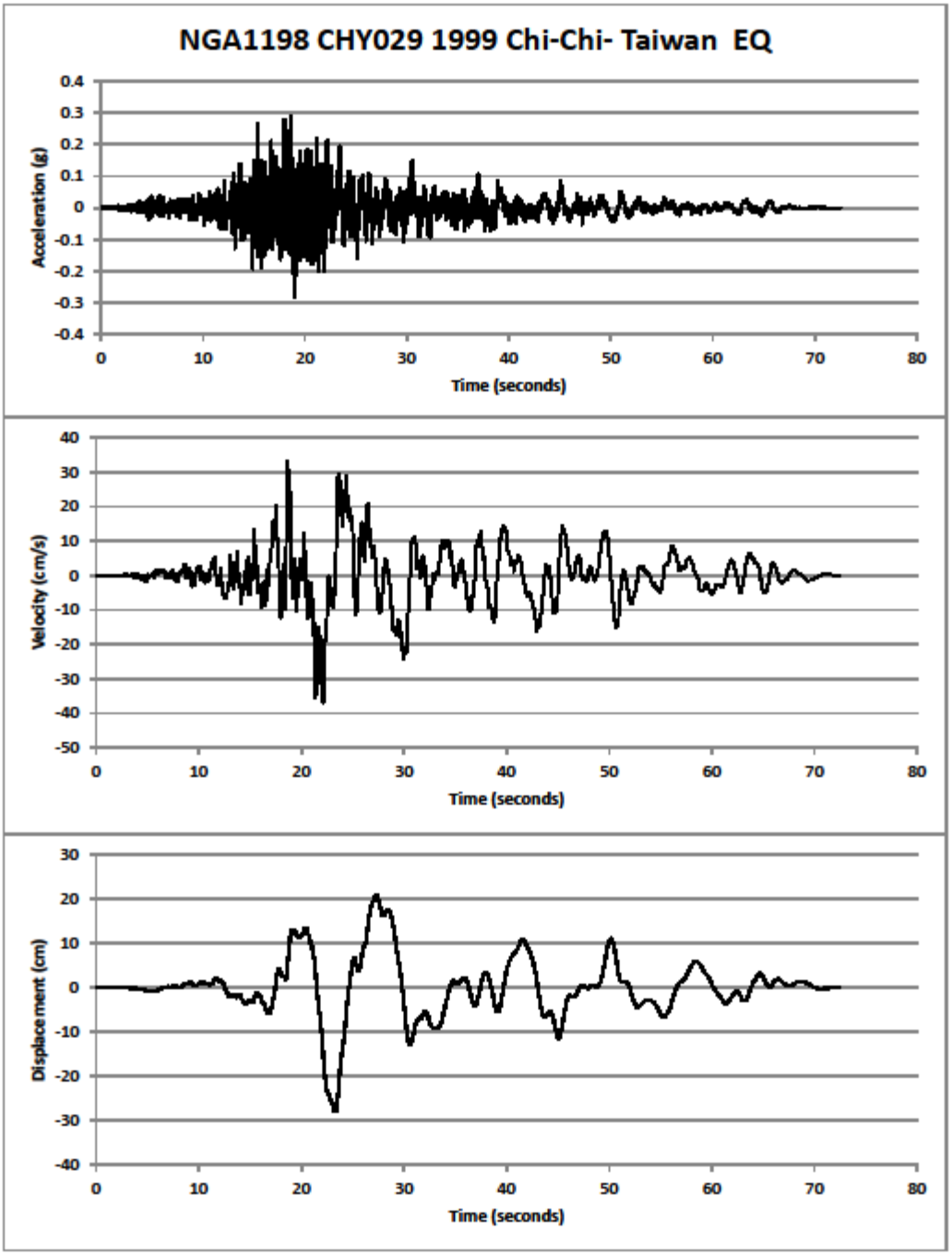


FIGURE **1**

Horizontal Acceleration, Velocity and Displacement Time Histories - NGA1198 CHY029 (East – West)
Hunters Point Site, San Francisco, CA

Golder Associates

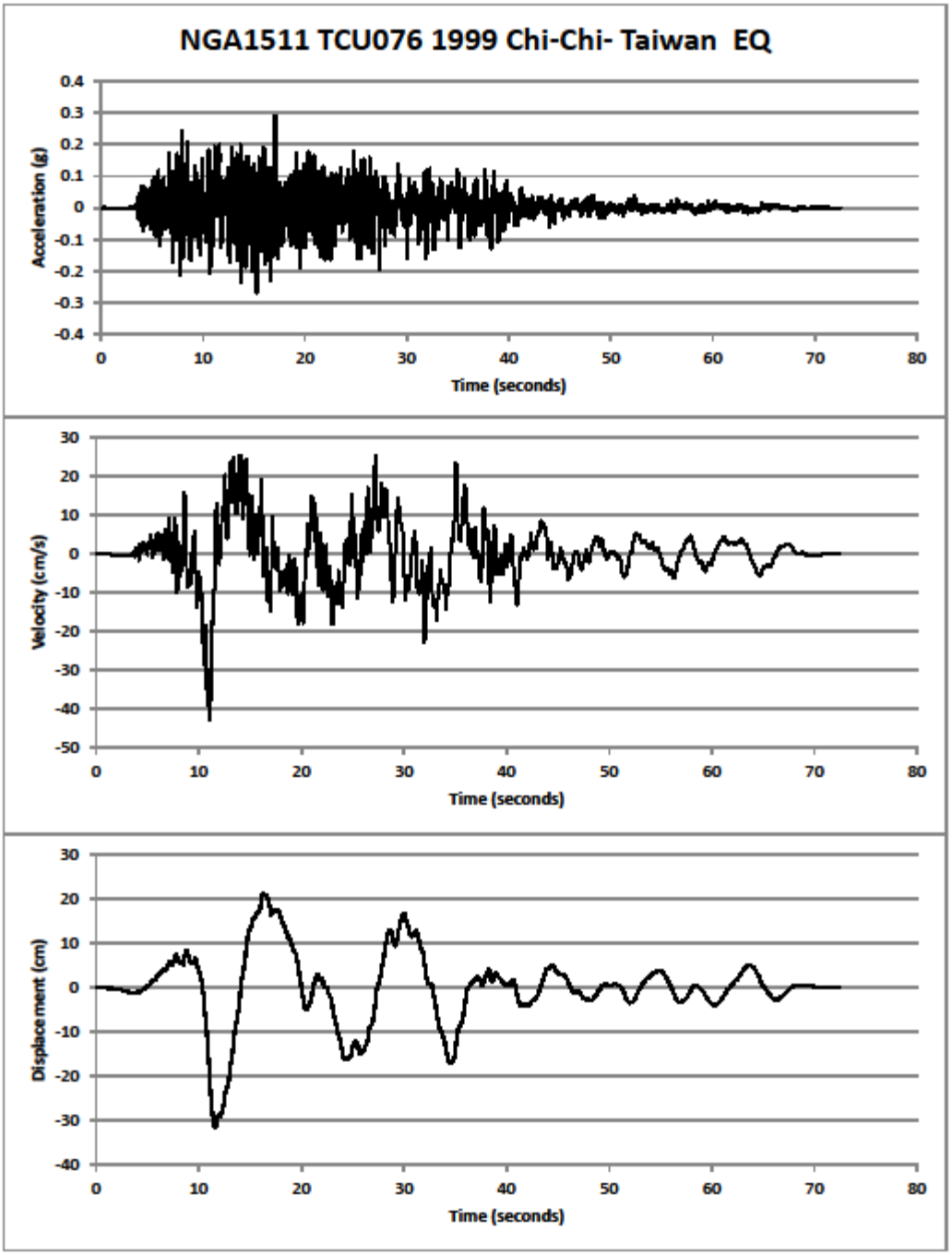


FIGURE **2**

Horizontal Acceleration, Velocity and Displacement Time Histories - NGA1511 TCU076 (East – West)
Hunters Point Site, San Francisco, CA

Golder Associates

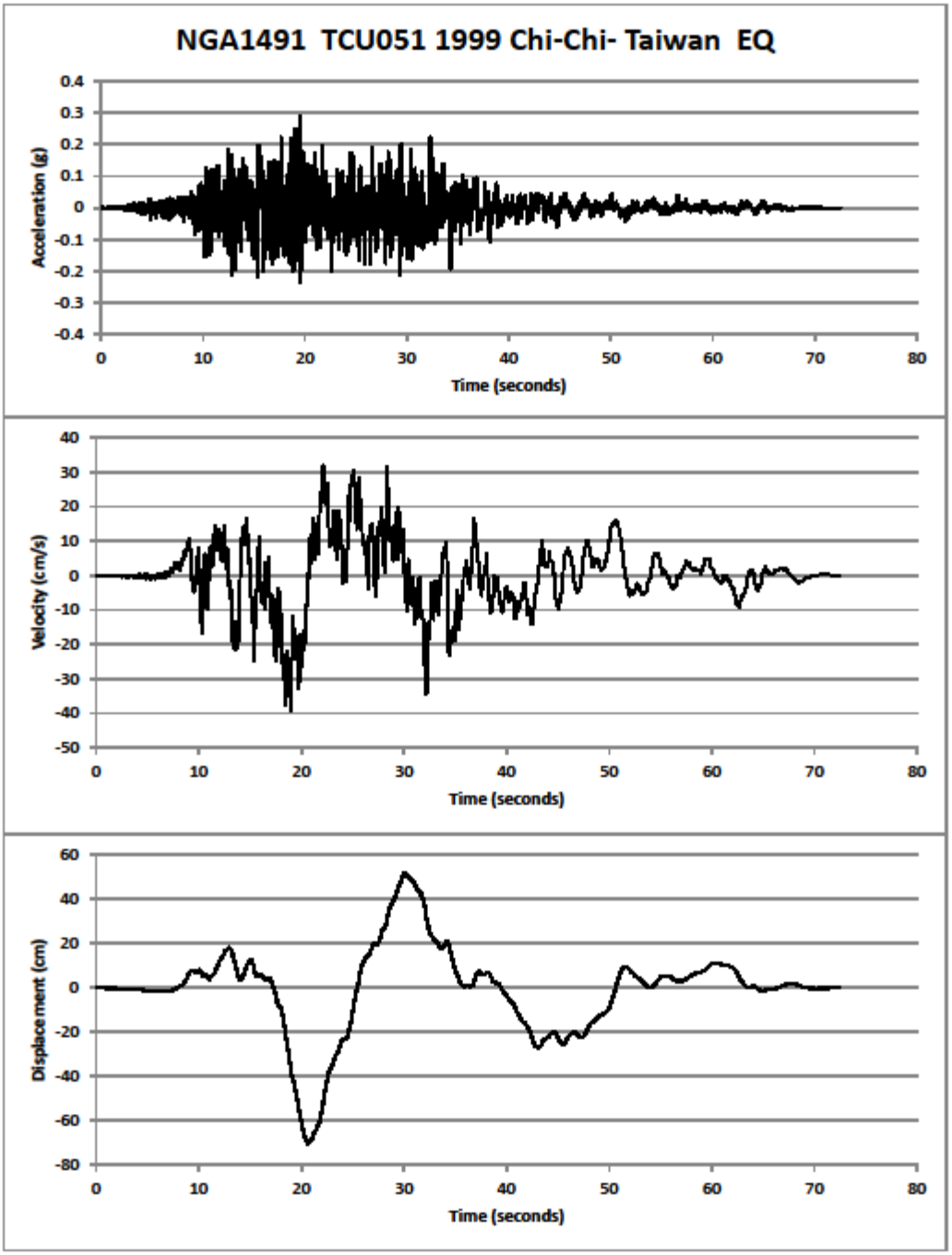


FIGURE **3**

Horizontal Acceleration, Velocity and Displacement Time Histories - NGA1491 TCU051 (East – West)
Hunters Point Site, San Francisco, CA

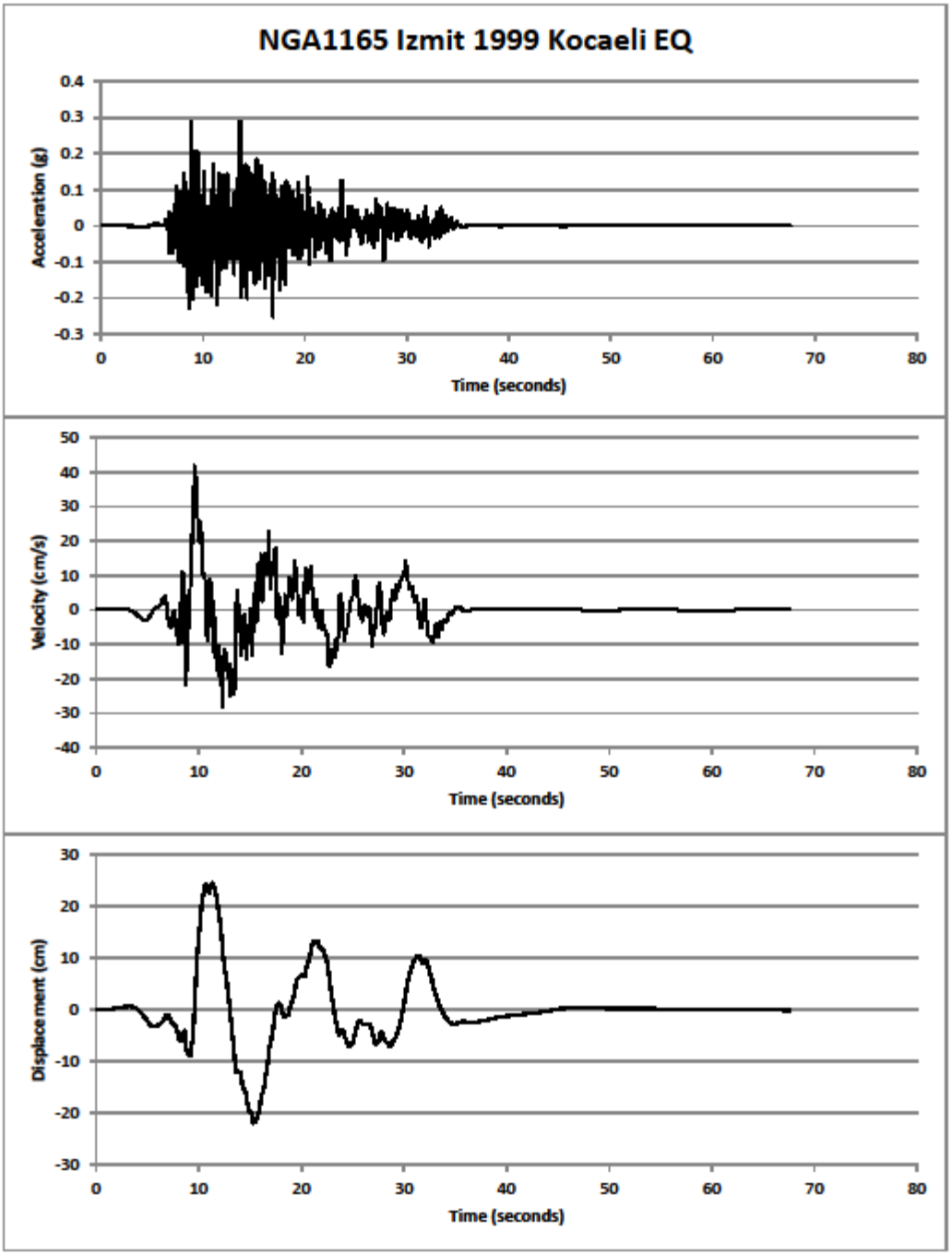


FIGURE **4**

Horizontal Acceleration, Velocity and Displacement Time Histories - NGA1165 Izmit (Fault Normal)
Hunters Point Site, San Francisco, CA

Golder Associates

ATTACHMENT E3

Symbols used in the Spreadsheet Tables of Attachment E-3	
Z	Depth below ground surface
N	Standard penetration resistance
PI	Plasticity index
σ_{vc}	Total vertical stress
σ'_{vc}	Effective vertical stress
$\alpha(z)$	Parameter used to estimate r_d
$\beta(z)$	Parameter used to estimate r_d
r_d	Shear stress reduction coefficient
CSR_{eq}	Cyclic stress ratio induced by the earthquake
C_R	SPT correction factor for rod length
C_S	SPT correction factor for omitting sampler liner
C_B	SPT correction factor for borehole diameter
C_E	SPT correction factor for energy ratio
N_{60}	SPT blow count corrected for 60% energy
C_N	SPT overburden correction factor
$N_{1,60}$	N_{60} corrected for an over burden effective stress of 1 atmospheres
C_σ	Coefficient used to compute K_σ
K_σ	Overburden correction factor
$\Delta(N_1)_{60}$	Fines correction for N
$(N_1)_{60cs}$	Equivalent clean sand $N_{1,60}$
$CRR_{M=7.5}$	Cyclic resistance ratio at earthquake magnitude of 7.5
CRR	Cyclic resistance ratio
$(FS)_L$	Factor of safety against liquefaction

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**B-501**

Test Boring Information:

Ground elevation		1.3 ft
Water table elevation		0 ft
Depth to ground water table		1.3 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3
Magnitude Scaling Factor	M_F	0.88

Input for N correction factors:

Is correction for non-standardized sampler required?	No	"No" or "Yes"
Borehole diameter	4 inch	
Energy ratio	60 %	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
5.5	0	Clay		> 7	613	350.92	-0.060	0.007	1.00	0.328	0.800	1.00	1.00	1.00	0	1.70	0	0.05	1.10	0.0	0.0	0.061	0.058	**N/A**
15.5	0	Clay		> 7	1763	876.92	-0.247	0.028	0.98	0.370	0.950	1.00	1.00	1.00	0	1.70	0	0.05	1.05	0.0	0.0	0.061	0.056	**N/A**
25.5	0	Clay		> 7	2913	1402.9	-0.485	0.054	0.95	0.373	0.950	1.00	1.00	1.00	0	1.38	0	0.05	1.02	0.0	0.0	0.061	0.054	**N/A**
30.5	2	Clayey Sand		> 7	3488	1665.9	-0.618	0.069	0.94	0.370	1.000	1.00	1.00	1.00	2	1.18	2	0.07	1.02	0.0	2.4	0.072	0.064	**N/A**
37.5	19	Clayey Sand		< 7	4293	2034.1	-0.815	0.091	0.92	0.364	1.000	1.00	1.00	1.00	19	1.02	19	0.13	1.01	0.0	19.3	0.198	0.174	**0.48**
40.5	21	Silty Sand		< 7	4638	2191.9	-0.902	0.101	0.91	0.362	1.000	1.00	1.00	1.00	21	0.98	21	0.14	1.00	0.0	20.7	0.214	0.187	**0.52**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**B-502**

Test Boring Information:

Ground elevation		1.8	ft
Water table elevation		0	ft
Depth to ground water table		1.8	ft
Moist unit weight of soil	γ_m	100	pcf
Saturated unit weight of soil	γ_{sat}	115	pcf

Earthquake Information:

Earthquake magnitude	M_w	8	
Peak horizontal ground surface acceleration	a_{max}	0.29	g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3	
Magnitude Scaling Factor	M_F	0.88	

Input for N correction factors:

Is correction for non-standardized sampler required?	No		"No" or "Yes"
Borehole diameter	4	inch	
Energy ratio	60	%	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
15.5	2	Clay		> 7	1755.5	900.62	-0.247	0.028	0.98	0.359	0.950	1.00	1.00	1.00	2	1.70	3	0.07	1.06	0.0	3.2	0.076	0.071	**N/A**
24.5	0	Clay		> 7	2790.5	1374	-0.459	0.052	0.95	0.366	0.950	1.00	1.00	1.00	0	1.40	0	0.05	1.02	0.0	0.0	0.061	0.054	**N/A**
31.5	15	Clayey Sand		< 7	3595.5	1742.2	-0.646	0.072	0.93	0.364	1.000	1.00	1.00	1.00	15	1.10	16	0.12	1.02	0.0	16.5	0.169	0.152	**0.42**
33	25	Clayey Sand		< 7	3768	1821.1	-0.687	0.077	0.93	0.363	1.000	1.00	1.00	1.00	25	1.06	27	0.17	1.03	0.0	26.5	0.332	0.298	**0.82**
35.5	31	Clayey Sand		< 7	4055.5	1952.6	-0.758	0.085	0.92	0.361	1.000	1.00	1.00	1.00	31	1.03	32	0.22	1.02	0.0	31.9	0.634	0.565	**1.57**
38.5	28	Silty Sand		< 7	4400.5	2110.4	-0.844	0.094	0.91	0.359	1.000	1.00	1.00	1.00	28	1.00	28	0.19	1.00	0.0	28.0	0.385	0.337	**0.94**
43.5	80	Silty Sand		< 7	4975.5	2373.4	-0.990	0.110	0.90	0.354	1.000	1.00	1.00	1.00	80	0.97	78	0.30	0.97	0.0	77.6	2.000	1.692	**4.78**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**S-01**

Test Boring Information:

Ground elevation		12 ft
Water table elevation		2.7 ft
Depth to ground water table		9.3 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3
Magnitude Scaling Factor	M_F	0.88

Input for N correction factors:

Is correction for non-standardized sampler required?	No	"No" or "Yes"
Borehole diameter	4 inch	
Energy ratio	60 %	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
2	31	Silty Sand		< 7	200	200	-0.009	0.002	1.00	0.189	0.750	1.00	1.00	1.00	23	1.70	40	0.30	1.10	0.0	39.5	2.000	1.927	**UNSAT**
4	25	Silty Sand		< 7	400	400	-0.037	0.005	1.00	0.188	0.750	1.00	1.00	1.00	19	1.70	32	0.22	1.10	0.0	31.9	0.632	0.609	**UNSAT**
6	13	Clay		> 7	600	600	-0.068	0.008	1.00	0.188	0.800	1.00	1.00	1.00	10	1.70	18	0.12	1.10	0.0	17.7	0.180	0.174	**UNSAT**
8	12	Clay		> 7	800	800	-0.101	0.012	0.99	0.187	0.850	1.00	1.00	1.00	10	1.69	17	0.12	1.10	0.0	17.2	0.176	0.170	**UNSAT**
10	7	Clay		> 7	1010.5	966.82	-0.137	0.016	0.99	0.195	0.850	1.00	1.00	1.00	6	1.60	9	0.09	1.07	0.0	9.5	0.115	0.107	**N/A**
12	7	Clay		> 7	1240.5	1072	-0.175	0.020	0.99	0.215	0.850	1.00	1.00	1.00	6	1.50	9	0.09	1.06	0.0	8.9	0.111	0.103	**N/A**
14		Clay		> 7																				
16	6	Clay		> 7	1700.5	1282.4	-0.257	0.029	0.98	0.244	0.950	1.00	1.00	1.00	6	1.35	8	0.08	1.04	0.0	7.7	0.103	0.094	**N/A**
18		Clay		> 7																				
20	6	Clay		> 7	2160.5	1492.8	-0.348	0.039	0.97	0.264	0.950	1.00	1.00	1.00	6	1.23	7	0.08	1.03	0.0	7.0	0.098	0.089	**N/A**
22		Clay		> 7																				
24		Clay		> 7																				
26	9	Clay		> 7	2850.5	1808.4	-0.498	0.056	0.95	0.283	0.950	1.00	1.00	1.00	9	1.09	9	0.09	1.01	0.0	9.3	0.113	0.101	**N/A**
28	16	Clay		> 7	3080.5	1913.6	-0.550	0.062	0.95	0.287	1.000	1.00	1.00	1.00	16	1.05	17	0.12	1.01	0.0	16.8	0.172	0.152	**N/A**
30	45	Clay		> 7	3310.5	2018.8	-0.604	0.068	0.94	0.290	1.000	1.00	1.00	1.00	45	1.01	46	0.30	1.01	0.0	45.6	2.000	1.776	**N/A**
32	6	Clay		> 7	3540.5	2124	-0.659	0.074	0.93	0.293	1.000	1.00	1.00	1.00	6	1.00	6	0.08	1.00	0.0	6.0	0.092	0.081	**N/A**
34		Clay		> 7																				
36	1	Clay		> 7	4000.5	2334.4	-0.772	0.086	0.92	0.298	1.000	1.00	1.00	1.00	1	0.93	1	0.06	0.99	0.0	0.9	0.065	0.057	**N/A**
38		Clay		> 7																				
40	1	Clay		> 7	4460.5	2544.8	-0.888	0.099	0.91	0.300	1.000	1.00	1.00	1.00	1	0.88	1	0.06	0.99	0.0	0.9	0.065	0.056	**N/A**
42		Clay		> 7																				
44		Clay		> 7																				
46	3	Clay		> 7	5150.5	2860.4	-1.063	0.118	0.89	0.301	1.000	1.00	1.00	1.00	3	0.82	2	0.07	0.98	0.0	2.5	0.072	0.062	**N/A**
48	20	Clay		> 7	5380.5	2965.6	-1.121	0.124	0.88	0.301	1.000	1.00	1.00	1.00	20	0.86	17	0.12	0.96	0.0	17.2	0.176	0.148	**N/A**
50	39	Silty Sand		< 7	5610.5	3070.8	-1.180	0.131	0.87	0.301	1.000	1.00	1.00	1.00	39	0.89	35	0.26	0.90	0.0	34.8	1.068	0.845	**2.81**
52	71	Silty Sand		< 7	5840.5	3176	-1.237	0.137	0.87	0.301	1.000	1.00	1.00	1.00	71	0.90	64	0.30	0.88	0.0	63.8	2.000	1.542	**5.13**
54	71	Silty Sand		< 7	6070.5	3281.2	-1.294	0.143	0.86	0.300	1.000	1.00	1.00	1.00	71	0.89	63	0.30	0.87	0.0	63.3	2.000	1.525	**5.08**
56	51	Silty Sand		< 7	6300.5	3386.4	-1.350	0.149	0.85	0.299	1.000	1.00	1.00	1.00	51	0.88	45	0.30	0.86	0.0	45.1	2.000	1.509	**5.04**
58	32	Silty Sand		< 7	6530.5	3491.6	-1.406	0.155	0.85	0.298	1.000	1.00	1.00	1.00	32	0.84	27	0.18	0.91	0.0	26.9	0.342	0.273	**0.92**
60	32	Silty Sand		< 7	6760.5	3596.8	-1.460	0.161	0.84	0.297	1.000	1.00	1.00	1.00	32	0.83	27	0.17	0.91	0.0	26.6	0.333	0.265	**0.89**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**S-02**

Test Boring Information:

Ground elevation		11 ft
Water table elevation		3 ft
Depth to ground water table		8 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3
Magnitude Scaling Factor	M_F	0.88

Input for N correction factors:

Is correction for non-standardized sampler required?	No	"No" or "Yes"
Borehole diameter	4 inch	
Energy ratio	60 %	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
2	16	Silt		< 7	200	200	-0.009	0.002	1.00	0.189	0.750	1.00	1.00	1.00	12	1.70	20	0.14	1.10	0.0	20.4	0.211	0.203	**UNSAT**
4	14	Sand		< 7	400	400	-0.037	0.005	1.00	0.188	0.750	1.00	1.00	1.00	11	1.70	18	0.12	1.10	0.0	17.9	0.182	0.176	**UNSAT**
6	11	Sand		<7	600	600	-0.068	0.008	1.00	0.188	0.800	1.00	1.00	1.00	9	1.70	15	0.11	1.10	0.0	15.0	0.156	0.150	**UNSAT**
8	16	Sand		< 7	800	800	-0.101	0.012	0.99	0.187	0.850	1.00	1.00	1.00	14	1.63	22	0.14	1.10	0.0	22.1	0.235	0.227	**1.21**
10	8	Sand		< 7	1030	905.2	-0.137	0.016	0.99	0.212	0.850	1.00	1.00	1.00	7	1.64	11	0.10	1.08	0.0	11.2	0.126	0.120	**0.56**
12	20	Sand		< 7	1260	1010.4	-0.175	0.020	0.99	0.232	0.850	1.00	1.00	1.00	17	1.41	24	0.16	1.10	0.0	24.0	0.268	0.259	**1.12**
14	15	Sand		< 7	1490	1115.6	-0.215	0.024	0.98	0.247	0.850	1.00	1.00	1.00	13	1.39	18	0.12	1.08	0.0	17.7	0.180	0.170	**0.69**
16	25	Sand		< 7	1720	1220.8	-0.257	0.029	0.98	0.259	0.950	1.00	1.00	1.00	24	1.25	30	0.20	1.10	0.0	29.8	0.470	0.453	**1.75**
18	12	Sand		< 7	1950	1326	-0.302	0.034	0.97	0.269	0.950	1.00	1.00	1.00	11	1.28	15	0.11	1.05	0.0	14.6	0.153	0.140	**0.52**
20	13	Sand		< 7	2180	1431.2	-0.348	0.039	0.97	0.278	0.950	1.00	1.00	1.00	12	1.22	15	0.11	1.04	0.0	15.1	0.157	0.143	**0.52**
22	13	Sand		< 7	2410	1536.4	-0.396	0.045	0.96	0.284	0.950	1.00	1.00	1.00	12	1.18	15	0.11	1.03	0.0	14.6	0.152	0.138	**0.49**
24	22	Sand		< 7	2640	1641.6	-0.446	0.050	0.96	0.290	0.950	1.00	1.00	1.00	21	1.12	23	0.15	1.04	0.0	23.3	0.255	0.232	**0.80**
26	8	Sand		< 7	2870	1746.8	-0.498	0.056	0.95	0.294	0.950	1.00	1.00	1.00	8	1.12	8	0.09	1.02	0.0	8.5	0.108	0.096	**0.33**
28	4	Clay		> 7	3100	1852	-0.550	0.062	0.95	0.298	1.000	1.00	1.00	1.00	4	1.09	4	0.07	1.01	0.0	4.4	0.082	0.073	**N/A**
30	4	Clay		> 7	3330	1957.2	-0.604	0.068	0.94	0.301	1.000	1.00	1.00	1.00	4	1.05	4	0.07	1.01	0.0	4.2	0.082	0.072	**N/A**
32		Clay		> 7																				
34		Clay		> 7																				
36		Clay		> 7																				
38		Clay		> 7																				
40		Clay		> 7																				
42		Clay		> 7																				
44		Clay		> 7																				
46		Clay		> 7																				
48	21	Clay		> 7	5400	2904	-1.121	0.124	0.88	0.309	1.000	1.00	1.00	1.00	21	0.87	18	0.13	0.96	0.0	18.3	0.187	0.157	**N/A**
50	38	Silty Sand		< 7	5630	3009.2	-1.180	0.131	0.87	0.308	1.000	1.00	1.00	1.00	38	0.90	34	0.25	0.91	0.0	34.1	0.920	0.735	**2.38**
52	38	Silty Sand		< 7	5860	3114.4	-1.237	0.137	0.87	0.308	1.000	1.00	1.00	1.00	38	0.89	34	0.24	0.91	0.0	33.7	0.860	0.682	**2.22**
54	44	Silty Sand		< 7	6090	3219.6	-1.294	0.143	0.86	0.307	1.000	1.00	1.00	1.00	44	0.89	39	0.30	0.88	0.0	39.2	2.000	1.535	**5.00**
56	57	Silty Sand		< 7	6320	3324.8	-1.350	0.149	0.85	0.306	1.000	1.00	1.00	1.00	57	0.89	51	0.30	0.87	0.0	50.6	2.000	1.518	**4.97**
58	51	Silty Sand		< 7	6550	3430	-1.406	0.155	0.85	0.304	1.000	1.00	1.00	1.00	51	0.88	45	0.30	0.86	0.0	44.9	2.000	1.502	**4.93**
60	51	Silty Sand		< 7	6780	3535.2	-1.460	0.161	0.84	0.303	1.000	1.00	1.00	1.00	51	0.87	45	0.30	0.85	0.0	44.6	2.000	1.486	**4.90**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**S-03**

Test Boring Information:

Ground elevation		12 ft
Water table elevation		2 ft
Depth to ground water table		10 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3
Magnitude Scaling Factor	M_F	0.88

Input for N correction factors:

Is correction for non-standardized sampler required?	No	"No" or "Yes"
Borehole diameter	4 inch	
Energy ratio	60 %	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
2	11	Silt		< 7	200	200	-0.009	0.002	1.00	0.189	0.750	1.00	1.00	1.00	8	1.70	14	0.11	1.10	0.0	14.0	0.148	0.143	**UNSAT**
4	13	Clayey Silt		< 7	400	400	-0.037	0.005	1.00	0.188	0.750	1.00	1.00	1.00	10	1.70	17	0.12	1.10	0.0	16.6	0.170	0.164	**UNSAT**
6	8	Sand		<7	600	600	-0.068	0.008	1.00	0.188	0.800	1.00	1.00	1.00	6	1.70	11	0.10	1.10	0.0	10.9	0.124	0.120	**UNSAT**
8	12	Sand		< 7	800	800	-0.101	0.012	0.99	0.187	0.850	1.00	1.00	1.00	10	1.69	17	0.12	1.10	0.0	17.2	0.176	0.170	**UNSAT**
10	7	Sand		< 7	1000	1000	-0.137	0.016	0.99	0.186	0.850	1.00	1.00	1.00	6	1.56	9	0.09	1.07	0.0	9.3	0.113	0.106	**0.57**
12	5	Clay		> 7	1230	1105.2	-0.175	0.020	0.99	0.207	0.850	1.00	1.00	1.00	4	1.50	6	0.08	1.05	0.0	6.4	0.094	0.087	**N/A**
14	10	Silty Sand		< 7	1460	1210.4	-0.215	0.024	0.98	0.223	0.850	1.00	1.00	1.00	9	1.37	12	0.10	1.05	0.0	11.6	0.130	0.120	**0.54**
16	24	Silty Sand		< 7	1690	1315.6	-0.257	0.029	0.98	0.236	0.950	1.00	1.00	1.00	23	1.22	28	0.18	1.09	0.0	27.8	0.376	0.358	**1.51**
18	21	Silty Sand		< 7	1920	1420.8	-0.302	0.034	0.97	0.248	0.950	1.00	1.00	1.00	20	1.19	24	0.15	1.06	0.0	23.8	0.264	0.245	**0.99**
20	12	Silty Sand		< 7	2150	1526	-0.348	0.039	0.97	0.257	0.950	1.00	1.00	1.00	11	1.19	14	0.11	1.03	0.0	13.5	0.144	0.131	**0.51**
22	31	Debris		< 7	2380	1631.2	-0.396	0.045	0.96	0.264	0.950	1.00	1.00	1.00	29	1.10	32	0.23	1.06	0.0	32.4	0.687	0.637	**2.41**
24	23	Debris		< 7	2610	1736.4	-0.446	0.050	0.96	0.271	0.950	1.00	1.00	1.00	22	1.09	24	0.15	1.03	0.0	23.8	0.263	0.238	**0.88**
26	33	Debris		< 7	2840	1841.6	-0.498	0.056	0.95	0.276	0.950	1.00	1.00	1.00	31	1.05	33	0.23	1.03	0.0	32.9	0.750	0.678	**2.45**
28	23	Debris		< 7	3070	1946.8	-0.550	0.062	0.95	0.281	1.000	1.00	1.00	1.00	23	1.04	24	0.15	1.01	0.0	23.8	0.264	0.235	**0.83**
30	23	Debris		< 7	3300	2052	-0.604	0.068	0.94	0.285	1.000	1.00	1.00	1.00	23	1.01	23	0.15	1.00	0.0	23.3	0.255	0.224	**0.79**
32	6	Clay		> 7	3530	2157.2	-0.659	0.074	0.93	0.288	1.000	1.00	1.00	1.00	6	0.99	6	0.08	1.00	0.0	5.9	0.092	0.080	**N/A**
34		Clay		> 7																				
36		Clay		> 7																				
38		Clay		> 7																				
40		Clay		> 7																				
42		Clay		> 7																				
44		Clay		> 7																				
46		Clay		> 7																				
48	16	Clay		> 7	5370	2998.8	-1.121	0.124	0.88	0.297	1.000	1.00	1.00	1.00	16	0.85	14	0.11	0.96	0.0	13.5	0.144	0.122	**N/A**
50	17	Silty Clay		> 7	5600	3104	-1.180	0.131	0.87	0.297	1.000	1.00	1.00	1.00	17	0.84	14	0.11	0.96	0.0	14.2	0.150	0.126	**N/A**
52	64	Silty Clay		> 7	5830	3209.2	-1.237	0.137	0.87	0.297	1.000	1.00	1.00	1.00	64	0.90	57	0.30	0.88	0.0	57.4	2.000	1.536	**N/A**
54	64	Silty Sand		< 7	6060	3314.4	-1.294	0.143	0.86	0.296	1.000	1.00	1.00	1.00	64	0.89	57	0.30	0.87	0.0	56.9	2.000	1.520	**5.13**
56	45	Silty Sand		< 7	6290	3419.6	-1.350	0.149	0.85	0.296	1.000	1.00	1.00	1.00	45	0.88	40	0.30	0.86	0.0	39.6	2.000	1.504	**5.08**
58	64	Silty Sand		< 7	6520	3524.8	-1.406	0.155	0.85	0.295	1.000	1.00	1.00	1.00	64	0.87	56	0.30	0.85	0.0	56.0	2.000	1.488	**5.04**
60	55	Silty Sand		< 7	6750	3630	-1.460	0.161	0.84	0.294	1.000	1.00	1.00	1.00	55	0.87	48	0.30	0.84	0.0	47.7	2.000	1.473	**5.01**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**S-04**

Test Boring Information:

Ground elevation		8	ft
Water table elevation		4.3	ft
Depth to ground water table		3.7	ft
Moist unit weight of soil	γ_m	100	pcf
Saturated unit weight of soil	γ_{sat}	115	pcf

Earthquake Information:

Earthquake magnitude	M_w	8	
Peak horizontal ground surface acceleration	a_{max}	0.29	g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3	
Magnitude Scaling Factor	M_F	0.88	

Input for N correction factors:

Is correction for non-standardized sampler required?	No		"No" or "Yes"
Borehole diameter	4	inch	
Energy ratio	60	%	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
2	19	Clay		> 7	200	200	-0.009	0.002	1.00	0.189	0.750	1.00	1.00	1.00	14	1.70	24	0.16	1.10	0.0	24.2	0.273	0.263	**UNSAT**
4	20	Clay		> 7	404.5	385.78	-0.037	0.005	1.00	0.198	0.750	1.00	1.00	1.00	15	1.70	26	0.17	1.10	0.0	25.5	0.302	0.291	**N/A**
6	17	Clay		> 7	634.5	490.98	-0.068	0.008	1.00	0.243	0.800	1.00	1.00	1.00	14	1.70	23	0.15	1.10	0.0	23.1	0.251	0.242	**N/A**
8	6	Clay		> 7	864.5	596.18	-0.101	0.012	0.99	0.271	0.850	1.00	1.00	1.00	5	1.70	9	0.09	1.10	0.0	8.7	0.109	0.105	**N/A**
10	7	Clay		> 7	1094.5	701.38	-0.137	0.016	0.99	0.291	0.850	1.00	1.00	1.00	6	1.70	10	0.09	1.10	0.0	10.1	0.119	0.115	**N/A**
12	2	Debris		< 7																				
14	6	Debris		< 7																				
16	1	Clay		> 7	1784.5	1017	-0.257	0.029	0.98	0.323	0.950	1.00	1.00	1.00	1	1.68	2	0.06	1.05	0.0	1.6	0.068	0.062	**N/A**
18		Clay		> 7	2014.5	1122.2	-0.302	0.034	0.97	0.329	0.950	1.00	1.00	1.00	0	1.64	0	0.05	1.03	0.0	0.0	0.061	0.055	**N/A**
20	3	Clay		> 7	2244.5	1227.4	-0.348	0.039	0.97	0.333	0.950	1.00	1.00	1.00	3	1.43	4	0.07	1.04	0.0	4.1	0.081	0.074	**N/A**
22		Clay		> 7	2474.5	1332.6	-0.396	0.045	0.96	0.337	0.950	1.00	1.00	1.00	0	1.44	0	0.05	1.02	0.0	0.0	0.061	0.055	**N/A**
24		Clay		> 7	2704.5	1437.8	-0.446	0.050	0.96	0.339	0.950	1.00	1.00	1.00	0	1.35	0	0.05	1.02	0.0	0.0	0.061	0.054	**N/A**
26	27	Silty Sand		< 7	2934.5	1543	-0.498	0.056	0.95	0.341	0.950	1.00	1.00	1.00	26	1.13	29	0.19	1.06	0.0	29.1	0.432	0.401	**1.18**
28	27	Silty Sand		< 7	3164.5	1648.2	-0.550	0.062	0.95	0.342	1.000	1.00	1.00	1.00	27	1.10	30	0.20	1.05	0.0	29.7	0.468	0.431	**1.26**
30	25	Silty Sand		< 7	3394.5	1753.4	-0.604	0.068	0.94	0.343	1.000	1.00	1.00	1.00	25	1.08	27	0.18	1.03	0.0	27.0	0.345	0.312	**0.91**
32	25	Silty Sand		< 7	3624.5	1858.6	-0.659	0.074	0.93	0.343	1.000	1.00	1.00	1.00	25	1.05	26	0.17	1.02	0.0	26.3	0.325	0.291	**0.85**
34	69	Sand		< 7	3854.5	1963.8	-0.715	0.080	0.93	0.343	1.000	1.00	1.00	1.00	69	1.02	70	0.30	1.02	0.0	70.4	2.000	1.790	**5.22**
36		Clayey Sand		> 7																				
38	51	Silty Sand		< 7	4314.5	2174.2	-0.830	0.093	0.91	0.342	1.000	1.00	1.00	1.00	51	0.99	51	0.30	0.99	0.0	50.6	2.000	1.738	**5.08**
40	41	Clayey Sand		> 7	4544.5	2279.4	-0.888	0.099	0.91	0.341	1.000	1.00	1.00	1.00	41	0.98	40	0.30	0.98	0.0	40.1	2.000	1.713	**N/A**
42	42	Silty Sand		< 7	4774.5	2384.6	-0.946	0.105	0.90	0.340	1.000	1.00	1.00	1.00	42	0.97	41	0.30	0.96	0.0	40.6	2.000	1.690	**4.97**
44		Silty Sand		< 7																				
46	73	Silty Sand		< 7	5234.5	2595	-1.063	0.118	0.89	0.338	1.000	1.00	1.00	1.00	73	0.95	69	0.30	0.94	0.0	69.2	2.000	1.646	**4.88**
48		Silty Sand		< 7																				
50	50	Silty Sand		< 7	5694.5	2805.4	-1.180	0.131	0.87	0.334	1.000	1.00	1.00	1.00	50	0.93	46	0.30	0.92	0.0	46.4	2.000	1.606	**4.80**
52		Silty Sand		< 7																				
54		Silty Sand		< 7																				
56	40	Silty Sand		< 7	6384.5	3121	-1.350	0.149	0.85	0.329	1.000	1.00	1.00	1.00	40	0.89	36	0.27	0.89	0.0	35.6	1.266	0.992	**3.02**
58		Silty Sand		< 7																				
60	86	Silty Sand		< 7	6844.5	3331.4	-1.460	0.161	0.84	0.325	1.000	1.00	1.00	1.00	86	0.89	76	0.30	0.87	0.0	76.3	2.000	1.517	**4.67**

STANDARD PENETRATION TEST-BASED LIQUEFACTION AND SETTLEMENT ANALYSES, AND ESTIMATION OF RESIDUAL SHEAR STRENGTH RATIO

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**S-05**

Test Boring Information:

Ground elevation		11 ft
Water table elevation		2.2 ft
Depth to ground water table		8.8 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Number of equivalent cycles (Pradel, 1998)	N_c	20.3
Magnitude Scaling Factor	M_F	0.88

Input for N correction factors:

Is correction for non-standardized sampler required?	No	"No" or "Yes"
Borehole diameter	4 inch	
Energy ratio	60 %	

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	N	Soil Type	Fines Content (%)	PI "< 7" or "> 7"	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	CSR_{eq}	C_R	C_S	C_B	C_E	N_{60}	C_N	$N_{1,60}$	C_σ	K_σ	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
2	21	Fill		< 7																				
4	60	Fill		< 7																				
6	13	Fill		<7																				
8	10	Fill		< 7																				
10	50	Fill		< 7																				
12	36	Fill		< 7																				
14	9	Fill		< 7																				
16	8	Fill		< 7																				
18	3	Fill		< 7																				
20		Fill		< 7																				
22		Clay		> 7																				
24		Clay		> 7																				
26	2	Clay		> 7	2858	1784.7	-0.498	0.056	0.95	0.287	0.950	1.00	1.00	1.00	2	1.12	2	0.07	1.01	0.0	2.1	0.071	0.063	**N/A**
28		Clay		> 7																				
30	0	Clay		> 7	3318	1995.1	-0.604	0.068	0.94	0.294	1.000	1.00	1.00	1.00	0	1.05	0	0.05	1.00	0.0	0.0	0.061	0.053	**N/A**
32		Clay		> 7																				
34		Clay		> 7																				
36	1	Clay		> 7	4008	2310.7	-0.772	0.086	0.92	0.301	1.000	1.00	1.00	1.00	1	0.94	1	0.06	0.99	0.0	0.9	0.065	0.057	**N/A**
38		Silty Sand		< 7																				
40	34	Silty Sand		< 7	4468	2521.1	-0.888	0.099	0.91	0.303	1.000	1.00	1.00	1.00	34	0.94	32	0.22	0.96	0.0	32.1	0.650	0.547	**1.80**
42	33	Silty Sand		< 7	4698	2626.3	-0.946	0.105	0.90	0.304	1.000	1.00	1.00	1.00	33	0.93	31	0.21	0.95	0.0	30.6	0.528	0.442	**1.45**
44	23	Silty Sand		< 7	4928	2731.5	-1.005	0.112	0.89	0.304	1.000	1.00	1.00	1.00	23	0.90	21	0.14	0.97	0.0	20.7	0.214	0.181	**0.60**
46	26	Silty Sand		< 7	5158	2836.7	-1.063	0.118	0.89	0.304	1.000	1.00	1.00	1.00	26	0.89	23	0.15	0.96	0.0	23.2	0.252	0.211	**0.69**
48	46	Silty Sand		< 7	5388	2941.9	-1.121	0.124	0.88	0.304	1.000	1.00	1.00	1.00	46	0.92	42	0.30	0.90	0.0	42.2	2.000	1.581	**5.20**
50	23	Silty Sand		< 7	5618	3047.1	-1.180	0.131	0.87	0.304	1.000	1.00	1.00	1.00	23	0.86	20	0.13	0.95	0.0	19.8	0.203	0.169	**0.56**
52	60	Silty Sand		< 7	5848	3152.3	-1.237	0.137	0.87	0.303	1.000	1.00	1.00	1.00	60	0.90	54	0.30	0.88	0.0	54.0	2.000	1.546	**5.10**
54		Silty Sand		< 7																				
56	43	Silty Sand		< 7	6308	3362.7	-1.350	0.149	0.85	0.302	1.000	1.00	1.00	1.00	43	0.88	38	0.30	0.86	0.0	37.8	2.000	1.512	**5.01**
58	24	Silty Sand		< 7	6538	3467.9	-1.406	0.155	0.85	0.301	1.000	1.00	1.00	1.00	24	0.82	20	0.13	0.94	0.0	19.6	0.201	0.165	**0.55**
60		Silty Sand		< 7																				

ATTACHMENT E4

Symbols used in the Spreadsheet Tables of Attachment E-4	
Z	Depth below ground surface
q_t	Cone tip resistance
f_s	Sleeve friction
σ_{vc}	Total vertical stress
σ'_{vc}	Effective vertical stress
Q	Normalized cone resistance
F	Normalized friction ration
I_c	Soil behavior type index
CSR_{eq}	Cyclic stress ratio induced by the earthquake
C_N	SPT overburden correction factor
Q_{c1N}	Normalized overburden corrected cone tip resistance
$Q_{c1N\text{-}cs}$	Q_{C1N} corrected for fines content
r_d	Shear stress reduction factor
CSR	cyclic stress ratio
K_σ	Overburden correction factor
$CRR_{M=7.5}$	Cyclic resistance ratio at earthquake magnitude of 7.5
CRR	Cyclic resistance ratio
$(FS)_L$	Factor of safety against liquefaction

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-01**

Test Boring Information:

Approx. ground elevation		21	ft	6.40 m
Approx. water table elevation		5.5	ft	1.68 m
Approx. depth to ground water table		15.5	ft	4.73 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	5066	59	2.3	2.3	328	1.17	1.6	Unsaturated	10			5066	1.70	85.3	95.2	1.00	0.189	1.1	0.135	0.130	**N/A**
0.45	1.5	8283	84	7.1	7.1	309	1.02	1.6	Unsaturated	10			8283	1.70	139.4	152.5	1.00	0.189	1.1	0.283	0.273	**N/A**
0.75	2.5	2097	86	11.8	11.8	60	4.13	2.5	Unsaturated	30			2097	1.70	35.3	76.2	1.00	0.189	1.1	0.108	0.104	**N/A**
1.05	3.4	2001	64	16.5	16.5	49	3.23	2.5	Unsaturated	30			2001	1.61	32.0	71.7	1.00	0.189	1.1	0.102	0.098	**N/A**
1.35	4.4	2356	75	21.2	21.2	50	3.20	2.5	Unsaturated	30			2356	1.51	35.2	76.1	1.00	0.188	1.1	0.107	0.103	**N/A**
1.65	5.4	15082	198	25.9	25.9	294	1.32	1.7	Unsaturated	11			15082	1.43	213.8	245.1	1.00	0.188	1.1	2.000	1.927	**N/A**
1.95	6.4	15015	393	30.7	30.7	269	2.62	1.9	Unsaturated	15			15015	1.37	203.6	261.8	1.00	0.188	1.1	2.000	1.927	**N/A**
2.23	7.3	14939	364	35.0	35.0	250	2.44	1.9	Unsaturated	15			14939	1.32	195.6	252.3	0.99	0.187	1.1	2.000	1.927	**N/A**
2.50	8.2	4912	143	39.3	39.3	77	2.93	2.3	Unsaturated	24			4912	1.28	62.4	109.1	0.99	0.187	1.1	0.158	0.152	**N/A**
2.80	9.2	4271	113	44.0	44.0	63	2.67	2.3	Unsaturated	24			4271	1.24	52.6	96.3	0.99	0.187	1.1	0.137	0.130	**N/A**
3.10	10.2	6291	252	48.7	48.7	89	4.03	2.4	Unsaturated	27			6291	1.21	75.5	128.4	0.99	0.186	1.1	0.199	0.191	**N/A**
3.40	11.2	3878	134	53.4	53.4	52	3.51	2.5	Unsaturated	30			3878	1.18	45.4	89.7	0.99	0.186	1.1	0.126	0.118	**N/A**
3.70	12.1	3993	115	58.2	58.2	51	2.92	2.4	Unsaturated	27			3993	1.16	45.7	88.9	0.98	0.186	1.1	0.125	0.116	**N/A**
4.03	13.2	6579	225	63.3	63.3	81	3.45	2.4	Unsaturated	27			6579	1.13	73.7	126.0	0.98	0.185	1.1	0.193	0.179	**N/A**
4.35	14.3	7316	169	68.4	68.4	87	2.34	2.2	Unsaturated	22			7316	1.11	80.3	129.6	0.98	0.185	1.1	0.202	0.186	**N/A**
4.65	15.3	96	1	73.1	73.1	0	4.23	4.5	Unsaturated	140			96	1.18	1.1	30.7	0.98	0.184	1.0	0.062	0.055	**N/A**
4.95	16.2	19717	211	78.4	76.2	224	1.07	1.7		11			19717	1.08	210.3	241.3	0.98	0.189	1.1	2.000	1.900	**2.00**
5.25	17.2	5401	244	83.8	78.6	60	4.59	2.5		30			5401	1.07	57.1	105.3	0.97	0.196	1.0	0.152	0.136	**0.70**
5.55	18.2	3534	130	89.2	81.1	38	3.78	2.6	Clay-Like	34			3534	1.06	37.1	79.3	0.97	0.201	1.0	0.112	0.100	**N/A**
5.85	19.2	6598	159	94.6	83.6	71	2.44	2.3		24			6598	1.05	68.7	117.3	0.97	0.207	1.0	0.174	0.156	**0.75**
6.15	20.2	6378	153	100.1	86.1	67	2.44	2.3		24			6378	1.04	65.9	113.7	0.97	0.212	1.0	0.167	0.149	**0.70**
6.45	21.2	15178	535	105.5	88.6	159	3.55	2.2		22			15178	1.04	155.6	227.2	0.96	0.216	1.0	2.000	1.821	**2.00**
6.75	22.2	27675	963	110.9	91.0	287	3.49	2.0		17			27675	1.03	281.6	370.0	0.96	0.221	1.0	2.000	1.806	**2.00**
7.05	23.1	23365	981	116.3	93.5	239	4.22	2.1		19			23365	1.02	236.1	323.8	0.96	0.225	1.0	2.000	1.792	**2.00**
7.35	24.1	12707	525	121.7	96.0	128	4.17	2.3		24			12707	1.01	127.5	194.7	0.96	0.229	1.0	0.902	0.800	**2.00**
7.65	25.1	3591	112	127.2	98.5	35	3.23	2.6	Clay-Like	34			3591	1.01	35.8	77.6	0.95	0.232	1.0	0.109	0.096	**N/A**
7.95	26.1	2001	18	132.6	101.0	18	0.97	2.5		30			2001	1.00	19.8	55.5	0.95	0.235	1.0	0.083	0.073	**0.31**
8.25	27.1	1484	16	138.1	103.5	13	1.21	2.7	Clay-Like	37			1484	0.99	14.6	49.6	0.95	0.238	1.0	0.077	0.067	**N/A**
8.55	28.1	1015	11	143.5	105.9	8	1.21	2.9	Clay-Like	45			1015	0.99	9.9	43.7	0.95	0.241	1.0	0.072	0.063	**N/A**
8.85	29.0	6761	37	148.9	108.4	63	0.56	1.9		15			6761	0.98	65.7	96.2	0.94	0.244	1.0	0.136	0.119	**0.49**
9.15	30.0	4922	40	154.3	110.9	45	0.84	2.1		19			4922	0.98	47.5	84.0	0.94	0.246	1.0	0.118	0.103	**0.42**
9.45	31.0	1772	19	159.7	113.4	15	1.19	2.6	Clay-Like	34			1772	0.97	17.0	52.4	0.94	0.249	1.0	0.080	0.069	**N/A**
9.75	32.0	2595	56	165.2	115.9	22	2.29	2.6	Clay-Like	34			2595	0.96	24.8	62.8	0.93	0.251	1.0	0.091	0.079	**N/A**
10.05	33.0	3677	69	170.6	118.3	32	1.97	2.5		30			3677	0.96	34.9	75.7	0.93	0.253	1.0	0.107	0.092	**0.36**
10.35	34.0	26008	407	176.0	120.8	234	1.58	1.8		13			26008	0.95	245.6	296.9	0.93	0.255	0.9	2.000	1.657	**2.00**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	28086	640	181.4	123.3	250	2.29	1.9		15			28086	0.95	263.8	334.2	0.92	0.256	0.9	2.000	1.647	**2.00**
10.95	35.9	17534	665	186.8	125.8	154	3.83	2.2		22			17534	0.94	163.8	237.9	0.92	0.258	0.9	2.000	1.636	**2.00**
11.25	36.9	16499	584	192.3	128.3	143	3.58	2.2		22			16499	0.94	153.4	224.4	0.92	0.259	0.9	2.000	1.626	**2.00**
11.55	37.9	19391	624	197.7	130.7	167	3.25	2.1		19			19391	0.93	179.4	251.6	0.91	0.261	0.9	2.000	1.616	**2.00**
11.85	38.9	8781	418	203.1	133.2	74	4.88	2.5		30			8781	0.93	80.8	137.0	0.91	0.262	1.0	0.223	0.187	**0.72**
12.15	39.9	5698	176	208.5	135.7	47	3.21	2.5		30			5698	0.93	52.2	98.7	0.91	0.263	1.0	0.140	0.119	**0.45**
12.45	40.9	5315	220	214.0	138.2	43	4.32	2.6	Clay-Like	34			5315	0.92	48.4	94.6	0.91	0.264	1.0	0.134	0.114	**N/A**
12.75	41.8	5382	230	219.4	140.7	43	4.45	2.6	Clay-Like	34			5382	0.92	48.8	95.1	0.90	0.265	1.0	0.135	0.114	**N/A**
13.05	42.8	5286	208	224.8	143.1	42	4.11	2.6	Clay-Like	34			5286	0.91	47.7	93.6	0.90	0.266	1.0	0.132	0.112	**N/A**
13.35	43.8	6224	315	230.3	145.6	49	5.26	2.6	Clay-Like	34			6224	0.91	56.0	104.7	0.90	0.267	1.0	0.150	0.126	**N/A**
13.65	44.8	7929	375	235.7	148.1	63	4.88	2.5		30			7929	0.90	71.0	123.8	0.89	0.268	1.0	0.188	0.157	**0.59**
13.95	45.8	14096	666	241.1	150.6	112	4.80	2.4		27			14096	0.90	125.6	194.9	0.89	0.268	0.9	0.911	0.719	**2.00**
14.25	46.8	30787	1029	246.5	153.1	245	3.37	2.1		19			30787	0.90	273.2	370.9	0.89	0.269	0.9	2.000	1.533	**2.00**
14.55	47.7	28259	1059	252.0	155.6	223	3.78	2.1		19			28259	0.89	249.7	341.0	0.88	0.269	0.9	2.000	1.524	**2.00**
14.85	48.7	11060	830	257.4	158.0	85	7.69	2.6	Clay-Like	34			11060	0.89	97.3	160.2	0.88	0.270	0.9	0.327	0.264	**N/A**
15.15	49.7	6042	265	262.8	160.5	45	4.59	2.6	Clay-Like	34			6042	0.88	52.9	100.6	0.88	0.270	1.0	0.144	0.120	**N/A**
15.45	50.7	11079	653	268.2	163.0	84	6.04	2.5		30			11079	0.88	96.7	158.2	0.87	0.270	0.9	0.315	0.253	**0.94**
15.75	51.7	20177	524	273.6	165.5	154	2.63	2.1		19			20177	0.88	175.4	246.5	0.87	0.271	0.9	2.000	1.492	**2.00**
16.05	52.7	23940	534	279.1	168.0	181	2.26	2.0		17			23940	0.87	207.3	277.8	0.86	0.271	0.8	2.000	1.484	**2.00**
16.35	53.6	19114	855	284.5	170.4	143	4.54	2.3		24			19114	0.87	164.8	243.7	0.86	0.271	0.8	2.000	1.476	**2.00**
16.66	54.6	15264	932	290.0	172.9	113	6.22	2.5		30			15264	0.87	131.1	204.2	0.86	0.271	0.9	1.395	1.040	**2.00**
16.95	55.6	23959	706	295.4	175.4	178	2.98	2.1		19			23959	0.86	205.1	284.3	0.85	0.271	0.8	2.000	1.461	**2.00**
17.25	56.6	28833	796	300.8	177.9	213	2.79	2.0		17			28833	0.86	245.9	325.7	0.85	0.271	0.8	2.000	1.454	**2.00**
17.55	57.6	24017	830	306.2	180.4	175	3.50	2.1		19			24017	0.86	204.1	283.0	0.85	0.271	0.8	2.000	1.446	**2.00**
17.85	58.6	14929	868	311.6	182.8	107	5.94	2.5		30			14929	0.86	126.4	197.9	0.84	0.271	0.8	1.035	0.768	**2.00**
18.16	59.6	11635	697	317.1	185.3	83	6.16	2.5		30			11635	0.85	98.2	160.2	0.84	0.271	0.9	0.327	0.256	**0.94**
18.45	60.5	19803	1002	322.5	187.8	141	5.14	2.3		24			19803	0.85	166.5	245.9	0.84	0.271	0.8	2.000	1.425	**2.00**
18.76	61.5	14948	1066	327.9	190.3	105	7.29	2.5		30			14948	0.85	125.2	196.3	0.83	0.271	0.8	0.967	0.712	**2.00**
19.03	62.4	19774	1359	332.9	192.6	139	6.99	2.5		30			19774	0.84	165.1	249.7	0.83	0.271	0.8	2.000	1.412	**2.00**
19.30	63.3	22772	1488	337.9	194.8	160	6.63	2.4		27			22772	0.84	189.6	279.8	0.83	0.270	0.8	2.000	1.406	**2.00**
19.60	64.3	20837	1090	343.3	197.3	145	5.32	2.3		24			20837	0.84	172.9	254.3	0.82	0.270	0.8	2.000	1.399	**2.00**
19.91	65.3	11520	773	348.7	199.8	79	6.92	2.6	Clay-Like	34			11520	0.84	95.3	157.4	0.82	0.270	0.9	0.310	0.240	**N/A**
20.20	66.3	8379	511	354.1	202.3	56	6.37	2.7	Clay-Like	37			8379	0.83	69.1	122.9	0.82	0.270	0.9	0.186	0.148	**N/A**
20.51	67.3	12114	619	359.6	204.8	82	5.26	2.5		30			12114	0.83	99.5	162.0	0.81	0.269	0.9	0.340	0.260	**0.97**
20.80	68.2	6579	286	365.0	207.2	43	4.61	2.6	Clay-Like	34			6579	0.83	53.9	101.9	0.81	0.269	0.9	0.146	0.118	**N/A**
21.10	69.2	3323	104	370.4	209.7	20	3.54	2.8	Clay-Like	41			3323	0.82	27.1	66.7	0.81	0.268	0.9	0.096	0.079	**N/A**
21.41	70.2	3064	117	375.8	212.2	18	4.35	2.9	Clay-Like	45			3064	0.82	24.9	63.9	0.80	0.268	0.9	0.092	0.076	**N/A**
21.70	71.2	2547	109	381.2	214.7	15	5.04	3.0	Clay-Like	49			2547	0.82	20.7	58.2	0.80	0.268	0.9	0.086	0.071	**N/A**
22.01	72.2	2643	102	386.7	217.2	15	4.50	3.0	Clay-Like	49			2643	0.82	21.4	59.2	0.80	0.267	0.9	0.087	0.072	**N/A**
22.30	73.2	9164	428	392.1	219.6	59	4.88	2.6	Clay-Like	34			9164	0.81	73.9	128.8	0.79	0.267	0.9	0.200	0.157	**N/A**
22.61	74.2	29781	873	397.5	222.1	196	2.97	2.1		19			29781	0.81	239.5	328.1	0.79	0.266	0.8	2.000	1.337	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-02**

Test Boring Information:

Ground elevation		20.5 ft	6.25 m
Water table elevation		4.9 ft	1.49 m
Depth to ground water table		15.6 ft	4.76 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	7871	26	2.3	2.3	510	0.33	1.1	Unsaturated	4			7871	1.70	132.5	132.5	1.00	0.189	1.1	0.210	0.202	**N/A**
0.45	1.5	5928	122	7.1	7.1	221	2.05	1.9	Unsaturated	15			5928	1.70	99.8	137.2	1.00	0.189	1.1	0.223	0.215	**N/A**
0.75	2.5	6598	263	11.8	11.8	191	4.00	2.2	Unsaturated	22			6598	1.70	111.1	169.5	1.00	0.189	1.1	0.402	0.388	**N/A**
1.05	3.4	4520	163	16.5	16.5	110	3.61	2.3	Unsaturated	24			4520	1.61	72.2	122.0	1.00	0.189	1.1	0.184	0.177	**N/A**
1.35	4.4	5736	217	21.2	21.2	123	3.80	2.3	Unsaturated	24			5736	1.51	85.7	139.7	1.00	0.188	1.1	0.231	0.223	**N/A**
1.65	5.4	15858	308	25.9	25.9	309	1.95	1.8	Unsaturated	13			15858	1.43	224.8	272.8	1.00	0.188	1.1	2.000	1.927	**N/A**
1.95	6.4	34301	693	30.7	30.7	615	2.02	1.7	Unsaturated	11			34301	1.37	465.1	522.7	1.00	0.188	1.1	2.000	1.927	**N/A**
2.23	7.3	10668	344	35.0	35.0	179	3.23	2.1	Unsaturated	19			10668	1.32	139.7	201.2	0.99	0.187	1.1	1.202	1.158	**N/A**
2.50	8.2	10313	307	39.3	39.3	163	2.99	2.1	Unsaturated	19			10313	1.28	131.0	190.1	0.99	0.187	1.1	0.753	0.726	**N/A**
2.80	9.2	8791	161	44.0	44.0	131	1.84	2.0	Unsaturated	17			8791	1.24	108.3	155.1	0.99	0.187	1.1	0.297	0.286	**N/A**
3.10	10.2	5133	163	48.7	48.7	72	3.20	2.4	Unsaturated	27			5133	1.21	61.6	110.0	0.99	0.186	1.1	0.160	0.152	**N/A**
3.40	11.2	11625	270	53.4	53.4	157	2.33	2.0	Unsaturated	17			11625	1.18	136.2	189.6	0.99	0.186	1.1	0.740	0.713	**N/A**
3.70	12.1	5583	192	58.2	58.2	72	3.48	2.4	Unsaturated	27			5583	1.16	63.9	113.1	0.98	0.186	1.1	0.166	0.154	**N/A**
4.03	13.2	7239	176	63.3	63.3	90	2.46	2.2	Unsaturated	22			7239	1.13	81.1	130.7	0.98	0.185	1.1	0.205	0.191	**N/A**
4.35	14.3	2882	57	68.4	68.4	34	2.04	2.5	Unsaturated	30			2882	1.11	31.6	71.3	0.98	0.185	1.0	0.101	0.092	**N/A**
4.65	15.3	6311	206	73.1	73.1	72	3.30	2.4	Unsaturated	27			6311	1.09	68.0	118.5	0.98	0.184	1.0	0.176	0.161	**N/A**
4.95	16.2	30164	350	78.3	76.4	342	1.16	1.6		10			30164	1.08	321.5	345.2	0.98	0.189	1.1	2.000	1.899	**2.00**
5.25	17.2	21115	391	83.7	78.8	235	1.86	1.9		15			21115	1.07	223.2	285.3	0.97	0.195	1.1	2.000	1.882	**2.00**
5.55	18.2	7431	224	89.2	81.3	81	3.05	2.3		24			7431	1.06	77.9	129.5	0.97	0.201	1.0	0.202	0.182	**0.91**
5.85	19.2	3897	96	94.6	83.8	41	2.52	2.5		30			3897	1.05	40.5	83.2	0.97	0.206	1.0	0.117	0.104	**0.51**
6.15	20.2	9557	178	100.0	86.3	101	1.88	2.1		19			9557	1.04	98.6	148.9	0.97	0.211	1.0	0.267	0.239	**1.13**
6.45	21.2	11750	184	105.4	88.8	123	1.58	2.0		17			11750	1.03	120.4	170.0	0.96	0.216	1.0	0.408	0.366	**1.70**
6.75	22.2	1705	86	110.9	91.3	17	5.41	3.0	Clay-Like	49			1705	1.03	17.3	53.7	0.96	0.220	1.0	0.081	0.072	**N/A**
7.05	23.1	3993	103	116.3	93.7	40	2.67	2.5		30			3993	1.02	40.3	82.9	0.96	0.224	1.0	0.117	0.103	**0.46**
7.35	24.1	1647	53	121.7	96.2	15	3.45	2.9	Clay-Like	45			1647	1.01	16.5	52.6	0.96	0.228	1.0	0.080	0.070	**N/A**
7.65	25.1	986	39	127.1	98.7	9	4.57	3.2	Clay-Like	58			986	1.01	9.8	43.5	0.95	0.231	1.0	0.072	0.063	**N/A**
7.95	26.1	479	15	132.5	101.2	3	4.42	3.5	Clay-Like	73			479	1.00	4.7	36.4	0.95	0.235	1.0	0.066	0.058	**N/A**
8.25	27.1	747	11	138.0	103.7	6	1.89	3.1	Clay-Like	53			747	0.99	7.3	40.2	0.95	0.238	1.0	0.069	0.060	**N/A**
8.55	28.1	689	11	143.4	106.1	5	2.10	3.2	Clay-Like	58			689	0.99	6.7	39.4	0.95	0.241	1.0	0.068	0.059	**N/A**
8.85	29.0	508	12	148.8	108.6	3	3.47	3.4	Clay-Like	67			508	0.98	4.9	36.8	0.94	0.243	1.0	0.066	0.058	**N/A**
9.15	30.0	2107	11	154.2	111.1	18	0.59	2.4		27			2107	0.98	20.3	55.2	0.94	0.246	1.0	0.083	0.072	**0.29**
9.45	31.0	3438	17	159.6	113.6	31	0.53	2.2		22			3438	0.97	33.0	68.3	0.94	0.248	1.0	0.098	0.085	**0.34**
9.75	32.0	1235	17	165.1	116.1	10	1.61	2.9	Clay-Like	45			1235	0.96	11.8	46.2	0.93	0.250	1.0	0.074	0.064	**N/A**
10.05	33.0	1235	9	170.5	118.6	10	0.81	2.7	Clay-Like	37			1235	0.96	11.7	45.7	0.93	0.252	1.0	0.073	0.064	**N/A**
10.35	34.0	1197	7	176.0	121.0	9	0.66	2.7	Clay-Like	37			1197	0.95	11.3	45.1	0.93	0.254	1.0	0.073	0.063	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	1561	6	181.4	123.5	12	0.42	2.5		30			1561	0.95	14.7	48.6	0.92	0.256	1.0	0.076	0.066	**0.26**
10.95	35.9	1590	13	186.8	126.0	12	0.96	2.7	Clay-Like	37			1590	0.94	14.8	49.9	0.92	0.257	1.0	0.077	0.067	**N/A**
11.25	36.9	13397	343	192.2	128.5	116	2.60	2.2		22			13397	0.94	124.5	186.9	0.92	0.259	0.9	0.671	0.556	**2.00**
11.55	37.9	20722	729	197.6	131.0	178	3.55	2.1		19			20722	0.93	191.6	267.2	0.91	0.260	0.9	2.000	1.615	**2.00**
11.85	38.9	25472	746	203.1	133.4	217	2.95	2.0		17			25472	0.93	234.3	311.4	0.91	0.262	0.9	2.000	1.605	**2.00**
12.15	39.9	14498	507	208.5	135.9	122	3.55	2.2		22			14498	0.92	132.7	197.6	0.91	0.263	0.9	1.021	0.827	**2.00**
12.45	40.9	8609	374	213.9	138.4	71	4.46	2.5		30			8609	0.92	78.4	133.8	0.91	0.264	1.0	0.213	0.179	**0.68**
12.75	41.8	4089	144	219.3	140.9	32	3.71	2.7	Clay-Like	37			4089	0.92	37.1	79.8	0.90	0.265	1.0	0.112	0.095	**N/A**
13.05	42.8	4568	171	224.7	143.4	36	3.95	2.6	Clay-Like	34			4568	0.91	41.2	84.9	0.90	0.266	1.0	0.119	0.101	**N/A**
13.35	43.8	4932	144	230.2	145.9	39	3.06	2.5		30			4932	0.91	44.3	88.2	0.90	0.266	1.0	0.124	0.105	**0.39**
13.65	44.8	5420	175	235.6	148.3	42	3.38	2.5		30			5420	0.90	48.5	93.8	0.89	0.267	1.0	0.133	0.112	**0.42**
13.95	45.8	8187	326	241.1	150.8	64	4.10	2.5		30			8187	0.90	72.9	126.5	0.89	0.268	0.9	0.194	0.161	**0.60**
14.25	46.8	15791	565	246.5	153.3	125	3.63	2.2		22			15791	0.90	140.0	207.1	0.89	0.268	0.9	1.616	1.246	**2.00**
14.55	47.7	25424	774	251.9	155.8	200	3.07	2.1		19			25424	0.89	224.5	309.1	0.88	0.269	0.9	2.000	1.524	**2.00**
14.85	48.7	32846	1068	257.3	158.3	257	3.28	2.0		17			32846	0.89	288.9	379.1	0.88	0.269	0.9	2.000	1.515	**2.00**
15.15	49.7	16634	703	262.7	160.7	128	4.29	2.3		24			16634	0.88	145.7	218.5	0.88	0.270	0.9	2.000	1.507	**2.00**
15.45	50.7	7632	341	268.2	163.2	57	4.63	2.5		30			7632	0.88	66.6	118.0	0.87	0.270	0.9	0.175	0.145	**0.54**
15.75	51.7	14929	549	273.6	165.7	113	3.74	2.3		24			14929	0.88	129.7	197.6	0.87	0.270	0.9	1.020	0.780	**2.00**
16.05	52.7	20311	395	279.0	168.2	153	1.97	2.0		17			20311	0.87	175.8	238.8	0.86	0.270	0.8	2.000	1.483	**2.00**
16.35	53.6	23509	519	284.4	170.7	177	2.23	2.0		17			23509	0.87	202.7	272.2	0.86	0.271	0.8	2.000	1.476	**2.00**
16.66	54.6	32731	756	289.9	173.2	245	2.33	1.9		15			32731	0.87	281.1	354.9	0.86	0.271	0.8	2.000	1.468	**2.00**
16.95	55.6	14527	987	295.3	175.6	107	6.94	2.5		30			14527	0.86	124.3	195.1	0.85	0.271	0.9	0.918	0.693	**2.00**
17.25	56.6	16126	656	300.7	178.1	118	4.14	2.3		24			16126	0.86	137.5	207.8	0.85	0.271	0.8	1.675	1.227	**2.00**
17.55	57.6	21450	543	306.1	180.6	156	2.57	2.1		19			21450	0.86	182.2	255.2	0.85	0.271	0.8	2.000	1.446	**2.00**
17.85	58.6	26047	565	311.5	183.1	189	2.20	2.0		17			26047	0.85	220.4	294.2	0.84	0.271	0.8	2.000	1.439	**2.00**
18.16	59.6	22312	675	317.0	185.6	160	3.07	2.1		19			22312	0.85	188.2	262.8	0.84	0.271	0.8	2.000	1.432	**2.00**
18.45	60.5	11893	718	322.4	188.0	84	6.21	2.5		30			11893	0.85	99.9	162.6	0.84	0.271	0.9	0.344	0.268	**0.99**
18.76	61.5	15111	854	327.9	190.5	106	5.78	2.5		30			15111	0.85	126.5	198.1	0.83	0.270	0.8	1.044	0.765	**2.00**
19.03	62.4	20560	550	332.8	192.8	145	2.72	2.1		19			20560	0.84	171.6	241.8	0.83	0.270	0.8	2.000	1.411	**2.00**
19.30	63.3	22408	419	337.8	195.1	157	1.90	2.0		17			22408	0.84	186.5	252.1	0.83	0.270	0.8	2.000	1.405	**2.00**
19.60	64.3	25166	495	343.2	197.5	175	1.99	2.0		17			25166	0.84	208.8	279.7	0.82	0.270	0.8	2.000	1.399	**2.00**
19.91	65.3	37998	726	348.6	200.0	264	1.93	1.8		13			37998	0.84	314.2	376.0	0.82	0.269	0.8	2.000	1.392	**2.00**
20.20	66.3	24610	857	354.0	202.5	169	3.53	2.2		22			24610	0.83	202.8	288.4	0.82	0.269	0.8	2.000	1.386	**2.00**
20.51	67.3	8168	448	359.5	205.0	54	5.74	2.6	Clay-Like	34			8168	0.83	67.1	119.6	0.81	0.269	0.9	0.179	0.143	**N/A**
20.80	68.2	12573	597	364.9	207.5	84	4.89	2.5		30			12573	0.83	103.0	166.6	0.81	0.268	0.9	0.376	0.285	**1.06**
21.10	69.2	24256	598	370.3	209.9	164	2.50	2.0		17			24256	0.82	198.0	266.3	0.81	0.268	0.8	2.000	1.367	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-03**

Test Boring Information:

Ground elevation		18	ft	5.49 m
Water table elevation		4.8	ft	1.46 m
Depth to ground water table		13.2	ft	4.02 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	1321	27	2.3	2.3	85	2.05	2.2	Unsaturated	22			1321	1.70	22.2	54.4	1.00	0.189	1.1	0.082	0.079	**N/A**
0.45	1.5	3802	54	7.1	7.1	142	1.42	1.9	Unsaturated	15			3802	1.70	64.0	94.2	1.00	0.189	1.1	0.133	0.128	**N/A**
0.75	2.5	8226	83	11.8	11.8	238	1.01	1.6	Unsaturated	10			8226	1.70	138.5	151.5	1.00	0.189	1.1	0.278	0.268	**N/A**
1.05	3.4	11884	129	16.5	16.5	290	1.09	1.6	Unsaturated	10			11884	1.61	189.8	205.8	1.00	0.189	1.1	1.514	1.459	**N/A**
1.35	4.4	10668	94	21.2	21.2	230	0.88	1.6	Unsaturated	10			10668	1.51	159.4	173.7	1.00	0.188	1.1	0.447	0.431	**N/A**
1.65	5.4	4462	169	25.9	25.9	87	3.81	2.4	Unsaturated	27			4462	1.43	63.2	112.2	1.00	0.188	1.1	0.164	0.158	**N/A**
1.95	6.4	3361	76	30.7	30.7	60	2.28	2.3	Unsaturated	24			3361	1.37	45.6	87.0	1.00	0.188	1.1	0.122	0.118	**N/A**
2.23	7.3	3897	131	35.0	35.0	65	3.39	2.4	Unsaturated	27			3897	1.32	51.0	96.0	0.99	0.187	1.1	0.136	0.131	**N/A**
2.50	8.2	1465	73	39.3	39.3	23	5.12	2.9	Unsaturated	45			1465	1.28	18.6	55.4	0.99	0.187	1.1	0.083	0.078	**N/A**
2.80	9.2	1513	45	44.0	44.0	22	3.06	2.7	Unsaturated	37			1513	1.24	18.6	55.0	0.99	0.187	1.1	0.083	0.077	**N/A**
3.10	10.2	1724	52	48.7	48.7	24	3.10	2.7	Unsaturated	37			1724	1.21	20.7	57.8	0.99	0.186	1.1	0.085	0.079	**N/A**
3.40	11.2	2001	53	53.4	53.4	26	2.72	2.6	Unsaturated	34			2001	1.18	23.4	61.0	0.99	0.186	1.0	0.089	0.082	**N/A**
3.70	12.1	2155	33	58.2	58.2	27	1.57	2.5	Unsaturated	30			2155	1.16	24.7	62.0	0.98	0.186	1.0	0.090	0.082	**N/A**
4.03	13.2	3476	35	63.3	63.3	43	1.03	2.2		22			3476	1.13	38.9	76.0	0.98	0.185	1.0	0.107	0.098	**0.53**
4.35	14.3	2902	49	69.2	66.0	35	1.73	2.4		27			2902	1.12	32.2	70.9	0.98	0.194	1.0	0.101	0.091	**0.47**
4.65	15.3	757	30	74.6	68.5	8	4.40	3.2	Clay-Like	58			757	1.11	8.3	41.5	0.98	0.201	1.0	0.070	0.063	**N/A**
4.95	16.2	4989	79	80.0	70.9	58	1.61	2.2		22			4989	1.10	54.2	95.8	0.98	0.208	1.0	0.136	0.123	**0.59**
5.25	17.2	6425	71	85.4	73.4	74	1.12	2.0		17			6425	1.09	69.2	106.6	0.97	0.214	1.0	0.154	0.139	**0.65**
5.55	18.2	1858	48	90.9	75.9	20	2.72	2.7	Clay-Like	37			1858	1.08	19.8	56.6	0.97	0.219	1.0	0.084	0.075	**N/A**
5.85	19.2	2001	43	96.3	78.4	21	2.26	2.7	Clay-Like	37			2001	1.07	21.2	58.4	0.97	0.224	1.0	0.086	0.077	**N/A**
6.15	20.2	852	20	101.7	80.9	8	2.67	3.0	Clay-Like	49			852	1.06	8.9	42.4	0.97	0.229	1.0	0.071	0.063	**N/A**
6.45	21.2	680	11	107.1	83.3	6	1.92	3.1	Clay-Like	53			680	1.05	7.1	39.9	0.96	0.234	1.0	0.069	0.061	**N/A**
6.75	22.2	814	12	112.6	85.8	8	1.71	3.0	Clay-Like	49			814	1.04	8.4	41.7	0.96	0.238	1.0	0.070	0.062	**N/A**
7.05	23.1	833	10	118.0	88.3	8	1.40	2.9	Clay-Like	45			833	1.04	8.5	41.8	0.96	0.241	1.0	0.070	0.062	**N/A**
7.35	24.1	824	11	123.4	90.8	7	1.57	3.0	Clay-Like	49			824	1.03	8.4	41.7	0.96	0.245	1.0	0.070	0.062	**N/A**
7.65	25.1	2806	18	128.9	93.3	28	0.67	2.3		24			2806	1.02	28.4	64.4	0.95	0.248	1.0	0.093	0.082	**0.33**
7.95	26.1	3313	20	134.3	95.7	32	0.63	2.2		22			3313	1.01	33.3	68.7	0.95	0.251	1.0	0.098	0.086	**0.34**
8.25	27.1	1561	18	139.7	98.2	14	1.27	2.7	Clay-Like	37			1561	1.01	15.6	50.9	0.95	0.254	1.0	0.078	0.069	**N/A**
8.55	28.1	1542	14	145.1	100.7	14	1.00	2.6	Clay-Like	34			1542	1.00	15.3	50.1	0.95	0.257	1.0	0.078	0.068	**N/A**
8.85	29.0	1714	13	150.6	103.2	15	0.83	2.6	Clay-Like	34			1714	0.99	16.9	52.2	0.94	0.259	1.0	0.080	0.070	**N/A**
9.15	30.0	2662	21	156.0	105.7	24	0.84	2.4		27			2662	0.99	26.0	62.8	0.94	0.261	1.0	0.091	0.079	**0.30**
9.45	31.0	6770	144	161.4	108.1	63	2.18	2.3		24			6770	0.98	65.8	113.6	0.94	0.263	1.0	0.167	0.145	**0.55**
9.75	32.0	14986	462	166.8	110.6	140	3.12	2.2		22			14986	0.98	144.9	213.3	0.93	0.265	1.0	2.000	1.704	**2.00**
10.05	33.0	7010	151	172.2	113.1	64	2.21	2.3		24			7010	0.97	67.4	115.6	0.93	0.267	1.0	0.171	0.147	**0.55**
10.35	34.0	12190	301	177.7	115.6	111	2.51	2.2		22			12190	0.97	116.5	176.5	0.93	0.269	1.0	0.484	0.412	**1.53**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	13320	391	183.1	118.1	120	2.98	2.2		22			13320	0.96	126.6	189.6	0.92	0.270	1.0	0.740	0.624	**2.00**
10.95	35.9	16155	641	188.5	120.5	144	4.01	2.2		22			16155	0.95	152.7	223.4	0.92	0.272	0.9	2.000	1.659	**2.00**
11.25	36.9	16892	582	193.9	123.0	150	3.49	2.2		22			16892	0.95	158.8	231.3	0.92	0.273	0.9	2.000	1.648	**2.00**
11.55	37.9	10581	401	199.3	125.5	92	3.86	2.4		27			10581	0.94	98.9	159.5	0.91	0.274	1.0	0.323	0.272	**0.99**
11.85	38.9	14862	552	204.8	128.0	129	3.77	2.3		24			14862	0.94	138.2	208.8	0.91	0.275	0.9	1.769	1.442	**2.00**
12.15	39.9	19832	853	210.2	130.5	171	4.35	2.2		22			19832	0.93	183.5	263.4	0.91	0.276	0.9	2.000	1.617	**2.00**
12.45	40.9	13004	589	215.7	133.0	110	4.61	2.4		27			13004	0.93	119.7	187.1	0.91	0.277	0.9	0.676	0.555	**2.00**
12.75	41.8	10945	551	221.1	135.4	92	5.14	2.5		30			10945	0.93	100.3	163.0	0.90	0.278	0.9	0.347	0.288	**1.04**
13.05	42.8	11530	524	226.5	137.9	96	4.64	2.4		27			11530	0.92	105.2	167.8	0.90	0.278	0.9	0.386	0.318	**1.14**
13.35	43.8	10342	494	231.9	140.4	85	4.89	2.5		30			10342	0.92	93.9	154.4	0.90	0.279	0.9	0.293	0.243	**0.87**
13.65	44.8	15906	705	237.3	142.9	130	4.50	2.3		24			15906	0.91	143.7	216.0	0.89	0.279	0.9	2.000	1.569	**2.00**
13.95	45.8	26640	770	242.8	145.4	218	2.92	2.0		17			26640	0.91	239.6	317.9	0.89	0.280	0.9	2.000	1.560	**2.00**
14.25	46.8	9346	578	248.2	147.8	74	6.35	2.6	Clay-Like	34			9346	0.90	83.7	141.9	0.89	0.280	0.9	0.239	0.197	**N/A**
14.55	47.7	14584	699	253.6	150.3	116	4.88	2.4		27			14584	0.90	130.0	200.8	0.88	0.280	0.9	1.178	0.923	**2.00**
14.85	48.7	20320	654	259.0	152.8	161	3.26	2.1		19			20320	0.90	180.4	252.9	0.88	0.281	0.9	2.000	1.534	**2.00**
15.15	49.7	19382	621	264.4	155.3	152	3.25	2.2		22			19382	0.89	171.3	247.6	0.88	0.281	0.9	2.000	1.525	**2.00**
15.45	50.7	10495	703	269.9	157.8	81	6.88	2.6	Clay-Like	34			10495	0.89	92.4	153.6	0.87	0.281	0.9	0.289	0.234	**N/A**
15.75	51.7	16873	731	275.3	160.2	130	4.40	2.3		24			16873	0.89	147.9	221.5	0.87	0.281	0.9	2.000	1.509	**2.00**
16.05	52.7	11731	631	280.8	162.7	89	5.51	2.5		30			11731	0.88	102.4	165.9	0.86	0.281	0.9	0.369	0.295	**1.05**
16.35	53.6	13378	731	286.2	165.2	101	5.58	2.5		30			13378	0.88	116.3	184.4	0.86	0.281	0.9	0.617	0.481	**1.71**
16.66	54.6	19592	1051	291.6	167.7	148	5.45	2.3		24			19592	0.87	169.7	250.1	0.86	0.281	0.8	2.000	1.485	**2.00**
16.95	55.6	24160	817	297.0	170.2	182	3.42	2.1		19			24160	0.87	208.5	288.6	0.85	0.281	0.8	2.000	1.477	**2.00**
17.25	56.6	35316	784	302.4	172.6	265	2.24	1.9		15			35316	0.87	303.5	381.9	0.85	0.281	0.8	2.000	1.470	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-04**

Test Boring Information:

Approx. ground elevation		17.5	ft	5.34 m
Approx. water table elevation		4.5	ft	1.37 m
Approx. depth to ground water table		13	ft	3.96 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	20349	53	2.3	2.3	1319	0.26	0.7	Unsaturated	1			20349	1.70	342.5	342.5	1.00	0.189	1.1	2.000	1.927	**N/A**
0.45	1.5	55081	346	7.1	7.1	2055	0.63	1.0	Unsaturated	3			55081	1.70	927.1	927.1	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	9902	164	11.8	11.8	286	1.66	1.8	Unsaturated	13			9902	1.70	166.7	205.7	1.00	0.189	1.1	1.505	1.450	**N/A**
1.05	3.4	6617	193	16.5	16.5	162	2.92	2.1	Unsaturated	19			6617	1.61	105.7	157.9	1.00	0.189	1.1	0.313	0.301	**N/A**
1.35	4.4	2806	122	21.2	21.2	60	4.38	2.5	Unsaturated	30			2806	1.51	41.9	85.0	1.00	0.188	1.1	0.120	0.115	**N/A**
1.65	5.4	1877	77	25.9	25.9	36	4.16	2.7	Unsaturated	37			1877	1.43	26.6	65.7	1.00	0.188	1.1	0.094	0.091	**N/A**
1.95	6.4	2700	72	30.7	30.7	48	2.70	2.4	Unsaturated	27			2700	1.37	36.6	76.8	1.00	0.188	1.1	0.108	0.104	**N/A**
2.23	7.3	3275	70	35.0	35.0	54	2.16	2.3	Unsaturated	24			3275	1.32	42.9	83.5	0.99	0.187	1.1	0.117	0.113	**N/A**
2.50	8.2	26190	312	39.3	39.3	414	1.19	1.6	Unsaturated	10			26190	1.28	332.6	357.0	0.99	0.187	1.1	2.000	1.927	**N/A**
2.80	9.2	35249	201	44.0	44.0	527	0.57	1.2	Unsaturated	4			35249	1.24	434.4	434.4	0.99	0.187	1.1	2.000	1.927	**N/A**
3.10	10.2	8092	77	48.7	48.7	114	0.96	1.9	Unsaturated	15			8092	1.21	97.1	133.9	0.99	0.186	1.1	0.214	0.206	**N/A**
3.40	11.2	1618	27	53.4	53.4	21	1.73	2.6	Unsaturated	34			1618	1.18	18.9	55.0	0.99	0.186	1.0	0.082	0.076	**N/A**
3.70	12.1	1283	45	58.2	58.2	16	3.67	2.9	Unsaturated	45			1283	1.16	14.7	50.1	0.98	0.186	1.0	0.078	0.071	**N/A**
4.03	13.2	1312	29	63.5	62.8	16	2.32	2.8	Clay-Like	41			1312	1.13	14.7	50.0	0.98	0.187	1.0	0.077	0.070	**N/A**
4.35	14.3	2921	71	69.3	65.5	35	2.49	2.5		30			2921	1.12	32.4	72.3	0.98	0.195	1.0	0.103	0.093	**0.48**
4.65	15.3	3151	57	74.8	68.0	37	1.85	2.4		27			3151	1.11	34.6	74.2	0.98	0.203	1.0	0.105	0.095	**0.47**
4.95	16.2	2202	39	80.2	70.5	25	1.84	2.5		30			2202	1.10	24.0	61.1	0.98	0.209	1.0	0.089	0.080	**0.38**
5.25	17.2	2155	26	85.6	72.9	24	1.26	2.5		30			2155	1.09	23.2	60.1	0.97	0.215	1.0	0.088	0.079	**0.37**
5.55	18.2	4692	44	91.0	75.4	53	0.96	2.1		19			4692	1.08	50.2	87.3	0.97	0.221	1.0	0.123	0.111	**0.50**
5.85	19.2	1053	11	96.4	77.9	11	1.15	2.8	Clay-Like	41			1053	1.07	11.2	45.2	0.97	0.226	1.0	0.073	0.065	**N/A**
6.15	20.2	479	6	101.9	80.4	4	1.59	3.2	Clay-Like	58			479	1.06	5.0	37.1	0.97	0.231	1.0	0.066	0.059	**N/A**
6.45	21.2	1637	28	107.3	82.9	17	1.83	2.7	Clay-Like	37			1637	1.05	17.1	52.9	0.96	0.235	1.0	0.080	0.071	**N/A**
6.75	22.2	517	4	112.7	85.4	4	0.99	3.1	Clay-Like	53			517	1.05	5.4	37.5	0.96	0.239	1.0	0.067	0.059	**N/A**
7.05	23.1	594	5	118.1	87.8	5	1.05	3.0	Clay-Like	49			594	1.04	6.1	38.6	0.96	0.243	1.0	0.067	0.060	**N/A**
7.35	24.1	651	4	123.5	90.3	6	0.76	2.9	Clay-Like	45			651	1.03	6.6	39.2	0.96	0.247	1.0	0.068	0.060	**N/A**
7.65	25.1	508	4	129.0	92.8	4	1.06	3.1	Clay-Like	53			508	1.02	5.1	37.3	0.95	0.250	1.0	0.066	0.059	**N/A**
7.95	26.1	680	5	134.4	95.3	6	0.92	3.0	Clay-Like	49			680	1.02	6.8	39.6	0.95	0.253	1.0	0.068	0.060	**N/A**
8.25	27.1	651	5	139.9	97.8	5	0.98	3.0	Clay-Like	49			651	1.01	6.5	39.1	0.95	0.256	1.0	0.068	0.060	**N/A**
8.55	28.1	498	4	145.3	100.2	4	1.13	3.2	Clay-Like	58			498	1.00	4.9	37.0	0.95	0.258	1.0	0.066	0.058	**N/A**
8.85	29.0	508	4	150.7	102.7	4	1.12	3.2	Clay-Like	58			508	1.00	5.0	37.0	0.94	0.261	1.0	0.066	0.058	**N/A**
9.15	30.0	680	4	156.1	105.2	5	0.76	3.0	Clay-Like	49			680	0.99	6.7	39.3	0.94	0.263	1.0	0.068	0.059	**N/A**
9.45	31.0	1073	4	161.5	107.7	9	0.44	2.7	Clay-Like	37			1073	0.98	10.4	44.0	0.94	0.265	1.0	0.072	0.063	**N/A**
9.75	32.0	1034	5	167.0	110.2	8	0.58	2.7	Clay-Like	37			1034	0.98	10.0	43.4	0.93	0.267	1.0	0.071	0.062	**N/A**
10.05	33.0	642	4	172.4	112.6	4	0.85	3.1	Clay-Like	53			642	0.97	6.2	38.7	0.93	0.268	1.0	0.068	0.059	**N/A**
10.35	34.0	900	4	177.8	115.1	7	0.55	2.8	Clay-Like	41			900	0.97	8.6	41.8	0.93	0.270	1.0	0.070	0.061	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	1896	3	183.2	117.6	16	0.18	2.3		24			1896	0.96	18.0	50.8	0.92	0.271	1.0	0.078	0.068	**0.25**
10.95	35.9	2978	4	188.6	120.1	25	0.14	2.1		19			2978	0.96	28.2	59.3	0.92	0.273	1.0	0.087	0.075	**0.28**
11.25	36.9	6943	34	194.1	122.6	61	0.50	1.9		15			6943	0.95	65.3	95.8	0.92	0.274	1.0	0.136	0.117	**0.43**
11.55	37.9	9519	169	199.5	125.0	83	1.81	2.1		19			9519	0.95	89.1	136.8	0.91	0.275	1.0	0.222	0.189	**0.69**
11.85	38.9	8331	108	204.9	127.5	71	1.33	2.1		19			8331	0.94	77.6	122.1	0.91	0.276	1.0	0.184	0.157	**0.57**
12.15	39.9	5506	155	210.3	130.0	46	2.93	2.5		30			5506	0.94	51.0	97.2	0.91	0.277	1.0	0.138	0.118	**0.42**
12.45	40.9	8666	177	215.8	132.5	73	2.09	2.2		22			8666	0.93	79.9	129.1	0.91	0.278	1.0	0.201	0.169	**0.61**
12.75	41.8	16863	452	221.2	135.0	142	2.72	2.1		19			16863	0.93	154.7	220.2	0.90	0.279	0.9	2.000	1.599	**2.00**
13.05	42.8	17677	493	226.6	137.4	148	2.83	2.1		19			17677	0.92	161.4	228.7	0.90	0.279	0.9	2.000	1.589	**2.00**
13.35	43.8	10543	233	232.1	139.9	87	2.26	2.2		22			10543	0.92	95.8	149.7	0.90	0.280	0.9	0.270	0.224	**0.80**
13.65	44.8	7287	54	237.5	142.4	59	0.77	2.0		17			7287	0.91	65.9	102.5	0.89	0.280	1.0	0.147	0.124	**0.44**
13.95	45.8	10055	136	242.9	144.9	81	1.39	2.1		19			10055	0.91	90.5	138.6	0.89	0.281	0.9	0.228	0.189	**0.67**
14.25	46.8	14814	321	248.3	147.4	119	2.20	2.1		19			14814	0.91	132.8	192.3	0.89	0.281	0.9	0.821	0.654	**2.00**
14.55	47.7	10342	159	253.8	149.9	82	1.58	2.1		19			10342	0.90	92.3	140.8	0.88	0.281	0.9	0.235	0.194	**0.69**
14.85	48.7	6952	145	259.2	152.3	54	2.17	2.3		24			6952	0.90	61.8	108.3	0.88	0.282	1.0	0.157	0.131	**0.46**
15.15	49.7	8532	216	264.6	154.8	66	2.61	2.3		24			8532	0.89	75.5	126.3	0.88	0.282	0.9	0.194	0.160	**0.57**
15.45	50.7	6493	157	270.0	157.3	49	2.52	2.4		27			6493	0.89	57.2	104.1	0.87	0.282	1.0	0.149	0.125	**0.44**
15.75	51.7	11798	333	275.4	159.8	91	2.89	2.3		24			11798	0.89	103.5	163.1	0.87	0.282	0.9	0.348	0.280	**0.99**
16.05	52.7	19803	773	280.9	162.3	152	3.96	2.2		22			19803	0.88	173.0	249.8	0.86	0.282	0.9	2.000	1.502	**2.00**
16.35	53.6	15092	651	286.3	164.7	115	4.40	2.3		24			15092	0.88	131.3	199.7	0.86	0.282	0.9	1.121	0.856	**2.00**
16.66	54.6	7670	300	291.8	167.2	57	4.07	2.5		30			7670	0.88	66.5	117.8	0.86	0.282	0.9	0.175	0.144	**0.51**
16.95	55.6	11252	466	297.2	169.7	84	4.25	2.4		27			11252	0.87	97.2	157.1	0.85	0.282	0.9	0.308	0.246	**0.87**
17.25	56.6	23662	558	302.6	172.2	177	2.39	2.0		17			23662	0.87	203.5	273.2	0.85	0.282	0.8	2.000	1.471	**2.00**
17.55	57.6	30930	409	308.0	174.7	230	1.34	1.7		11			30930	0.87	265.0	301.7	0.85	0.282	0.8	2.000	1.463	**2.00**
17.85	58.6	10955	413	313.4	177.1	79	3.88	2.4		27			10955	0.86	93.5	152.3	0.84	0.281	0.9	0.282	0.225	**0.80**
18.16	59.6	7948	320	318.9	179.6	57	4.19	2.5		30			7948	0.86	67.6	119.3	0.84	0.281	0.9	0.178	0.145	**0.52**
18.45	60.5	6234	273	324.3	182.1	44	4.62	2.6	Clay-Like	34			6234	0.86	52.8	100.5	0.84	0.281	0.9	0.143	0.118	**N/A**
18.76	61.5	6866	347	329.7	184.6	48	5.31	2.6	Clay-Like	34			6866	0.85	58.0	107.4	0.83	0.281	0.9	0.155	0.127	**N/A**
19.03	62.4	7709	440	334.7	186.9	54	5.97	2.6	Clay-Like	34			7709	0.85	64.9	116.7	0.83	0.280	0.9	0.173	0.140	**N/A**
19.30	63.3	12257	551	339.6	189.1	86	4.62	2.4		27			12257	0.85	102.8	164.7	0.83	0.280	0.9	0.360	0.279	**1.00**
19.60	64.3	14824	594	345.0	191.6	104	4.10	2.3		24			14824	0.84	124.0	190.0	0.82	0.280	0.8	0.750	0.558	**2.00**
19.91	65.3	15762	573	350.5	194.1	110	3.72	2.3		24			15762	0.84	131.4	199.7	0.82	0.279	0.8	1.123	0.815	**2.00**
20.20	66.3	14546	494	355.9	196.6	101	3.48	2.3		24			14546	0.84	120.8	185.9	0.82	0.279	0.9	0.647	0.482	**1.73**
20.51	67.3	9758	346	361.4	199.1	66	3.68	2.4		27			9758	0.84	80.8	135.4	0.81	0.278	0.9	0.218	0.173	**0.62**
20.80	68.2	5037	132	366.8	201.6	33	2.83	2.6	Clay-Like	34			5037	0.83	41.6	85.4	0.81	0.278	0.9	0.120	0.098	**N/A**
21.10	69.2	3974	105	372.2	204.0	25	2.92	2.7	Clay-Like	37			3974	0.83	32.7	73.9	0.81	0.277	0.9	0.105	0.086	**N/A**
21.41	70.2	3419	83	377.6	206.5	21	2.73	2.7	Clay-Like	37			3419	0.83	28.0	67.7	0.80	0.277	0.9	0.097	0.080	**N/A**
21.70	71.2	2873	74	383.0	209.0	17	2.97	2.8	Clay-Like	41			2873	0.83	23.5	61.8	0.80	0.276	0.9	0.090	0.074	**N/A**
22.01	72.2	2739	61	388.5	211.5	16	2.60	2.8	Clay-Like	41			2739	0.82	22.3	60.2	0.80	0.276	0.9	0.088	0.073	**N/A**
22.30	73.2	2662	55	393.9	214.0	15	2.42	2.8	Clay-Like	41			2662	0.82	21.6	59.3	0.79	0.275	0.9	0.087	0.072	**N/A**
22.61	74.2	2442	43	399.3	216.4	14	2.11	2.8	Clay-Like	41			2442	0.82	19.8	56.8	0.79	0.275	0.9	0.084	0.070	**N/A**
22.91	75.1	2471	35	404.7	218.9	14	1.69	2.7	Clay-Like	37			2471	0.82	19.9	56.8	0.79	0.274	0.9	0.084	0.070	**N/A**
23.20	76.1	2633	42	410.1	221.4	15	1.89	2.7	Clay-Like	37			2633	0.81	21.2	58.5	0.78	0.273	0.9	0.086	0.071	**N/A**
23.51	77.1	2739	45	415.6	223.9	15	1.94	2.7	Clay-Like	37			2739	0.81	22.0	59.5	0.78	0.273	0.9	0.087	0.072	**N/A**
23.80	78.1	15465	345	421.0	226.4	99	2.29	2.2		22			15465	0.81	123.8	186.0	0.78	0.272	0.8	0.649	0.466	**1.71**
24.11	79.1	13215	344	426.5	228.8	84	2.69	2.3		24			13215	0.81	105.4	165.7	0.77	0.272	0.8	0.368	0.274	**1.01**
24.41	80.1	3514	112	431.9	231.3	20	3.63	2.8	Clay-Like	41			3514	0.80	28.0	67.9	0.77	0.271	0.9	0.097	0.079	**N/A**
24.71	81.0	3074	123	437.3	233.8	17	4.66	2.9	Clay-Like	45			3074	0.80	24.4	63.2	0.77	0.270	0.9	0.091	0.075	**N/A**
25.01	82.0	20416	435	442.7	236.3	129	2.18	2.1		19			20416	0.80	161.5	228.9	0.76	0.270	0.7	2.000	1.304	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-06**

Test Boring Information:

Approx. ground elevation		11	ft	3.35 m
Approx. water table elevation		2.2	ft	0.67 m
Approx. depth to ground water table		8.8	ft	2.68 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	16164	76	2.3	2.3	1048	0.47	1.0	Unsaturated	3			16164	1.70	272.1	272.1	1.00	0.189	1.1	2.000	1.927	**N/A**
0.45	1.5	12027	142	7.1	7.1	448	1.18	1.5	Unsaturated	8			12027	1.70	202.4	209.3	1.00	0.189	1.1	1.820	1.754	**N/A**
0.75	2.5	5650	166	11.8	11.8	163	2.94	2.1	Unsaturated	19			5650	1.70	95.1	144.4	1.00	0.189	1.1	0.248	0.239	**N/A**
1.05	3.4	25233	155	16.5	16.5	617	0.62	1.2	Unsaturated	4			25233	1.61	403.0	403.0	1.00	0.189	1.1	2.000	1.927	**N/A**
1.35	4.4	22034	215	21.2	21.2	475	0.97	1.4	Unsaturated	7			22034	1.51	329.2	331.6	1.00	0.188	1.1	2.000	1.927	**N/A**
1.65	5.4	10495	81	25.9	25.9	204	0.78	1.6	Unsaturated	10			10495	1.43	148.8	162.4	1.00	0.188	1.1	0.343	0.330	**N/A**
1.95	6.4	9193	138	30.7	30.7	164	1.51	1.9	Unsaturated	15			9193	1.37	124.6	167.0	1.00	0.188	1.1	0.380	0.366	**N/A**
2.23	7.3	6512	81	35.0	35.0	109	1.26	1.9	Unsaturated	15			6512	1.32	85.3	119.8	0.99	0.187	1.1	0.179	0.172	**N/A**
2.50	8.2	4644	111	39.3	39.3	73	2.41	2.3	Unsaturated	24			4644	1.28	59.0	104.6	0.99	0.187	1.1	0.150	0.145	**N/A**
2.80	9.2	1427	62	44.3	43.2	21	4.50	2.9	Clay-Like	45			1427	1.25	17.7	54.1	0.99	0.192	1.1	0.082	0.076	**N/A**
3.10	10.2	1302	35	49.7	45.6	18	2.83	2.8	Clay-Like	41			1302	1.23	15.9	51.6	0.99	0.203	1.1	0.079	0.073	**N/A**
3.40	11.2	2518	78	55.1	48.1	35	3.15	2.6	Clay-Like	34			2518	1.22	30.3	70.3	0.99	0.213	1.1	0.100	0.093	**N/A**
3.70	12.1	4855	93	60.6	50.6	67	1.94	2.2		22			4855	1.20	57.7	100.3	0.98	0.222	1.1	0.143	0.135	**0.61**
4.03	13.2	575	13	66.5	53.3	7	2.64	3.1	Clay-Like	53			575	1.18	6.7	39.4	0.98	0.231	1.0	0.068	0.062	**N/A**
4.35	14.3	508	6	72.3	56.0	6	1.32	3.0	Clay-Like	49			508	1.17	5.9	38.2	0.98	0.239	1.0	0.067	0.061	**N/A**
4.65	15.3	460	5	77.8	58.5	5	1.25	3.1	Clay-Like	53			460	1.16	5.3	37.4	0.98	0.245	1.0	0.067	0.060	**N/A**
4.95	16.2	402	7	83.2	60.9	4	2.10	3.3	Clay-Like	62			402	1.14	4.6	36.4	0.98	0.251	1.0	0.066	0.059	**N/A**
5.25	17.2	354	7	88.6	63.4	3	2.52	3.4	Clay-Like	67			354	1.13	4.0	35.5	0.97	0.256	1.0	0.065	0.059	**N/A**
5.55	18.2	412	6	94.0	65.9	4	1.81	3.2	Clay-Like	58			412	1.12	4.6	36.4	0.97	0.261	1.0	0.066	0.059	**N/A**
5.85	19.2	440	7	99.4	68.4	4	1.97	3.2	Clay-Like	58			440	1.11	4.8	36.8	0.97	0.266	1.0	0.066	0.059	**N/A**
6.15	20.2	508	7	104.9	70.9	5	1.66	3.1	Clay-Like	53			508	1.10	5.5	37.8	0.97	0.270	1.0	0.067	0.060	**N/A**
6.45	21.2	421	7	110.3	73.3	4	2.16	3.3	Clay-Like	62			421	1.09	4.5	36.3	0.96	0.273	1.0	0.066	0.059	**N/A**
6.75	22.2	546	7	115.8	75.8	5	1.56	3.1	Clay-Like	53			546	1.08	5.8	38.2	0.96	0.277	1.0	0.067	0.060	**N/A**
7.05	23.1	555	9	121.2	78.3	5	1.98	3.2	Clay-Like	58			555	1.07	5.9	38.2	0.96	0.280	1.0	0.067	0.060	**N/A**
7.35	24.1	498	7	126.6	80.8	4	1.80	3.2	Clay-Like	58			498	1.06	5.2	37.3	0.96	0.282	1.0	0.067	0.059	**N/A**
7.65	25.1	527	8	132.0	83.3	4	1.94	3.2	Clay-Like	58			527	1.05	5.5	37.7	0.95	0.285	1.0	0.067	0.059	**N/A**
7.95	26.1	575	8	137.4	85.7	5	1.75	3.2	Clay-Like	58			575	1.04	5.9	38.3	0.95	0.287	1.0	0.067	0.060	**N/A**
8.25	27.1	622	7	142.9	88.2	5	1.40	3.1	Clay-Like	53			622	1.04	6.4	38.9	0.95	0.289	1.0	0.068	0.060	**N/A**
8.55	28.1	670	8	148.3	90.7	5	1.47	3.1	Clay-Like	53			670	1.03	6.8	39.5	0.95	0.291	1.0	0.068	0.060	**N/A**
8.85	29.0	613	8	153.7	93.2	5	1.67	3.1	Clay-Like	53			613	1.02	6.2	38.7	0.94	0.293	1.0	0.068	0.059	**N/A**
9.15	30.0	661	7	159.1	95.7	5	1.34	3.1	Clay-Like	53			661	1.01	6.6	39.3	0.94	0.295	1.0	0.068	0.060	**N/A**
9.45	31.0	996	5	164.5	98.1	8	0.58	2.7	Clay-Like	37			996	1.01	9.9	43.3	0.94	0.296	1.0	0.071	0.063	**N/A**
9.75	32.0	814	4	170.0	100.6	6	0.59	2.8	Clay-Like	41			814	1.00	8.1	41.0	0.93	0.297	1.0	0.069	0.061	**N/A**
10.05	33.0	699	8	175.4	103.1	5	1.46	3.1	Clay-Like	53			699	0.99	6.9	39.6	0.93	0.298	1.0	0.068	0.060	**N/A**
10.35	34.0	651	5	180.8	105.6	5	1.02	3.1	Clay-Like	53			651	0.99	6.4	38.9	0.93	0.299	1.0	0.068	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	670	11	186.2	108.1	5	2.18	3.2	Clay-Like	58			670	0.98	6.5	39.1	0.92	0.300	1.0	0.068	0.059	**N/A**
10.95	35.9	2959	58	191.6	110.5	26	2.11	2.6	Clay-Like	34			2959	0.98	28.6	68.0	0.92	0.301	1.0	0.097	0.084	**N/A**
11.25	36.9	2346	48	197.1	113.0	20	2.23	2.7	Clay-Like	37			2346	0.97	22.5	60.3	0.92	0.302	1.0	0.088	0.077	**N/A**
11.55	37.9	4223	85	202.5	115.5	37	2.12	2.4		27			4223	0.97	40.4	81.8	0.91	0.302	1.0	0.115	0.100	**0.33**
11.85	38.9	6224	160	208.0	118.0	55	2.66	2.4		27			6224	0.96	59.1	106.7	0.91	0.303	1.0	0.154	0.132	**0.44**
12.15	39.9	7843	154	213.4	120.5	69	2.02	2.2		22			7843	0.95	74.1	121.6	0.91	0.303	1.0	0.183	0.157	**0.52**
12.45	40.9	17122	463	218.8	123.0	151	2.74	2.1		19			17122	0.95	160.9	228.2	0.91	0.304	0.9	2.000	1.648	**2.00**
12.75	41.8	17323	554	224.2	125.4	152	3.24	2.2		22			17323	0.94	162.0	235.5	0.90	0.304	0.9	2.000	1.638	**2.00**
13.05	42.8	16241	354	229.6	127.9	141	2.21	2.0		17			16241	0.94	151.1	208.2	0.90	0.304	0.9	1.712	1.397	**2.00**
13.35	43.8	14613	325	235.1	130.4	125	2.26	2.1		19			14613	0.93	135.3	195.5	0.90	0.304	0.9	0.934	0.766	**2.00**
13.65	44.8	13627	353	240.5	132.9	115	2.64	2.2		22			13627	0.93	125.5	188.2	0.89	0.304	0.9	0.703	0.577	**1.90**
13.95	45.8	16250	247	245.9	135.4	137	1.54	1.9		15			16250	0.93	148.9	196.2	0.89	0.304	0.9	0.961	0.780	**2.00**
14.25	46.8	16279	344	251.3	137.8	136	2.14	2.0		17			16279	0.92	148.5	204.9	0.89	0.304	0.9	1.445	1.156	**2.00**
14.55	47.7	20387	335	256.8	140.3	169	1.66	1.9		15			20387	0.92	185.1	239.6	0.88	0.304	0.9	2.000	1.579	**2.00**
14.85	48.7	20062	538	262.2	142.8	165	2.72	2.1		19			20062	0.91	181.3	254.1	0.88	0.304	0.9	2.000	1.569	**2.00**
15.15	49.7	21038	562	267.6	145.3	171	2.71	2.1		19			21038	0.91	189.3	264.2	0.88	0.304	0.9	2.000	1.560	**2.00**
15.45	50.7	11271	486	273.1	147.8	90	4.41	2.4		27			11271	0.90	100.9	162.2	0.87	0.304	0.9	0.341	0.278	**0.92**
15.75	51.7	7977	290	278.5	150.2	62	3.77	2.5		30			7977	0.90	71.1	124.0	0.87	0.303	0.9	0.189	0.157	**0.52**
16.05	52.7	19841	591	283.9	152.7	157	3.02	2.1		19			19841	0.90	176.1	247.5	0.86	0.303	0.9	2.000	1.534	**2.00**
16.35	53.6	21824	587	289.3	155.2	172	2.73	2.1		19			21824	0.89	192.9	268.9	0.86	0.303	0.9	2.000	1.526	**2.00**
16.66	54.6	17582	515	294.8	157.7	137	2.98	2.2		22			17582	0.89	154.8	226.2	0.86	0.302	0.9	2.000	1.517	**2.00**
16.95	55.6	16729	363	300.2	160.2	129	2.21	2.1		19			16729	0.89	146.7	210.0	0.85	0.302	0.9	1.899	1.435	**2.00**
17.25	56.6	10601	380	305.6	162.6	80	3.69	2.4		27			10601	0.88	92.6	151.1	0.85	0.301	0.9	0.276	0.223	**0.74**
17.55	57.6	14584	315	311.0	165.1	110	2.21	2.1		19			14584	0.88	126.8	184.8	0.85	0.301	0.9	0.624	0.487	**1.62**
17.85	58.6	7584	270	316.4	167.6	56	3.72	2.5		30			7584	0.87	65.7	116.8	0.84	0.300	0.9	0.173	0.142	**0.47**
18.16	59.6	6579	309	321.9	170.1	48	4.94	2.6	Clay-Like	34			6579	0.87	56.8	105.8	0.84	0.300	0.9	0.152	0.126	**N/A**
18.45	60.5	12420	489	327.3	172.6	91	4.05	2.4		27			12420	0.87	106.8	169.9	0.84	0.299	0.9	0.406	0.319	**1.07**
18.76	61.5	16768	357	332.7	175.1	123	2.17	2.1		19			16768	0.86	143.6	206.1	0.83	0.299	0.8	1.536	1.136	**2.00**
19.03	62.4	10629	413	337.7	177.3	77	4.01	2.4		27			10629	0.86	90.7	148.6	0.83	0.298	0.9	0.265	0.212	**0.71**
19.30	63.3	13493	468	342.7	179.6	97	3.56	2.3		24			13493	0.86	114.8	177.9	0.83	0.297	0.9	0.504	0.388	**1.31**
19.60	64.3	7546	343	348.1	182.1	53	4.76	2.6	Clay-Like	34			7546	0.86	64.0	115.4	0.82	0.297	0.9	0.170	0.138	**N/A**
19.91	65.3	4003	104	353.5	184.6	27	2.86	2.6	Clay-Like	34			4003	0.85	33.8	74.9	0.82	0.296	0.9	0.106	0.088	**N/A**
20.20	66.3	3476	100	358.9	187.0	23	3.19	2.7	Clay-Like	37			3476	0.85	29.3	69.3	0.82	0.295	0.9	0.099	0.082	**N/A**
20.51	67.3	2854	79	364.4	189.5	18	3.19	2.8	Clay-Like	41			2854	0.85	23.9	62.4	0.81	0.295	1.0	0.091	0.075	**N/A**
20.80	68.2	3467	99	369.8	192.0	22	3.19	2.7	Clay-Like	37			3467	0.84	29.0	68.9	0.81	0.294	0.9	0.098	0.081	**N/A**
21.10	69.2	3112	85	375.2	194.5	20	3.11	2.8	Clay-Like	41			3112	0.84	25.9	65.1	0.81	0.293	0.9	0.094	0.078	**N/A**
21.41	70.2	2739	67	380.6	197.0	17	2.84	2.8	Clay-Like	41			2739	0.84	22.7	60.8	0.80	0.293	0.9	0.089	0.074	**N/A**
21.70	71.2	2624	56	386.0	199.4	16	2.52	2.8	Clay-Like	41			2624	0.84	21.7	59.4	0.80	0.292	0.9	0.087	0.072	**N/A**
22.01	72.2	2471	50	391.5	201.9	15	2.40	2.8	Clay-Like	41			2471	0.83	20.4	57.6	0.80	0.291	0.9	0.085	0.071	**N/A**
22.30	73.2	2595	50	396.9	204.4	15	2.27	2.8	Clay-Like	41			2595	0.83	21.3	58.9	0.79	0.290	0.9	0.087	0.072	**N/A**
22.61	74.2	2729	58	402.4	206.9	16	2.51	2.8	Clay-Like	41			2729	0.83	22.4	60.3	0.79	0.289	0.9	0.088	0.073	**N/A**
22.91	75.1	10869	189	407.8	209.4	72	1.80	2.2		22			10869	0.83	88.8	140.6	0.79	0.289	0.9	0.235	0.183	**0.64**
23.20	76.1	11252	362	413.2	211.8	74	3.34	2.4		27			11252	0.82	91.6	149.8	0.78	0.288	0.9	0.271	0.209	**0.73**
23.51	77.1	8025	371	418.6	214.3	52	4.87	2.6	Clay-Like	34			8025	0.82	65.1	117.0	0.78	0.287	0.9	0.173	0.138	**N/A**
23.80	78.1	12487	515	424.0	216.8	81	4.27	2.4		27			12487	0.82	101.1	162.3	0.78	0.286	0.9	0.342	0.259	**0.90**
24.11	79.1	8446	387	429.5	219.3	54	4.83	2.6	Clay-Like	34			8446	0.82	68.2	121.0	0.77	0.285	0.9	0.182	0.144	**N/A**
24.41	80.1	20732	595	434.9	221.8	135	2.93	2.2		22			20732	0.81	166.8	241.7	0.77	0.285	0.8	2.000	1.338	**2.00**
24.71	81.0	10993	568	440.3	224.3	70	5.38	2.5		30			10993	0.81	88.2	146.8	0.77	0.284	0.9	0.258	0.198	**0.70**
25.01	82.0	7048	324	445.7	226.7	44	4.90	2.6	Clay-Like	34			7048	0.81	56.4	105.2	0.76	0.283	0.9	0.151	0.121	**N/A**
25.30	83.0	7010	375	451.1	229.2	43	5.72	2.7	Clay-Like	37			7010	0.81	55.9	105.2	0.76	0.282	0.9	0.151	0.120	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
25.61	84.0	15350	604	456.6	231.7	97	4.06	2.4		27			15350	0.80	122.1	190.2	0.76	0.281	0.8	0.757	0.533	**1.90**
25.91	85.0	10016	431	462.0	234.2	62	4.51	2.5		30			10016	0.80	79.4	135.2	0.75	0.281	0.9	0.217	0.168	**0.60**
26.21	86.0	12200	408	467.4	236.7	76	3.48	2.4		27			12200	0.80	96.5	156.3	0.75	0.280	0.9	0.303	0.227	**0.81**
26.51	86.9	16069	753	472.9	239.1	100	4.83	2.4		27			16069	0.80	126.7	196.4	0.75	0.279	0.8	0.970	0.665	**2.00**
26.81	87.9	16059	632	478.3	241.6	100	4.06	2.3		24			16059	0.79	126.3	193.1	0.75	0.278	0.8	0.846	0.584	**2.00**
27.11	88.9	17304	495	483.7	244.1	107	2.94	2.2		22			17304	0.79	135.7	201.5	0.74	0.277	0.8	1.220	0.817	**2.00**
27.41	89.9	25252	1017	489.1	246.6	157	4.11	2.2		22			25252	0.79	197.6	281.6	0.74	0.277	0.7	2.000	1.282	**2.00**
27.71	90.9	23346	1040	494.6	249.1	144	4.55	2.3		24			23346	0.79	182.2	266.5	0.74	0.276	0.7	2.000	1.277	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-07**

Test Boring Information:

Approx. ground elevation		12	ft	3.66 m
Approx. water table elevation		1.2	ft	0.37 m
Approx. depth to ground water table		10.8	ft	3.29 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	8302	59	2.3	2.3	538	0.72	1.3	Unsaturated	6			8302	1.70	139.7	139.9	1.00	0.189	1.1	0.232	0.223	**N/A**
0.45	1.5	3543	107	7.1	7.1	132	3.03	2.2	Unsaturated	22			3543	1.70	59.6	102.9	1.00	0.189	1.1	0.147	0.142	**N/A**
0.75	2.5	25798	594	11.8	11.8	746	2.30	1.7	Unsaturated	11			25798	1.70	434.2	488.6	1.00	0.189	1.1	2.000	1.927	**N/A**
1.05	3.4	31218	137	16.5	16.5	763	0.44	1.0	Unsaturated	3			31218	1.61	498.6	498.6	1.00	0.189	1.1	2.000	1.927	**N/A**
1.35	4.4	7852	28	21.2	21.2	169	0.35	1.5	Unsaturated	8			7852	1.51	117.3	122.1	1.00	0.188	1.1	0.184	0.177	**N/A**
1.65	5.4	5937	65	25.9	25.9	115	1.10	1.9	Unsaturated	15			5937	1.43	84.2	118.4	1.00	0.188	1.1	0.176	0.170	**N/A**
1.95	6.4	3093	92	30.7	30.7	55	3.00	2.4	Unsaturated	27			3093	1.37	41.9	83.9	1.00	0.188	1.1	0.118	0.114	**N/A**
2.23	7.3	5669	78	35.0	35.0	95	1.38	2.0	Unsaturated	17			5669	1.32	74.2	112.8	0.99	0.187	1.1	0.165	0.159	**N/A**
2.50	8.2	4156	40	39.3	39.3	65	0.98	2.1	Unsaturated	19			4156	1.28	52.8	90.6	0.99	0.187	1.1	0.128	0.122	**N/A**
2.80	9.2	2451	36	44.0	44.0	36	1.51	2.4	Unsaturated	27			2451	1.24	30.2	68.3	0.99	0.187	1.1	0.098	0.091	**N/A**
3.10	10.2	2614	35	48.7	48.7	37	1.38	2.3	Unsaturated	24			2614	1.21	31.4	68.3	0.99	0.186	1.1	0.098	0.091	**N/A**
3.40	11.2	2375	27	53.7	52.6	32	1.16	2.3		24			2375	1.19	27.9	63.8	0.99	0.190	1.1	0.092	0.085	**0.45**
3.70	12.1	2365	11	59.1	55.1	31	0.46	2.2		22			2365	1.17	27.5	61.2	0.98	0.199	1.0	0.089	0.082	**0.41**
4.03	13.2	2518	12	65.0	57.8	32	0.51	2.2		22			2518	1.16	28.9	63.0	0.98	0.208	1.0	0.091	0.083	**0.40**
4.35	14.3	1398	32	70.9	60.5	17	2.38	2.8	Clay-Like	41			1398	1.14	15.8	51.5	0.98	0.216	1.0	0.079	0.072	**N/A**
4.65	15.3	1446	45	76.3	63.0	17	3.29	2.8	Clay-Like	41			1446	1.13	16.2	52.0	0.98	0.223	1.0	0.079	0.072	**N/A**
4.95	16.2	1283	46	81.7	65.5	15	3.83	2.9	Clay-Like	45			1283	1.12	14.2	49.5	0.98	0.230	1.0	0.077	0.070	**N/A**
5.25	17.2	1427	45	87.1	67.9	16	3.36	2.9	Clay-Like	45			1427	1.11	15.7	51.4	0.97	0.235	1.0	0.079	0.071	**N/A**
5.55	18.2	1647	27	92.6	70.4	18	1.72	2.6	Clay-Like	34			1647	1.10	17.9	53.6	0.97	0.241	1.0	0.081	0.073	**N/A**
5.85	19.2	1618	36	98.0	72.9	18	2.39	2.7	Clay-Like	37			1618	1.09	17.5	53.4	0.97	0.245	1.0	0.081	0.073	**N/A**
6.15	20.2	2978	42	103.5	75.4	33	1.47	2.4		27			2978	1.08	31.8	70.5	0.97	0.250	1.0	0.100	0.090	**0.36**
6.45	21.2	2049	50	108.9	77.9	22	2.57	2.7	Clay-Like	37			2049	1.07	21.7	59.2	0.96	0.254	1.0	0.087	0.078	**N/A**
6.75	22.2	2193	39	114.3	80.4	23	1.89	2.6	Clay-Like	34			2193	1.06	23.1	60.5	0.96	0.258	1.0	0.088	0.079	**N/A**
7.05	23.1	4443	91	119.7	82.8	47	2.10	2.4		27			4443	1.05	46.4	89.7	0.96	0.261	1.0	0.127	0.113	**0.43**
7.35	24.1	4740	48	125.1	85.3	50	1.04	2.2		22			4740	1.05	49.1	89.2	0.96	0.264	1.0	0.126	0.112	**0.42**
7.65	25.1	3888	60	130.6	87.8	40	1.61	2.4		27			3888	1.04	39.9	81.2	0.95	0.267	1.0	0.114	0.101	**0.38**
7.95	26.1	5928	107	136.0	90.3	61	1.85	2.2		22			5928	1.03	60.5	103.9	0.95	0.270	1.0	0.149	0.132	**0.49**
8.25	27.1	7038	136	141.4	92.8	71	1.97	2.2		22			7038	1.02	71.3	117.9	0.95	0.272	1.0	0.175	0.155	**0.57**
8.55	28.1	1781	116	146.8	95.2	17	7.09	3.1	Clay-Like	53			1781	1.02	17.9	54.5	0.95	0.275	1.0	0.082	0.072	**N/A**
8.85	29.0	2222	89	152.3	97.7	21	4.30	2.8	Clay-Like	41			2222	1.01	22.2	60.1	0.94	0.277	1.0	0.088	0.077	**N/A**
9.15	30.0	2921	134	157.7	100.2	27	4.85	2.8	Clay-Like	41			2921	1.00	29.0	69.2	0.94	0.279	1.0	0.099	0.086	**N/A**
9.45	31.0	3514	177	163.1	102.7	33	5.29	2.8	Clay-Like	41			3514	1.00	34.6	76.9	0.94	0.280	1.0	0.108	0.095	**N/A**
9.75	32.0	8599	264	168.6	105.2	82	3.13	2.3		24			8599	0.99	84.2	137.8	0.93	0.282	1.0	0.225	0.196	**0.70**
10.05	33.0	1609	93	174.0	107.6	14	6.47	3.1	Clay-Like	53			1609	0.98	15.7	51.5	0.93	0.283	1.0	0.079	0.069	**N/A**
10.35	34.0	1120	6	179.4	110.1	9	0.61	2.7	Clay-Like	37			1120	0.98	10.8	44.5	0.93	0.285	1.0	0.072	0.063	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	1005	5	184.8	112.6	8	0.58	2.8	Clay-Like	41			1005	0.97	9.7	43.2	0.92	0.286	1.0	0.071	0.062	**N/A**
10.95	35.9	910	2	190.2	115.1	7	0.27	2.7	Clay-Like	37			910	0.97	8.7	41.6	0.92	0.287	1.0	0.070	0.061	**N/A**
11.25	36.9	958	3	195.7	117.6	7	0.38	2.7	Clay-Like	37			958	0.96	9.1	42.2	0.92	0.288	1.0	0.070	0.061	**N/A**
11.55	37.9	852	2	201.1	120.0	6	0.29	2.8	Clay-Like	41			852	0.96	8.1	41.0	0.91	0.289	1.0	0.069	0.060	**N/A**
11.85	38.9	958	2	206.5	122.5	7	0.25	2.7	Clay-Like	37			958	0.95	9.0	42.1	0.91	0.290	1.0	0.070	0.061	**N/A**
12.15	39.9	977	3	211.9	125.0	7	0.38	2.8	Clay-Like	41			977	0.95	9.1	42.5	0.91	0.290	1.0	0.071	0.061	**N/A**
12.45	40.9	900	4	217.4	127.5	6	0.56	2.9	Clay-Like	45			900	0.94	8.4	41.6	0.91	0.291	1.0	0.070	0.060	**N/A**
12.75	41.8	948	5	222.8	130.0	6	0.66	2.9	Clay-Like	45			948	0.94	8.8	42.1	0.90	0.291	1.0	0.070	0.061	**N/A**
13.05	42.8	1216	19	228.2	132.4	9	1.94	3.0	Clay-Like	49			1216	0.93	11.2	45.5	0.90	0.292	1.0	0.073	0.063	**N/A**
13.35	43.8	804	6	233.6	134.9	5	1.01	3.0	Clay-Like	49			804	0.93	7.4	40.3	0.90	0.292	1.0	0.069	0.059	**N/A**
13.65	44.8	2097	54	239.0	137.4	16	2.89	2.8	Clay-Like	41			2097	0.92	19.1	56.0	0.89	0.293	1.0	0.084	0.071	**N/A**
13.95	45.8	10055	138	244.5	139.9	82	1.41	2.1		19			10055	0.92	91.4	139.7	0.89	0.293	1.0	0.231	0.193	**0.66**
14.25	46.8	18903	174	249.9	142.4	155	0.93	1.7		11			18903	0.91	170.9	197.8	0.89	0.293	0.9	1.032	0.824	**2.00**
14.55	47.7	11922	237	255.4	144.9	96	2.04	2.1		19			11922	0.91	107.3	160.0	0.88	0.293	0.9	0.326	0.268	**0.91**
14.85	48.7	5736	237	260.8	147.3	45	4.34	2.6	Clay-Like	34			5736	0.91	51.4	98.6	0.88	0.293	1.0	0.140	0.118	**N/A**
15.15	49.7	5822	216	266.2	149.8	45	3.90	2.6	Clay-Like	34			5822	0.90	52.0	99.3	0.88	0.293	1.0	0.141	0.119	**N/A**
15.45	50.7	5430	213	271.6	152.3	42	4.12	2.6	Clay-Like	34			5430	0.90	48.2	94.3	0.87	0.293	1.0	0.133	0.112	**N/A**
15.75	51.7	7795	320	277.0	154.8	60	4.25	2.5		30			7795	0.89	69.0	121.2	0.87	0.293	0.9	0.182	0.151	**0.52**
16.05	52.7	14929	393	282.5	157.3	116	2.68	2.2		22			14929	0.89	131.5	196.0	0.86	0.293	0.9	0.954	0.743	**2.00**
16.35	53.6	23423	375	287.9	159.7	182	1.62	1.9		15			23423	0.89	205.5	264.1	0.86	0.293	0.9	2.000	1.510	**2.00**
16.66	54.6	28048	284	293.3	162.2	216	1.02	1.7		11			28048	0.88	245.1	279.7	0.86	0.292	0.9	2.000	1.502	**2.00**
16.95	55.6	33985	394	298.7	164.7	261	1.17	1.7		11			33985	0.88	295.8	335.7	0.85	0.292	0.9	2.000	1.494	**2.00**
17.25	56.6	35086	388	304.1	167.2	267	1.12	1.6		10			35086	0.88	304.1	326.8	0.85	0.292	0.8	2.000	1.486	**2.00**
17.55	57.6	27330	239	309.6	169.7	206	0.89	1.6		10			27330	0.87	236.0	254.7	0.85	0.291	0.8	2.000	1.479	**2.00**
17.85	58.6	8819	316	315.0	172.2	64	3.72	2.4		27			8819	0.87	75.9	128.9	0.84	0.291	0.9	0.200	0.163	**0.56**
18.16	59.6	9375	359	320.5	174.6	68	3.97	2.4		27			9375	0.87	80.3	134.8	0.84	0.291	0.9	0.216	0.175	**0.60**
18.45	60.5	16375	458	325.9	177.1	120	2.85	2.2		22			16375	0.86	139.8	206.8	0.84	0.290	0.8	1.588	1.169	**2.00**
18.76	61.5	18443	359	331.3	179.6	134	1.98	2.0		17			18443	0.86	156.9	215.3	0.83	0.290	0.8	2.000	1.449	**2.00**
19.03	62.4	16538	658	336.3	181.9	119	4.06	2.3		24			16538	0.86	140.2	211.3	0.83	0.289	0.8	2.000	1.442	**2.00**
19.30	63.3	16049	530	341.2	184.1	115	3.37	2.2		22			16049	0.85	135.6	201.3	0.83	0.289	0.8	1.211	0.891	**2.00**
19.60	64.3	24783	349	346.6	186.6	178	1.43	1.8		13			24783	0.85	208.7	254.2	0.82	0.288	0.8	2.000	1.429	**2.00**
19.91	65.3	23375	416	352.1	189.1	166	1.81	1.9		15			23375	0.85	196.1	252.9	0.82	0.288	0.8	2.000	1.422	**2.00**
20.20	66.3	18491	297	357.5	191.6	130	1.64	2.0		17			18491	0.84	154.6	212.5	0.82	0.287	0.8	2.000	1.415	**2.00**
20.51	67.3	4606	169	362.9	194.1	30	3.97	2.7	Clay-Like	37			4606	0.84	38.4	81.6	0.81	0.287	0.9	0.115	0.095	**N/A**
20.80	68.2	4434	196	368.3	196.6	29	4.83	2.8	Clay-Like	41			4434	0.84	36.8	79.8	0.81	0.286	0.9	0.112	0.092	**N/A**
21.10	69.2	8369	338	373.7	199.0	56	4.23	2.5		30			8369	0.84	69.3	121.6	0.81	0.285	0.9	0.183	0.147	**0.51**
21.41	70.2	17208	303	379.2	201.5	118	1.80	2.0		17			17208	0.83	142.0	196.9	0.80	0.285	0.8	0.990	0.715	**2.00**
21.70	71.2	13703	257	384.6	204.0	93	1.93	2.1		19			13703	0.83	112.7	166.8	0.80	0.284	0.9	0.378	0.288	**1.01**
22.01	72.2	3112	57	390.1	206.5	19	2.11	2.7	Clay-Like	37			3112	0.83	25.5	64.3	0.80	0.284	0.9	0.093	0.077	**N/A**
22.30	73.2	5717	291	395.5	209.0	37	5.47	2.7	Clay-Like	37			5717	0.83	46.7	92.8	0.79	0.283	0.9	0.131	0.106	**N/A**
22.61	74.2	10208	485	400.9	211.4	67	4.94	2.5		30			10208	0.82	83.2	140.1	0.79	0.282	0.9	0.233	0.182	**0.64**
22.91	75.1	23413	450	406.3	213.9	156	1.96	2.0		17			23413	0.82	190.2	256.6	0.79	0.281	0.8	2.000	1.357	**2.00**
23.20	76.1	13071	360	411.7	216.4	86	2.84	2.3		24			13071	0.82	105.9	166.2	0.78	0.281	0.9	0.372	0.280	**1.00**
23.51	77.1	9710	489	417.2	218.9	62	5.27	2.6	Clay-Like	34			9710	0.82	78.4	134.8	0.78	0.280	0.9	0.216	0.169	**N/A**
23.80	78.1	19736	520	422.6	221.4	129	2.69	2.1		19			19736	0.81	158.9	225.5	0.78	0.279	0.8	2.000	1.339	**2.00**
24.11	79.1	33784	353	428.0	223.9	222	1.06	1.7		11			33784	0.81	271.1	308.5	0.77	0.279	0.8	2.000	1.333	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-08**

Test Boring Information:

Approx. ground elevation		12	ft	3.66 m
Approx. water table elevation		2.7	ft	0.82 m
Approx. depth to ground water table		9.3	ft	2.84 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	9586	75	2.3	2.3	621	0.78	1.3	Unsaturated	6			9586	1.70	161.3	161.5	1.00	0.189	1.1	0.336	0.324	**N/A**
0.45	1.5	12736	209	7.1	7.1	475	1.64	1.6	Unsaturated	10			12736	1.70	214.4	231.8	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	32539	172	11.8	11.8	941	0.53	1.1	Unsaturated	4			32539	1.70	547.7	547.7	1.00	0.189	1.1	2.000	1.927	**N/A**
1.05	3.4	18118	122	16.5	16.5	443	0.67	1.3	Unsaturated	6			18118	1.61	289.4	289.6	1.00	0.189	1.1	2.000	1.927	**N/A**
1.35	4.4	7230	177	21.2	21.2	155	2.46	2.1	Unsaturated	19			7230	1.51	108.0	160.9	1.00	0.188	1.1	0.332	0.320	**N/A**
1.65	5.4	6445	174	25.9	25.9	125	2.72	2.1	Unsaturated	19			6445	1.43	91.3	139.7	1.00	0.188	1.1	0.231	0.223	**N/A**
1.95	6.4	4893	77	30.7	30.7	87	1.58	2.1	Unsaturated	19			4893	1.37	66.3	107.9	1.00	0.188	1.1	0.156	0.150	**N/A**
2.23	7.3	2413	55	35.0	35.0	40	2.30	2.4	Unsaturated	27			2413	1.32	31.6	70.2	0.99	0.187	1.1	0.100	0.095	**N/A**
2.50	8.2	3141	51	39.3	39.3	49	1.64	2.3	Unsaturated	24			3141	1.28	39.9	79.5	0.99	0.187	1.1	0.112	0.106	**N/A**
2.80	9.2	1580	51	44.0	44.0	23	3.30	2.7	Unsaturated	37			1580	1.24	19.5	56.1	0.99	0.187	1.1	0.084	0.078	**N/A**
3.10	10.2	1436	56	49.4	46.8	20	4.07	2.8	Clay-Like	41			1436	1.23	17.4	53.6	0.99	0.197	1.1	0.081	0.075	**N/A**
3.40	11.2	1685	62	54.8	49.2	23	3.82	2.8	Clay-Like	41			1685	1.21	20.2	57.3	0.99	0.207	1.1	0.085	0.078	**N/A**
3.70	12.1	1101	48	60.2	51.7	14	4.60	3.0	Clay-Like	49			1101	1.19	13.0	47.9	0.98	0.216	1.0	0.075	0.069	**N/A**
4.03	13.2	977	39	66.1	54.4	12	4.31	3.0	Clay-Like	49			977	1.18	11.4	45.7	0.98	0.225	1.0	0.073	0.067	**N/A**
4.35	14.3	1178	45	72.0	57.1	15	4.07	2.9	Clay-Like	45			1178	1.16	13.6	48.6	0.98	0.233	1.0	0.076	0.069	**N/A**
4.65	15.3	1580	76	77.4	59.6	19	5.03	2.9	Clay-Like	45			1580	1.15	18.0	54.5	0.98	0.240	1.0	0.082	0.075	**N/A**
4.95	16.2	1216	53	82.8	62.1	14	4.65	3.0	Clay-Like	49			1216	1.14	13.7	48.8	0.98	0.245	1.0	0.076	0.069	**N/A**
5.25	17.2	1408	51	88.2	64.5	16	3.85	2.9	Clay-Like	45			1408	1.13	15.7	51.4	0.97	0.251	1.0	0.079	0.071	**N/A**
5.55	18.2	1245	46	93.7	67.0	14	3.99	3.0	Clay-Like	49			1245	1.11	13.7	48.9	0.97	0.256	1.0	0.076	0.069	**N/A**
5.85	19.2	1302	46	99.1	69.5	14	3.82	2.9	Clay-Like	45			1302	1.10	14.2	49.5	0.97	0.260	1.0	0.077	0.069	**N/A**
6.15	20.2	1168	39	104.5	72.0	12	3.69	3.0	Clay-Like	49			1168	1.09	12.6	47.4	0.97	0.264	1.0	0.075	0.067	**N/A**
6.45	21.2	1800	38	109.9	74.5	19	2.27	2.7	Clay-Like	37			1800	1.08	19.3	55.9	0.96	0.268	1.0	0.083	0.075	**N/A**
6.75	22.2	1312	19	115.4	77.0	14	1.60	2.7	Clay-Like	37			1312	1.07	14.0	48.7	0.96	0.272	1.0	0.076	0.068	**N/A**
7.05	23.1	1685	29	120.8	79.4	17	1.84	2.7	Clay-Like	37			1685	1.07	17.8	53.9	0.96	0.275	1.0	0.081	0.072	**N/A**
7.35	24.1	1867	38	126.2	81.9	19	2.20	2.7	Clay-Like	37			1867	1.06	19.5	56.2	0.96	0.278	1.0	0.084	0.075	**N/A**
7.65	25.1	1934	30	131.7	84.4	19	1.65	2.6	Clay-Like	34			1934	1.05	20.1	56.5	0.95	0.280	1.0	0.084	0.075	**N/A**
7.95	26.1	3993	122	137.1	86.9	41	3.15	2.5		30			3993	1.04	41.1	84.0	0.95	0.283	1.0	0.118	0.105	**0.37**
8.25	27.1	13301	681	142.5	89.4	138	5.17	2.3		24			13301	1.03	136.0	205.8	0.95	0.285	1.0	1.514	1.372	**2.00**
8.55	28.1	7000	170	147.9	91.8	71	2.49	2.3		24			7000	1.03	71.1	120.5	0.95	0.287	1.0	0.181	0.160	**0.56**
8.85	29.0	910	12	153.4	94.3	8	1.65	3.0	Clay-Like	49			910	1.02	9.2	42.7	0.94	0.289	1.0	0.071	0.062	**N/A**
9.15	30.0	967	11	158.8	96.8	8	1.42	2.9	Clay-Like	45			967	1.01	9.7	43.3	0.94	0.290	1.0	0.071	0.063	**N/A**
9.45	31.0	776	8	164.2	99.3	6	1.25	3.0	Clay-Like	49			776	1.00	7.7	40.7	0.94	0.292	1.0	0.069	0.061	**N/A**
9.75	32.0	757	8	169.6	101.8	6	1.31	3.0	Clay-Like	49			757	1.00	7.5	40.4	0.93	0.293	1.0	0.069	0.060	**N/A**
10.05	33.0	718	10	175.0	104.2	5	1.76	3.1	Clay-Like	53			718	0.99	7.1	39.8	0.93	0.294	1.0	0.068	0.060	**N/A**
10.35	34.0	747	9	180.5	106.7	5	1.52	3.1	Clay-Like	53			747	0.99	7.3	40.2	0.93	0.296	1.0	0.069	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	747	9	185.9	109.2	5	1.54	3.1	Clay-Like	53			747	0.98	7.2	40.1	0.92	0.297	1.0	0.069	0.060	**N/A**
10.95	35.9	689	10	191.3	111.7	5	1.92	3.2	Clay-Like	58			689	0.97	6.6	39.3	0.92	0.297	1.0	0.068	0.059	**N/A**
11.25	36.9	785	9	196.7	114.2	5	1.46	3.1	Clay-Like	53			785	0.97	7.5	40.5	0.92	0.298	1.0	0.069	0.060	**N/A**
11.55	37.9	833	10	202.1	116.6	6	1.52	3.0	Clay-Like	49			833	0.96	7.9	41.0	0.91	0.299	1.0	0.069	0.060	**N/A**
11.85	38.9	881	11	207.6	119.1	6	1.56	3.0	Clay-Like	49			881	0.96	8.4	41.6	0.91	0.299	1.0	0.070	0.061	**N/A**
12.15	39.9	852	11	213.0	121.6	6	1.65	3.1	Clay-Like	53			852	0.95	8.0	41.2	0.91	0.300	1.0	0.070	0.060	**N/A**
12.45	40.9	843	11	218.5	124.1	6	1.69	3.1	Clay-Like	53			843	0.95	7.9	41.0	0.91	0.300	1.0	0.069	0.060	**N/A**
12.75	41.8	2145	11	223.9	126.6	17	0.60	2.5		30			2145	0.94	20.0	55.8	0.90	0.301	1.0	0.083	0.072	**0.24**
13.05	42.8	871	11	229.3	129.0	6	1.64	3.1	Clay-Like	53			871	0.94	8.1	41.2	0.90	0.301	1.0	0.070	0.060	**N/A**
13.35	43.8	948	5	234.7	131.5	6	0.67	2.9	Clay-Like	45			948	0.93	8.8	42.1	0.90	0.301	1.0	0.070	0.061	**N/A**
13.65	44.8	1341	13	240.1	134.0	9	1.22	2.8	Clay-Like	41			1341	0.93	12.3	46.8	0.89	0.301	1.0	0.074	0.064	**N/A**
13.95	45.8	1513	13	245.6	136.5	11	1.06	2.7	Clay-Like	37			1513	0.92	13.8	48.6	0.89	0.301	1.0	0.076	0.065	**N/A**
14.25	46.8	1484	6	251.0	139.0	10	0.47	2.6	Clay-Like	34			1484	0.92	13.5	47.7	0.89	0.301	1.0	0.075	0.064	**N/A**
14.55	47.7	3783	23	256.4	141.5	29	0.65	2.3		24			3783	0.91	34.3	72.1	0.88	0.301	1.0	0.102	0.087	**0.29**
14.85	48.7	24189	248	261.8	143.9	198	1.04	1.7		11			24189	0.91	218.1	249.9	0.88	0.301	0.9	2.000	1.565	**2.00**
15.15	49.7	37184	493	267.2	146.4	303	1.34	1.7		11			37184	0.91	333.8	377.7	0.88	0.301	0.9	2.000	1.556	**2.00**
15.45	50.7	33277	503	272.7	148.9	269	1.52	1.7		11			33277	0.90	297.4	337.5	0.87	0.301	0.9	2.000	1.547	**2.00**
15.75	51.7	29485	475	278.1	151.4	236	1.63	1.8		13			29485	0.90	262.4	316.2	0.87	0.301	0.9	2.000	1.539	**2.00**
16.05	52.7	27924	358	283.6	153.9	221	1.30	1.7		11			27924	0.89	247.4	282.3	0.86	0.300	0.9	2.000	1.530	**2.00**
16.35	53.6	30902	481	289.0	156.3	243	1.57	1.8		13			30902	0.89	272.6	328.1	0.86	0.300	0.9	2.000	1.522	**2.00**
16.66	54.6	22896	377	294.4	158.8	178	1.67	1.9		15			22896	0.89	201.2	258.9	0.86	0.300	0.9	2.000	1.513	**2.00**
16.95	55.6	18252	347	299.8	161.3	140	1.93	2.0		17			18252	0.88	159.7	218.9	0.85	0.299	0.9	2.000	1.505	**2.00**
17.25	56.6	4204	133	305.2	163.8	30	3.41	2.7	Clay-Like	37			4204	0.88	36.6	79.3	0.85	0.299	1.0	0.112	0.093	**N/A**
17.55	57.6	4951	182	310.7	166.3	36	3.92	2.6	Clay-Like	34			4951	0.88	43.0	87.3	0.85	0.298	1.0	0.123	0.102	**N/A**
17.85	58.6	13684	327	316.1	168.7	102	2.45	2.2		22			13684	0.87	118.3	178.9	0.84	0.298	0.9	0.519	0.405	**1.36**
18.16	59.6	33411	358	321.5	171.2	251	1.08	1.6		10			33411	0.87	287.8	309.5	0.84	0.297	0.8	2.000	1.474	**2.00**
18.45	60.5	46740	455	326.9	173.7	350	0.98	1.5		8			46740	0.87	401.1	412.6	0.84	0.297	0.8	2.000	1.466	**2.00**
18.76	61.5	32156	470	332.4	176.2	238	1.48	1.8		13			32156	0.86	274.9	330.7	0.83	0.296	0.8	2.000	1.459	**2.00**
19.03	62.4	9298	424	337.3	178.5	67	4.73	2.5		30			9298	0.86	79.2	134.9	0.83	0.296	0.9	0.216	0.174	**0.59**
19.30	63.3	13991	598	342.3	180.7	101	4.38	2.4		27			13991	0.86	118.8	185.9	0.83	0.295	0.9	0.648	0.493	**1.67**
19.60	64.3	27129	802	347.7	183.2	197	3.00	2.1		19			27129	0.85	229.5	315.4	0.82	0.295	0.8	2.000	1.438	**2.00**
19.91	65.3	37615	810	353.2	185.7	272	2.17	1.9		15			37615	0.85	317.1	398.2	0.82	0.294	0.8	2.000	1.431	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-09**

Test Boring Information:

Approx. ground elevation		11	ft	3.35 m
Approx. water table elevation		3.5	ft	1.07 m
Approx. depth to ground water table		7.5	ft	2.29 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	9442	52	2.3	2.3	612	0.55	1.2	Unsaturated	4			9442	1.70	158.9	158.9	1.00	0.189	1.1	0.319	0.307	**N/A**
0.45	1.5	17131	112	7.1	7.1	639	0.65	1.2	Unsaturated	4			17131	1.70	288.4	288.4	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	6244	53	11.8	11.8	180	0.85	1.7	Unsaturated	11			6244	1.70	105.1	125.1	1.00	0.189	1.1	0.191	0.184	**N/A**
1.05	3.4	4089	21	16.5	16.5	100	0.52	1.7	Unsaturated	11			4089	1.61	65.3	81.2	1.00	0.189	1.1	0.114	0.110	**N/A**
1.35	4.4	2978	15	21.2	21.2	64	0.52	1.9	Unsaturated	15			2978	1.51	44.5	70.8	1.00	0.188	1.1	0.101	0.097	**N/A**
1.65	5.4	2250	8	25.9	25.9	43	0.34	2.0	Unsaturated	17			2250	1.43	31.9	60.3	1.00	0.188	1.1	0.088	0.085	**N/A**
1.95	6.4	2815	41	30.7	30.7	50	1.48	2.3	Unsaturated	24			2815	1.37	38.2	77.3	1.00	0.188	1.1	0.109	0.105	**N/A**
2.23	7.3	14594	151	35.0	35.0	245	1.04	1.6	Unsaturated	10			14594	1.32	191.1	207.2	0.99	0.187	1.1	1.629	1.570	**N/A**
2.50	8.2	6387	55	39.8	37.7	103	0.86	1.9		15			6387	1.30	82.0	115.8	0.99	0.197	1.1	0.171	0.165	**0.83**
2.80	9.2	3064	48	45.3	40.2	47	1.59	2.3		24			3064	1.28	38.7	78.0	0.99	0.210	1.1	0.110	0.104	**0.50**
3.10	10.2	5190	72	50.7	42.7	78	1.40	2.1		19			5190	1.26	64.5	105.5	0.99	0.221	1.1	0.152	0.146	**0.66**
3.40	11.2	4204	21	56.1	45.1	61	0.51	1.9		15			4204	1.24	51.5	79.2	0.99	0.231	1.1	0.111	0.105	**0.45**
3.70	12.1	2404	22	61.5	47.6	34	0.94	2.3		24			2404	1.22	29.0	65.2	0.98	0.240	1.1	0.094	0.087	**0.36**
4.03	13.2	4702	52	67.4	50.3	65	1.12	2.1		19			4702	1.20	55.9	94.6	0.98	0.248	1.1	0.134	0.126	**0.51**
4.35	14.3	2346	17	73.3	53.0	31	0.76	2.3		24			2346	1.19	27.5	63.3	0.98	0.255	1.1	0.092	0.084	**0.33**
4.65	15.3	1724	22	78.7	55.5	22	1.34	2.5		30			1724	1.17	20.0	55.7	0.98	0.261	1.0	0.083	0.076	**0.29**
4.95	16.2	2394	39	84.1	58.0	30	1.70	2.5		30			2394	1.16	27.4	65.7	0.98	0.267	1.0	0.094	0.086	**0.32**
5.25	17.2	3955	71	89.5	60.4	49	1.83	2.3		24			3955	1.15	44.8	86.0	0.97	0.272	1.0	0.121	0.111	**0.41**
5.55	18.2	2317	30	95.0	62.9	28	1.34	2.4		27			2317	1.13	26.0	62.7	0.97	0.276	1.0	0.091	0.083	**0.30**
5.85	19.2	3447	46	100.4	65.4	41	1.37	2.3		24			3447	1.12	38.3	77.4	0.97	0.280	1.0	0.109	0.099	**0.35**
6.15	20.2	10131	115	105.8	67.9	121	1.15	1.9		15			10131	1.11	111.4	151.1	0.97	0.284	1.1	0.276	0.258	**0.91**
6.45	21.2	8714	67	111.2	70.4	102	0.78	1.8		13			8714	1.10	94.9	122.9	0.96	0.287	1.0	0.186	0.170	**0.59**
6.75	22.2	9212	62	116.7	72.9	106	0.68	1.8		13			9212	1.09	99.4	128.1	0.96	0.290	1.0	0.198	0.181	**0.62**
7.05	23.1	9155	92	122.1	75.3	103	1.02	1.9		15			9155	1.08	97.9	134.9	0.96	0.293	1.0	0.217	0.198	**0.67**
7.35	24.1	10601	126	127.5	77.8	118	1.21	1.9		15			10601	1.07	112.4	152.4	0.96	0.295	1.0	0.283	0.258	**0.87**
7.65	25.1	12008	112	132.9	80.3	132	0.94	1.8		13			12008	1.06	126.3	159.1	0.95	0.297	1.0	0.320	0.292	**0.98**
7.95	26.1	9499	134	138.4	82.8	102	1.43	2.0		17			9499	1.05	99.1	143.7	0.95	0.299	1.0	0.245	0.221	**0.74**
8.25	27.1	8628	132	143.8	85.3	91	1.56	2.1		19			8628	1.05	89.3	137.1	0.95	0.301	1.0	0.223	0.200	**0.66**
8.55	28.1	6052	132	149.2	87.7	63	2.24	2.3		24			6052	1.04	62.2	108.8	0.95	0.303	1.0	0.158	0.140	**0.46**
8.85	29.0	4759	113	154.7	90.2	48	2.45	2.4		27			4759	1.03	48.5	92.7	0.94	0.304	1.0	0.131	0.116	**0.38**
9.15	30.0	2767	114	160.1	92.7	27	4.37	2.8	Clay-Like	41			2767	1.02	28.0	67.9	0.94	0.306	1.0	0.097	0.086	**N/A**
9.45	31.0	6799	134	165.5	95.2	68	2.02	2.2		22			6799	1.02	68.4	114.2	0.94	0.307	1.0	0.168	0.148	**0.48**
9.75	32.0	3993	46	170.9	97.7	38	1.20	2.3		24			3993	1.01	39.9	79.5	0.93	0.308	1.0	0.112	0.098	**0.32**
10.05	33.0	4070	57	176.3	100.1	39	1.48	2.3		24			4070	1.00	40.4	80.2	0.93	0.309	1.0	0.113	0.099	**0.32**
10.35	34.0	7393	126	181.8	102.6	71	1.75	2.2		22			7393	1.00	72.9	120.0	0.93	0.310	1.0	0.180	0.157	**0.51**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	11357	130	187.2	105.1	108	1.17	1.9		15			11357	0.99	111.3	151.0	0.92	0.310	1.0	0.276	0.240	**0.77**
10.95	35.9	5420	106	192.6	107.6	50	2.03	2.3		24			5420	0.98	52.8	96.5	0.92	0.311	1.0	0.137	0.119	**0.38**
11.25	36.9	7565	117	198.0	110.1	70	1.59	2.2		22			7565	0.98	73.2	120.5	0.92	0.311	1.0	0.181	0.156	**0.50**
11.55	37.9	4453	163	203.4	112.6	40	3.83	2.6	Clay-Like	34			4453	0.97	42.8	87.1	0.91	0.312	1.0	0.123	0.106	**N/A**
11.85	38.9	1733	46	208.9	115.0	14	3.02	2.9	Clay-Like	45			1733	0.97	16.6	52.7	0.91	0.312	1.0	0.080	0.069	**N/A**
12.15	39.9	1053	16	214.3	117.5	8	1.94	3.0	Clay-Like	49			1053	0.96	10.0	43.9	0.91	0.312	1.0	0.072	0.062	**N/A**
12.45	40.9	967	16	219.8	120.0	7	2.18	3.1	Clay-Like	53			967	0.96	9.2	42.7	0.91	0.312	1.0	0.071	0.061	**N/A**
12.75	41.8	938	17	225.2	122.5	6	2.42	3.1	Clay-Like	53			938	0.95	8.8	42.2	0.90	0.313	1.0	0.070	0.061	**N/A**
13.05	42.8	1264	16	230.6	125.0	9	1.58	2.9	Clay-Like	45			1264	0.95	11.8	46.2	0.90	0.313	1.0	0.074	0.064	**N/A**
13.35	43.8	910	11	236.0	127.4	6	1.71	3.1	Clay-Like	53			910	0.94	8.5	41.8	0.90	0.313	1.0	0.070	0.060	**N/A**
13.65	44.8	833	10	241.4	129.9	5	1.62	3.1	Clay-Like	53			833	0.94	7.7	40.7	0.89	0.312	1.0	0.069	0.060	**N/A**
13.95	45.8	862	12	246.9	132.4	5	2.02	3.1	Clay-Like	53			862	0.93	7.9	41.0	0.89	0.312	1.0	0.069	0.060	**N/A**
14.25	46.8	1781	15	252.3	134.9	13	1.00	2.7	Clay-Like	37			1781	0.93	16.3	51.9	0.89	0.312	1.0	0.079	0.068	**N/A**
14.55	47.7	10333	35	257.7	137.4	85	0.35	1.7		11			10333	0.92	94.3	113.2	0.88	0.312	1.0	0.166	0.140	**0.45**
14.85	48.7	19047	66	263.1	139.8	158	0.35	1.5		8			19047	0.92	173.1	179.2	0.88	0.312	0.9	0.523	0.427	**1.37**
15.15	49.7	12525	67	268.5	142.3	102	0.55	1.7		11			12525	0.91	113.3	134.1	0.88	0.311	1.0	0.214	0.179	**0.57**
15.45	50.7	13588	101	274.0	144.8	110	0.76	1.8		13			13588	0.91	122.3	154.5	0.87	0.311	0.9	0.294	0.242	**0.78**
15.75	51.7	10428	242	279.4	147.3	83	2.39	2.2		22			10428	0.91	93.5	146.7	0.87	0.310	0.9	0.257	0.212	**0.68**
16.05	52.7	15973	251	284.8	149.8	127	1.60	2.0		17			15973	0.90	142.5	197.5	0.86	0.310	0.9	1.019	0.803	**2.00**
16.35	53.6	11893	374	290.2	152.3	93	3.23	2.3		24			11893	0.90	105.7	166.0	0.86	0.310	0.9	0.370	0.300	**0.97**
16.66	54.6	8618	463	295.7	154.7	66	5.57	2.6	Clay-Like	34			8618	0.89	76.2	131.9	0.86	0.309	0.9	0.208	0.172	**N/A**
16.95	55.6	12200	467	301.1	157.2	94	3.93	2.4		27			12200	0.89	107.5	170.9	0.85	0.308	0.9	0.416	0.333	**1.08**
17.25	56.6	11903	425	306.5	159.7	91	3.67	2.3		24			11903	0.89	104.4	164.3	0.85	0.308	0.9	0.357	0.287	**0.93**
17.55	57.6	4893	210	312.0	162.2	36	4.58	2.7	Clay-Like	37			4893	0.88	42.8	87.5	0.85	0.307	1.0	0.123	0.103	**N/A**
17.85	58.6	7498	359	317.4	164.7	56	5.00	2.6	Clay-Like	34			7498	0.88	65.3	117.2	0.84	0.307	0.9	0.174	0.143	**N/A**
18.16	59.6	24591	453	322.8	167.1	187	1.87	1.9		15			24591	0.88	213.2	273.3	0.84	0.306	0.8	2.000	1.487	**2.00**
18.45	60.5	35766	505	328.2	169.6	270	1.42	1.7		11			35766	0.87	308.9	350.1	0.84	0.305	0.8	2.000	1.479	**2.00**
18.76	61.5	27799	463	333.7	172.1	208	1.68	1.8		13			27799	0.87	239.1	289.4	0.83	0.305	0.8	2.000	1.471	**2.00**
19.03	62.4	8503	430	338.6	174.4	61	5.27	2.6	Clay-Like	34			8503	0.87	72.9	127.4	0.83	0.304	0.9	0.196	0.160	**N/A**
19.30	63.3	4702	255	343.6	176.7	33	5.84	2.8	Clay-Like	41			4702	0.86	40.2	84.3	0.83	0.303	0.9	0.119	0.098	**N/A**
19.60	64.3	5257	268	349.0	179.1	36	5.46	2.7	Clay-Like	37			5257	0.86	44.7	90.2	0.82	0.302	0.9	0.127	0.105	**N/A**
19.91	65.3	12104	491	354.5	181.6	87	4.18	2.4		27			12104	0.86	102.7	164.4	0.82	0.302	0.9	0.358	0.280	**0.93**
20.20	66.3	13272	639	359.9	184.1	95	4.95	2.4		27			13272	0.85	112.2	177.1	0.82	0.301	0.9	0.491	0.377	**1.25**
20.51	67.3	22973	847	365.3	186.6	164	3.74	2.2		22			22973	0.85	193.5	276.3	0.81	0.300	0.8	2.000	1.429	**2.00**
20.80	68.2	28058	473	370.7	189.1	200	1.71	1.9		15			28058	0.85	235.5	300.1	0.81	0.299	0.8	2.000	1.422	**2.00**
21.10	69.2	16174	532	376.1	191.5	113	3.37	2.2		22			16174	0.84	135.3	200.9	0.81	0.299	0.8	1.185	0.862	**2.00**
21.41	70.2	20435	484	381.6	194.0	143	2.41	2.1		19			20435	0.84	170.3	240.1	0.80	0.298	0.8	2.000	1.408	**2.00**
21.70	71.2	9949	441	387.0	196.5	68	4.62	2.5		30			9949	0.84	82.6	139.4	0.80	0.297	0.9	0.231	0.182	**0.61**
22.01	72.2	13435	614	392.4	199.0	92	4.71	2.4		27			13435	0.84	111.2	175.8	0.80	0.296	0.9	0.475	0.358	**1.21**
22.30	73.2	16758	551	397.8	201.5	115	3.37	2.2		22			16758	0.83	138.3	204.8	0.79	0.295	0.8	1.435	1.016	**2.00**
22.61	74.2	23854	561	403.3	204.0	163	2.39	2.0		17			23854	0.83	196.2	264.1	0.79	0.294	0.8	2.000	1.382	**2.00**
22.91	75.1	16576	276	408.7	206.4	112	1.71	2.0		17			16576	0.83	135.9	189.3	0.79	0.293	0.8	0.732	0.534	**1.82**
23.20	76.1	12889	424	414.1	208.9	86	3.40	2.3		24			12889	0.83	105.4	165.5	0.78	0.293	0.9	0.367	0.278	**0.95**
23.51	77.1	13349	700	419.6	211.4	88	5.41	2.5		30			13349	0.82	108.8	174.3	0.78	0.292	0.9	0.456	0.340	**1.17**
23.80	78.1	34521	474	425.0	213.9	232	1.39	1.8		13			34521	0.82	280.4	337.0	0.78	0.291	0.8	2.000	1.357	**2.00**
24.11	79.1	50600	419	430.4	216.4	339	0.84	1.5		8			50600	0.82	409.8	421.5	0.77	0.290	0.8	2.000	1.351	**2.00**
24.41	80.1	14517	250	435.8	218.8	95	1.77	2.1		19			14517	0.82	117.2	172.6	0.77	0.289	0.8	0.435	0.323	**1.12**
24.71	81.0	5612	54	441.3	221.3	35	1.04	2.3		24			5612	0.81	45.2	86.5	0.77	0.288	0.9	0.122	0.099	**0.34**
25.01	82.0	3811	72	446.7	223.8	22	2.13	2.6	Clay-Like	34			3811	0.81	30.6	70.6	0.76	0.287	0.9	0.100	0.082	**N/A**
25.30	83.0	3189	57	452.1	226.3	18	2.10	2.7	Clay-Like	37			3189	0.81	25.5	64.3	0.76	0.286	0.9	0.093	0.076	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
25.61	84.0	2949	66	457.5	228.8	16	2.65	2.8	Clay-Like	41			2949	0.81	23.5	61.9	0.76	0.286	0.9	0.090	0.074	**N/A**
25.91	85.0	2834	61	462.9	231.2	15	2.58	2.8	Clay-Like	41			2834	0.80	22.6	60.6	0.75	0.285	0.9	0.088	0.073	**N/A**
26.21	86.0	2748	54	468.4	233.7	15	2.35	2.8	Clay-Like	41			2748	0.80	21.8	59.6	0.75	0.284	0.9	0.087	0.072	**N/A**
26.51	86.9	2480	53	473.8	236.2	13	2.63	2.9	Clay-Like	45			2480	0.80	19.6	56.8	0.75	0.283	0.9	0.084	0.069	**N/A**
26.81	87.9	2461	49	479.2	238.7	13	2.46	2.9	Clay-Like	45			2461	0.80	19.4	56.5	0.75	0.282	0.9	0.084	0.069	**N/A**
27.11	88.9	2384	47	484.6	241.2	12	2.47	2.9	Clay-Like	45			2384	0.79	18.8	55.6	0.74	0.281	0.9	0.083	0.068	**N/A**
27.41	89.9	2289	53	490.0	243.6	11	2.93	2.9	Clay-Like	45			2289	0.79	18.0	54.5	0.74	0.281	0.9	0.082	0.067	**N/A**
27.71	90.9	2155	44	495.5	246.1	11	2.66	2.9	Clay-Like	45			2155	0.79	16.9	53.0	0.74	0.280	0.9	0.080	0.066	**N/A**
28.01	91.9	3007	49	500.9	248.6	16	1.95	2.7	Clay-Like	37			3007	0.79	23.5	61.5	0.73	0.279	0.9	0.090	0.073	**N/A**
28.31	92.9	4769	148	506.4	251.1	27	3.48	2.7	Clay-Like	37			4769	0.79	37.1	79.9	0.73	0.278	0.9	0.113	0.090	**N/A**
28.61	93.8	6042	322	511.8	253.6	35	5.82	2.8	Clay-Like	41			6042	0.78	46.9	93.4	0.73	0.277	0.9	0.132	0.105	**N/A**
28.91	94.8	8992	376	517.2	256.1	53	4.44	2.6	Clay-Like	34			8992	0.78	69.7	123.1	0.73	0.277	0.9	0.186	0.144	**N/A**
29.21	95.8	11999	557	522.6	258.5	71	4.86	2.5		30			11999	0.78	92.7	152.9	0.72	0.276	0.8	0.285	0.211	**0.77**
29.51	96.8	7948	353	528.0	261.0	46	4.76	2.6	Clay-Like	34			7948	0.78	61.3	111.8	0.72	0.275	0.9	0.163	0.127	**N/A**
29.81	97.8	18587	327	533.5	263.5	111	1.81	2.1		19			18587	0.78	142.9	205.2	0.72	0.274	0.7	1.467	0.941	**2.00**
30.11	98.8	11807	271	538.9	266.0	69	2.40	2.3		24			11807	0.77	90.5	146.1	0.72	0.274	0.9	0.255	0.190	**0.69**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-10**

Test Boring Information:

Approx. ground elevation		11 ft	3.35 m
Approx. water table elevation		3 ft	0.91 m
Approx. depth to ground water table		8 ft	2.44 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	25855	121	2.3	2.3	1676	0.47	0.9	Unsaturated	2			25855	1.70	435.2	435.2	1.00	0.189	1.1	2.000	1.927	**N/A**
0.45	1.5	23375	286	7.1	7.1	872	1.23	1.4	Unsaturated	7			23375	1.70	393.4	396.2	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	16586	259	11.8	11.8	480	1.56	1.6	Unsaturated	10			16586	1.70	279.2	300.4	1.00	0.189	1.1	2.000	1.927	**N/A**
1.05	3.4	3467	70	16.5	16.5	84	2.03	2.2	Unsaturated	22			3467	1.61	55.4	97.3	1.00	0.189	1.1	0.138	0.133	**N/A**
1.35	4.4	1992	34	21.2	21.2	42	1.70	2.3	Unsaturated	24			1992	1.51	29.8	66.2	1.00	0.188	1.1	0.095	0.092	**N/A**
1.65	5.4	1762	35	25.9	25.9	34	2.04	2.5	Unsaturated	30			1762	1.43	25.0	62.4	1.00	0.188	1.1	0.091	0.087	**N/A**
1.95	6.4	1484	33	30.7	30.7	26	2.24	2.6	Unsaturated	34			1484	1.37	20.1	56.6	1.00	0.188	1.1	0.084	0.080	**N/A**
2.23	7.3	1886	43	35.0	35.0	31	2.33	2.5	Unsaturated	30			1886	1.32	24.7	62.0	0.99	0.187	1.1	0.090	0.086	**N/A**
2.50	8.2	1034	32	39.4	38.8	16	3.18	2.8	Clay-Like	41			1034	1.29	13.2	47.9	0.99	0.190	1.1	0.076	0.071	**N/A**
2.80	9.2	1005	19	44.9	41.3	15	1.99	2.8	Clay-Like	41			1005	1.27	12.6	47.1	0.99	0.203	1.1	0.075	0.070	**N/A**
3.10	10.2	1140	34	50.3	43.8	16	3.08	2.8	Clay-Like	41			1140	1.25	14.1	49.1	0.99	0.214	1.1	0.077	0.071	**N/A**
3.40	11.2	536	11	55.7	46.3	7	2.39	3.1	Clay-Like	53			536	1.23	6.5	39.1	0.99	0.224	1.1	0.068	0.062	**N/A**
3.70	12.1	709	13	61.2	48.8	9	2.07	2.9	Clay-Like	45			709	1.21	8.5	41.7	0.98	0.233	1.0	0.070	0.064	**N/A**
4.03	13.2	1973	56	67.1	51.5	26	2.96	2.7	Clay-Like	37			1973	1.19	23.3	61.3	0.98	0.241	1.1	0.089	0.082	**N/A**
4.35	14.3	1791	63	72.9	54.1	23	3.68	2.8	Clay-Like	41			1791	1.18	20.9	58.3	0.98	0.249	1.0	0.086	0.079	**N/A**
4.65	15.3	2030	57	78.4	56.6	26	2.94	2.7	Clay-Like	37			2030	1.16	23.4	61.4	0.98	0.255	1.0	0.089	0.082	**N/A**
4.95	16.2	1302	46	83.8	59.1	16	3.77	2.9	Clay-Like	45			1302	1.15	14.9	50.3	0.98	0.261	1.0	0.078	0.071	**N/A**
5.25	17.2	1484	33	89.2	61.6	18	2.33	2.7	Clay-Like	37			1484	1.14	16.7	52.5	0.97	0.266	1.0	0.080	0.073	**N/A**
5.55	18.2	1446	48	94.6	64.1	17	3.54	2.9	Clay-Like	45			1446	1.13	16.1	52.1	0.97	0.270	1.0	0.080	0.072	**N/A**
5.85	19.2	1752	80	100.0	66.5	20	4.87	2.9	Clay-Like	45			1752	1.12	19.4	56.4	0.97	0.274	1.0	0.084	0.076	**N/A**
6.15	20.2	4012	86	105.5	69.0	47	2.21	2.4		27			4012	1.11	43.9	86.5	0.97	0.278	1.0	0.122	0.111	**0.40**
6.45	21.2	3419	50	110.9	71.5	39	1.51	2.3		24			3419	1.10	37.1	75.8	0.96	0.282	1.0	0.107	0.097	**0.34**
6.75	22.2	2432	77	116.3	74.0	27	3.31	2.7	Clay-Like	37			2432	1.09	26.1	65.1	0.96	0.285	1.0	0.094	0.084	**N/A**
7.05	23.1	4137	94	121.7	76.5	46	2.34	2.4		27			4137	1.08	44.1	86.7	0.96	0.288	1.0	0.122	0.110	**0.38**
7.35	24.1	1886	100	127.1	79.0	20	5.66	2.9	Clay-Like	45			1886	1.07	19.9	57.2	0.96	0.290	1.0	0.085	0.076	**N/A**
7.65	25.1	2241	67	132.6	81.4	23	3.18	2.7	Clay-Like	37			2241	1.06	23.5	61.5	0.95	0.293	1.0	0.090	0.080	**N/A**
7.95	26.1	2538	64	138.0	83.9	26	2.67	2.6	Clay-Like	34			2538	1.05	26.4	65.0	0.95	0.295	1.0	0.094	0.083	**N/A**
8.25	27.1	2356	55	143.4	86.4	24	2.47	2.6	Clay-Like	34			2356	1.04	24.3	62.2	0.95	0.297	1.0	0.090	0.080	**N/A**
8.55	28.1	1456	41	148.8	88.9	14	3.15	2.9	Clay-Like	45			1456	1.03	14.9	50.4	0.95	0.298	1.0	0.078	0.069	**N/A**
8.85	29.0	728	14	154.3	91.4	6	2.50	3.1	Clay-Like	53			728	1.03	7.4	40.3	0.94	0.300	1.0	0.069	0.061	**N/A**
9.15	30.0	632	9	159.7	93.8	5	1.82	3.2	Clay-Like	58			632	1.02	6.4	38.9	0.94	0.301	1.0	0.068	0.060	**N/A**
9.45	31.0	622	8	165.1	96.3	5	1.68	3.2	Clay-Like	58			622	1.01	6.2	38.7	0.94	0.303	1.0	0.068	0.059	**N/A**
9.75	32.0	527	7	170.6	98.8	4	1.88	3.3	Clay-Like	62			527	1.01	5.2	37.3	0.93	0.304	1.0	0.066	0.058	**N/A**
10.05	33.0	632	4	176.0	101.3	5	0.84	3.0	Clay-Like	49			632	1.00	6.3	38.8	0.93	0.305	1.0	0.068	0.059	**N/A**
10.35	34.0	584	5	181.4	103.8	4	1.19	3.2	Clay-Like	58			584	0.99	5.7	38.0	0.93	0.306	1.0	0.067	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	536	5	186.8	106.2	3	1.37	3.2	Clay-Like	58			536	0.99	5.2	37.4	0.92	0.306	1.0	0.067	0.058	**N/A**
10.95	35.9	766	6	192.2	108.7	5	1.00	3.0	Clay-Like	49			766	0.98	7.4	40.4	0.92	0.307	1.0	0.069	0.060	**N/A**
11.25	36.9	651	6	197.7	111.2	4	1.27	3.1	Clay-Like	53			651	0.97	6.3	38.8	0.92	0.308	1.0	0.068	0.059	**N/A**
11.55	37.9	584	6	203.1	113.7	4	1.51	3.2	Clay-Like	58			584	0.97	5.6	37.9	0.91	0.308	1.0	0.067	0.058	**N/A**
11.85	38.9	747	7	208.5	116.2	5	1.25	3.1	Clay-Like	53			747	0.96	7.1	39.9	0.91	0.308	1.0	0.069	0.060	**N/A**
12.15	39.9	795	8	213.9	118.7	5	1.32	3.1	Clay-Like	53			795	0.96	7.5	40.5	0.91	0.309	1.0	0.069	0.060	**N/A**
12.45	40.9	747	7	219.4	121.1	5	1.27	3.1	Clay-Like	53			747	0.95	7.0	39.8	0.91	0.309	1.0	0.068	0.059	**N/A**
12.75	41.8	1216	6	224.8	123.6	9	0.58	2.7	Clay-Like	37			1216	0.95	11.4	45.3	0.90	0.309	1.0	0.073	0.063	**N/A**
13.05	42.8	785	4	230.2	126.1	5	0.69	3.0	Clay-Like	49			785	0.94	7.3	40.2	0.90	0.309	1.0	0.069	0.059	**N/A**
13.35	43.8	699	6	235.7	128.6	4	1.24	3.1	Clay-Like	53			699	0.94	6.5	39.1	0.90	0.309	1.0	0.068	0.059	**N/A**
13.65	44.8	718	4	241.1	131.1	4	0.80	3.1	Clay-Like	53			718	0.93	6.6	39.3	0.89	0.309	1.0	0.068	0.059	**N/A**
13.95	45.8	900	7	246.5	133.5	6	1.03	3.0	Clay-Like	49			900	0.93	8.3	41.5	0.89	0.309	1.0	0.070	0.060	**N/A**
14.25	46.8	1676	5	251.9	136.0	12	0.34	2.5		30			1676	0.92	15.3	49.5	0.89	0.309	1.0	0.077	0.066	**0.21**
14.55	47.7	6521	24	257.4	138.5	53	0.38	1.9		15			6521	0.92	59.4	88.7	0.88	0.309	1.0	0.125	0.106	**0.34**
14.85	48.7	18166	90	262.8	141.0	150	0.50	1.6		10			18166	0.92	164.7	179.3	0.88	0.309	0.9	0.524	0.427	**1.38**
15.15	49.7	32338	172	268.2	143.5	266	0.54	1.4		7			32338	0.91	291.9	294.1	0.88	0.308	0.9	2.000	1.567	**2.00**
15.45	50.7	22676	141	273.6	146.0	184	0.63	1.6		10			22676	0.91	203.7	220.6	0.87	0.308	0.9	2.000	1.558	**2.00**
15.75	51.7	25463	128	279.0	148.4	205	0.51	1.5		8			25463	0.90	227.8	235.2	0.87	0.308	0.9	2.000	1.549	**2.00**
16.05	52.7	14804	64	284.5	150.9	117	0.44	1.6		10			14804	0.90	131.8	144.5	0.86	0.307	0.9	0.248	0.204	**0.66**
16.35	53.6	3179	75	289.9	153.4	23	2.59	2.7	Clay-Like	37			3179	0.90	28.2	67.9	0.86	0.307	1.0	0.097	0.082	**N/A**
16.66	54.6	3572	62	295.3	155.9	26	1.90	2.5		30			3572	0.89	31.5	71.2	0.86	0.306	1.0	0.101	0.085	**0.28**
16.95	55.6	5717	91	300.7	158.4	43	1.68	2.3		24			5717	0.89	50.3	93.2	0.85	0.306	1.0	0.132	0.110	**0.36**
17.25	56.6	3294	168	306.1	160.8	23	5.61	2.9	Clay-Like	45			3294	0.88	28.8	69.2	0.85	0.305	1.0	0.099	0.083	**N/A**
17.55	57.6	2787	117	311.6	163.3	19	4.72	2.9	Clay-Like	45			2787	0.88	24.3	63.1	0.85	0.305	1.0	0.091	0.077	**N/A**
17.85	58.6	2614	108	317.0	165.8	18	4.71	2.9	Clay-Like	45			2614	0.88	22.7	60.9	0.84	0.304	1.0	0.089	0.075	**N/A**
18.16	59.6	11577	261	322.5	168.3	86	2.32	2.2		22			11577	0.87	100.2	155.4	0.84	0.304	0.9	0.298	0.239	**0.79**
18.45	60.5	25405	324	327.9	170.8	191	1.29	1.8		13			25405	0.87	219.0	266.1	0.84	0.303	0.8	2.000	1.475	**2.00**
18.76	61.5	36475	418	333.3	173.3	273	1.16	1.6		10			36475	0.87	313.2	336.4	0.83	0.302	0.8	2.000	1.468	**2.00**
19.03	62.4	33708	559	338.3	175.5	250	1.68	1.8		13			33708	0.86	288.5	346.3	0.83	0.302	0.8	2.000	1.461	**2.00**
19.30	63.3	25453	464	343.2	177.8	187	1.85	1.9		15			25453	0.86	217.1	278.0	0.83	0.301	0.8	2.000	1.454	**2.00**
19.60	64.3	25290	348	348.6	180.3	185	1.39	1.8		13			25290	0.86	214.9	261.4	0.82	0.300	0.8	2.000	1.447	**2.00**
19.91	65.3	10917	332	354.1	182.8	78	3.15	2.3		24			10917	0.86	92.4	148.6	0.82	0.300	0.9	0.265	0.210	**0.70**
20.20	66.3	10323	389	359.5	185.2	73	3.90	2.4		27			10323	0.85	87.1	143.8	0.82	0.299	0.9	0.246	0.196	**0.65**
20.51	67.3	6895	390	365.0	187.7	47	5.97	2.7	Clay-Like	37			6895	0.85	58.0	108.0	0.81	0.298	0.9	0.156	0.127	**N/A**
20.80	68.2	5889	273	370.4	190.2	40	4.95	2.7	Clay-Like	37			5889	0.85	49.3	96.4	0.81	0.297	0.9	0.137	0.112	**N/A**
21.10	69.2	10754	490	375.8	192.7	74	4.72	2.5		30			10754	0.84	89.8	149.0	0.81	0.296	0.9	0.267	0.210	**0.71**
21.41	70.2	21450	862	381.2	195.2	150	4.09	2.2		22			21450	0.84	178.5	256.9	0.80	0.296	0.8	2.000	1.405	**2.00**
21.70	71.2	9844	485	386.6	197.6	67	5.12	2.5		30			9844	0.84	81.6	138.1	0.80	0.295	0.9	0.226	0.179	**0.61**
22.01	72.2	10974	370	392.1	200.1	74	3.49	2.4		27			10974	0.83	90.7	148.6	0.80	0.294	0.9	0.265	0.207	**0.70**
22.30	73.2	17342	476	397.5	202.6	118	2.81	2.2		22			17342	0.83	142.9	210.8	0.79	0.293	0.8	1.981	1.373	**2.00**
22.61	74.2	17831	542	402.9	205.1	121	3.11	2.2		22			17831	0.83	146.4	215.4	0.79	0.292	0.8	2.000	1.379	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-11**

Test Boring Information:

Approx. ground elevation		11	ft	3.35 m
Approx. water table elevation		4.7	ft	1.43 m
Approx. depth to ground water table		6.3	ft	1.92 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	9528	111	2.3	2.3	617.6	1.17	1.5	Unsaturated	8			9528	1.70	160.4	166.2	1.00	0.189	1.1	0.372	0.359	**N/A**
0.45	1.5	28096	248	7.1	7.1	1047.9	0.88	1.2	Unsaturated	4			28096	1.70	472.9	472.9	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	24495	168	11.8	11.8	708.5	0.68	1.2	Unsaturated	4			24495	1.70	412.3	412.3	1.00	0.189	1.1	2.000	1.927	**N/A**
1.05	3.4	12248	81	16.5	16.5	299.3	0.67	1.4	Unsaturated	7			12248	1.61	195.6	197.3	1.00	0.189	1.1	1.006	0.970	**N/A**
1.35	4.4	9729	59	21.2	21.2	209.3	0.61	1.5	Unsaturated	8			9729	1.51	145.4	150.8	1.00	0.188	1.1	0.275	0.265	**N/A**
1.65	5.4	4654	28	25.9	25.9	90.3	0.60	1.8	Unsaturated	13			4654	1.43	66.0	89.5	1.00	0.188	1.1	0.126	0.122	**N/A**
1.95	6.4	2183	29	30.7	30.4	38.8	1.33	2.3		24			2183	1.37	29.7	66.1	1.00	0.190	1.1	0.095	0.091	**0.48**
2.23	7.3	555	15	35.7	32.7	9.0	2.95	3.0	Clay-Like	49			555	1.35	7.4	40.3	0.99	0.205	1.1	0.069	0.065	**N/A**
2.50	8.2	124	5	40.7	35.0	1.4	5.71	3.9	Clay-Like	96			124	1.61	2.0	32.3	0.99	0.217	1.1	0.063	0.059	**N/A**
2.80	9.2	134	5	46.1	37.5	1.4	5.44	3.8	Clay-Like	90			134	1.53	2.0	32.5	0.99	0.230	1.1	0.063	0.058	**N/A**
3.10	10.2	144	4	51.5	39.9	1.4	4.16	3.8	Clay-Like	90			144	1.47	2.1	32.6	0.99	0.240	1.1	0.063	0.058	**N/A**
3.40	11.2	134	3	56.9	42.4	1.2	3.72	3.8	Clay-Like	90			134	1.45	1.9	32.4	0.99	0.250	1.1	0.063	0.058	**N/A**
3.70	12.1	134	3	62.4	44.9	1.1	4.01	3.9	Clay-Like	96			134	1.42	1.9	32.2	0.98	0.258	1.0	0.063	0.058	**N/A**
4.03	13.2	124	3	68.3	47.6	1.0	5.11	4.0	Clay-Like	103			124	1.40	1.7	31.9	0.98	0.266	1.0	0.063	0.057	**N/A**
4.35	14.3	124	3	74.1	50.3	1.0	5.70	4.0	Clay-Like	103			124	1.37	1.7	31.8	0.98	0.272	1.0	0.063	0.057	**N/A**
4.65	15.3	134	2	79.6	52.8	1.0	3.52	3.9	Clay-Like	96			134	1.32	1.8	32.0	0.98	0.278	1.0	0.063	0.057	**N/A**
4.95	16.2	134	3	85.0	55.2	1.0	5.85	4.0	Clay-Like	103			134	1.30	1.7	31.9	0.98	0.283	1.0	0.063	0.057	**N/A**
5.25	17.2	134	3	90.4	57.7	1.0	6.58	4.0	Clay-Like	103			134	1.27	1.7	31.9	0.97	0.287	1.0	0.063	0.057	**N/A**
5.55	18.2	134	3	95.8	60.2	1.0	7.52	4.1	Clay-Like	110			134	1.25	1.7	31.7	0.97	0.291	1.0	0.062	0.056	**N/A**
5.85	19.2	144	4	101.2	62.7	1.0	9.03	4.1	Clay-Like	110			144	1.22	1.7	31.8	0.97	0.295	1.0	0.063	0.056	**N/A**
6.15	20.2	153	5	106.7	65.2	1.0	10.29	4.1	Clay-Like	110			153	1.19	1.8	31.9	0.97	0.298	1.0	0.063	0.056	**N/A**
6.45	21.2	134	2	112.1	67.7	1.0	8.72	4.1	Clay-Like	110			134	1.19	1.6	31.6	0.96	0.301	1.0	0.062	0.056	**N/A**
6.75	22.2	134	4	117.6	70.1	1.0	23.20	4.3	Clay-Like	124			134	1.17	1.6	31.4	0.96	0.304	1.0	0.062	0.056	**N/A**
7.05	23.1	144	2	123.0	72.6	1.0	9.26	4.1	Clay-Like	110			144	1.15	1.6	31.7	0.96	0.306	1.0	0.062	0.056	**N/A**
7.35	24.1	153	3	128.4	75.1	1.0	11.56	4.2	Clay-Like	117			153	1.13	1.7	31.7	0.96	0.308	1.0	0.062	0.056	**N/A**
7.65	25.1	144	3	133.8	77.6	1.0	29.23	4.4	Clay-Like	132			144	1.12	1.6	31.4	0.95	0.310	1.0	0.062	0.055	**N/A**
7.95	26.1	201	2	139.2	80.1	1.0	3.09	3.9	Clay-Like	96			201	1.08	2.1	32.6	0.95	0.312	1.0	0.063	0.056	**N/A**
8.25	27.1	153	3	144.7	82.5	1.0	33.61	4.4	Clay-Like	132			153	1.08	1.6	31.4	0.95	0.313	1.0	0.062	0.055	**N/A**
8.55	28.1	182	4	150.1	85.0	1.0	12.02	4.2	Clay-Like	117			182	1.06	1.9	32.0	0.95	0.314	1.0	0.063	0.055	**N/A**
8.85	29.0	163	3	155.5	87.5	1.0	39.54	4.5	Clay-Like	140			163	1.06	1.7	31.4	0.94	0.316	1.0	0.062	0.055	**N/A**
9.15	30.0	153	2	160.9	90.0	1.0	0.10	3.5	Clay-Like	73			153	1.05	1.6	32.2	0.94	0.317	1.0	0.063	0.055	**N/A**
9.45	31.0	163	3	166.3	92.5	1.0	0.10	3.5	Clay-Like	73			163	1.03	1.7	32.3	0.94	0.318	1.0	0.063	0.055	**N/A**
9.75	32.0	153	3	171.8	95.0	1.0	0.10	3.5	Clay-Like	73			153	1.02	1.6	32.2	0.93	0.318	1.0	0.063	0.055	**N/A**
10.05	33.0	192	2	177.2	97.4	1.0	13.36	4.2	Clay-Like	117			192	1.01	1.9	32.0	0.93	0.319	1.0	0.063	0.055	**N/A**
10.35	34.0	192	2	182.6	99.9	1.0	21.58	4.3	Clay-Like	124			192	1.00	1.9	31.9	0.93	0.320	1.0	0.063	0.055	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	182	2	188.0	102.4	1.0	0.10	3.5	Clay-Like	73			182	1.00	1.8	32.5	0.92	0.320	1.0	0.063	0.055	**N/A**
10.95	35.9	201	3	193.4	104.9	1.0	37.56	4.5	Clay-Like	140			201	0.99	2.0	31.8	0.92	0.320	1.0	0.063	0.055	**N/A**
11.25	36.9	182	2	198.9	107.4	1.0	0.10	3.5	Clay-Like	73			182	0.98	1.8	32.4	0.92	0.321	1.0	0.063	0.055	**N/A**
11.55	37.9	163	3	204.3	109.8	1.0	0.10	3.5	Clay-Like	73			163	0.97	1.6	32.2	0.91	0.321	1.0	0.063	0.055	**N/A**
11.85	38.9	220	3	209.8	112.3	1.0	27.39	4.4	Clay-Like	132			220	0.97	2.1	32.1	0.91	0.321	1.0	0.063	0.055	**N/A**
12.15	39.9	220	2	215.2	114.8	1.0	37.66	4.5	Clay-Like	140			220	0.96	2.1	32.0	0.91	0.321	1.0	0.063	0.054	**N/A**
12.45	40.9	383	2	220.6	117.3	1.5	1.18	3.5	Clay-Like	73			383	0.96	3.6	35.0	0.91	0.321	1.0	0.065	0.056	**N/A**
12.75	41.8	211	2	226.0	119.8	1.0	0.10	3.5	Clay-Like	73			211	0.95	2.0	32.7	0.90	0.321	1.0	0.063	0.055	**N/A**
13.05	42.8	192	2	231.4	122.2	1.0	0.10	3.5	Clay-Like	73			192	0.94	1.8	32.5	0.90	0.321	1.0	0.063	0.054	**N/A**
13.35	43.8	230	2	236.9	124.7	1.0	0.10	3.5	Clay-Like	73			230	0.94	2.1	32.9	0.90	0.321	1.0	0.063	0.055	**N/A**
13.65	44.8	220	2	242.3	127.2	1.0	0.10	3.5	Clay-Like	73			220	0.93	2.0	32.8	0.89	0.320	1.0	0.063	0.055	**N/A**
13.95	45.8	785	2	247.7	129.7	4.7	0.36	2.9	Clay-Like	45			785	0.94	7.3	40.1	0.89	0.320	1.0	0.069	0.059	**N/A**
14.25	46.8	603	2	253.1	132.2	3.0	0.55	3.1	Clay-Like	53			603	0.93	5.6	37.8	0.89	0.320	1.0	0.067	0.058	**N/A**
14.55	47.7	1408	9	258.6	134.7	9.8	0.75	2.7	Clay-Like	37			1408	0.93	12.9	47.3	0.88	0.319	1.0	0.075	0.064	**N/A**
14.85	48.7	9193	55	264.0	137.1	75.8	0.61	1.9		15			9193	0.92	84.0	118.2	0.88	0.319	1.0	0.176	0.148	**0.46**
15.15	49.7	3083	75	269.4	139.6	23.7	2.65	2.7	Clay-Like	37			3083	0.92	28.0	67.7	0.88	0.318	1.0	0.097	0.082	**N/A**
15.45	50.7	2471	58	274.9	142.1	18.3	2.66	2.8	Clay-Like	41			2471	0.91	22.4	60.3	0.87	0.318	1.0	0.088	0.075	**N/A**
15.75	51.7	4012	133	280.3	144.6	30.8	3.57	2.7	Clay-Like	37			4012	0.91	36.1	78.6	0.87	0.317	1.0	0.111	0.094	**N/A**
16.05	52.7	10036	425	285.7	147.1	79.9	4.36	2.4		27			10036	0.91	90.0	147.6	0.86	0.317	0.9	0.261	0.215	**0.68**
16.35	53.6	8341	343	291.1	149.5	65.4	4.26	2.5		30			8341	0.90	74.5	128.5	0.86	0.316	0.9	0.199	0.165	**0.52**
16.66	54.6	8006	384	296.6	152.0	62.1	4.98	2.5		30			8006	0.90	71.2	124.1	0.86	0.315	0.9	0.189	0.157	**0.50**
16.95	55.6	9203	437	302.0	154.5	71.1	4.91	2.5		30			9203	0.89	81.4	137.8	0.85	0.315	0.9	0.225	0.185	**0.59**
17.25	56.6	9720	522	307.4	157.0	74.6	5.54	2.5		30			9720	0.89	85.7	143.5	0.85	0.314	0.9	0.245	0.200	**0.64**
17.55	57.6	14517	500	312.8	159.5	111.8	3.52	2.3		24			14517	0.89	127.4	194.5	0.85	0.313	0.9	0.897	0.697	**2.00**
17.85	58.6	29360	510	318.2	161.9	226.8	1.76	1.8		13			29360	0.88	256.7	309.6	0.84	0.313	0.9	2.000	1.503	**2.00**
18.16	59.6	54143	753	323.7	164.4	417.0	1.40	1.6		10			54143	0.88	471.4	503.8	0.84	0.312	0.9	2.000	1.495	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-12**

Test Boring Information:

Approx. ground elevation		7.9	ft	2.41 m
Approx. water table elevation		1.5	ft	0.46 m
Approx. depth to ground water table		6.4	ft	1.95 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	7919	40	2.3	2.3	513	0.51	1.2	Unsaturated	4			7919	1.70	133.3	133.3	1.00	0.189	1.1	0.212	0.204	**N/A**
0.45	1.5	7249	53	7.1	7.1	270	0.73	1.5	Unsaturated	8			7249	1.70	122.0	126.9	1.00	0.189	1.1	0.195	0.188	**N/A**
0.75	2.5	3553	24	11.8	11.8	102	0.68	1.8	Unsaturated	13			3553	1.70	59.8	82.4	1.00	0.189	1.1	0.116	0.112	**N/A**
1.05	3.4	8436	47	16.5	16.5	206	0.56	1.5	Unsaturated	8			8436	1.61	134.7	140.0	1.00	0.189	1.1	0.232	0.224	**N/A**
1.35	4.4	12305	92	21.2	21.2	265	0.75	1.5	Unsaturated	8			12305	1.51	183.9	190.2	1.00	0.188	1.1	0.757	0.730	**N/A**
1.65	5.4	3265	64	25.9	25.9	63	1.98	2.3	Unsaturated	24			3265	1.43	46.3	87.9	1.00	0.188	1.1	0.124	0.119	**N/A**
1.95	6.4	316	11	30.7	30.7	5	3.69	3.3	Clay-Like	62			316	1.37	4.3	36.0	1.00	0.188	1.1	0.065	0.062	**N/A**
2.23	7.3	201	8	35.6	32.9	3	4.63	3.6	Clay-Like	78			201	1.44	2.9	33.8	0.99	0.203	1.1	0.064	0.060	**N/A**
2.50	8.2	153	6	40.6	35.2	2	5.10	3.7	Clay-Like	84			153	1.52	2.3	33.0	0.99	0.216	1.1	0.063	0.059	**N/A**
2.80	9.2	163	4	46.1	37.7	2	3.28	3.6	Clay-Like	78			163	1.46	2.4	33.1	0.99	0.228	1.1	0.063	0.059	**N/A**
3.10	10.2	144	5	51.5	40.2	1	5.19	3.8	Clay-Like	90			144	1.46	2.1	32.6	0.99	0.239	1.1	0.063	0.058	**N/A**
3.40	11.2	124	3	56.9	42.6	1	4.25	3.9	Clay-Like	96			124	1.47	1.8	32.1	0.99	0.248	1.1	0.063	0.058	**N/A**
3.70	12.1	134	4	62.3	45.1	1	5.34	4.0	Clay-Like	103			134	1.41	1.9	32.1	0.98	0.256	1.0	0.063	0.058	**N/A**
4.03	13.2	134	3	68.2	47.8	1	4.36	3.9	Clay-Like	96			134	1.38	1.8	32.1	0.98	0.264	1.0	0.063	0.057	**N/A**
4.35	14.3	134	6	74.0	50.5	1	9.57	4.1	Clay-Like	110			134	1.35	1.8	31.9	0.98	0.271	1.0	0.063	0.057	**N/A**
4.65	15.3	220	5	79.5	53.0	2	3.40	3.6	Clay-Like	78			220	1.22	2.7	33.5	0.98	0.277	1.0	0.064	0.058	**N/A**
4.95	16.2	192	5	84.9	55.5	1	4.49	3.8	Clay-Like	90			192	1.23	2.3	32.9	0.98	0.282	1.0	0.063	0.057	**N/A**
5.25	17.2	163	5	90.3	57.9	1	6.61	4.0	Clay-Like	103			163	1.24	2.0	32.3	0.97	0.286	1.0	0.063	0.057	**N/A**
5.55	18.2	144	7	95.8	60.4	1	14.00	4.2	Clay-Like	117			144	1.24	1.8	31.8	0.97	0.290	1.0	0.062	0.056	**N/A**
5.85	19.2	172	6	101.2	62.9	1	8.07	4.1	Clay-Like	110			172	1.19	2.0	32.2	0.97	0.294	1.0	0.063	0.057	**N/A**
6.15	20.2	239	3	106.6	65.4	2	2.16	3.6	Clay-Like	78			239	1.13	2.7	33.6	0.97	0.297	1.0	0.064	0.057	**N/A**
6.45	21.2	144	3	112.0	67.9	1	9.09	4.1	Clay-Like	110			144	1.18	1.7	31.7	0.96	0.300	1.0	0.062	0.056	**N/A**
6.75	22.2	249	3	117.5	70.4	2	2.18	3.6	Clay-Like	78			249	1.10	2.7	33.6	0.96	0.302	1.0	0.064	0.057	**N/A**
7.05	23.1	239	4	122.9	72.8	1	3.29	3.8	Clay-Like	90			239	1.10	2.6	33.3	0.96	0.305	1.0	0.064	0.057	**N/A**
7.35	24.1	211	3	128.3	75.3	1	3.49	3.9	Clay-Like	96			211	1.10	2.3	32.8	0.96	0.307	1.0	0.063	0.056	**N/A**
7.65	25.1	268	4	133.7	77.8	2	2.85	3.7	Clay-Like	84			268	1.07	2.8	33.7	0.95	0.309	1.0	0.064	0.057	**N/A**
7.95	26.1	239	4	139.1	80.3	1	3.82	3.9	Clay-Like	96			239	1.07	2.5	33.1	0.95	0.311	1.0	0.063	0.056	**N/A**
8.25	27.1	268	2	144.6	82.8	1	1.55	3.6	Clay-Like	78			268	1.05	2.8	33.7	0.95	0.312	1.0	0.064	0.057	**N/A**
8.55	28.1	201	4	150.0	85.2	1	7.50	4.1	Clay-Like	110			201	1.06	2.1	32.3	0.95	0.313	1.0	0.063	0.056	**N/A**
8.85	29.0	297	3	155.5	87.7	1	2.03	3.6	Clay-Like	78			297	1.04	3.1	34.1	0.94	0.315	1.0	0.064	0.057	**N/A**
9.15	30.0	278	4	160.9	90.2	1	3.28	3.8	Clay-Like	90			278	1.03	2.8	33.6	0.94	0.316	1.0	0.064	0.056	**N/A**
9.45	31.0	163	4	166.3	92.7	1	0.10	3.5	Clay-Like	73			163	1.03	1.7	32.3	0.94	0.317	1.0	0.063	0.055	**N/A**
9.75	32.0	306	3	171.7	95.2	1	2.13	3.7	Clay-Like	84			306	1.02	3.1	34.0	0.93	0.317	1.0	0.064	0.056	**N/A**
10.05	33.0	297	3	177.1	97.6	1	2.40	3.7	Clay-Like	84			297	1.01	3.0	33.9	0.93	0.318	1.0	0.064	0.056	**N/A**
10.35	34.0	211	5	182.6	100.1	1	17.04	4.2	Clay-Like	117			211	1.00	2.1	32.2	0.93	0.319	1.0	0.063	0.055	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	383	4	188.0	102.6	2	1.96	3.5	Clay-Like	73			383	1.00	3.8	35.1	0.92	0.319	1.0	0.065	0.057	**N/A**
10.95	35.9	373	5	193.4	105.1	2	2.66	3.6	Clay-Like	78			373	0.99	3.7	34.9	0.92	0.320	1.0	0.065	0.057	**N/A**
11.25	36.9	287	3	198.8	107.6	1	3.25	3.9	Clay-Like	96			287	0.98	2.8	33.4	0.92	0.320	1.0	0.064	0.056	**N/A**
11.55	37.9	383	2	204.2	110.1	2	1.07	3.5	Clay-Like	73			383	0.98	3.7	35.1	0.91	0.320	1.0	0.065	0.056	**N/A**
11.85	38.9	881	8	209.7	112.5	6	1.14	3.0	Clay-Like	49			881	0.97	8.5	41.8	0.91	0.320	1.0	0.070	0.061	**N/A**
12.15	39.9	862	12	215.1	115.0	6	1.92	3.1	Clay-Like	53			862	0.97	8.2	41.5	0.91	0.320	1.0	0.070	0.061	**N/A**
12.45	40.9	239	4	220.5	117.5	1	20.32	4.3	Clay-Like	124			239	0.96	2.3	32.4	0.91	0.320	1.0	0.063	0.055	**N/A**
12.75	41.8	345	4	225.9	120.0	1	3.22	3.8	Clay-Like	90			345	0.96	3.3	34.2	0.90	0.320	1.0	0.064	0.056	**N/A**
13.05	42.8	326	5	231.3	122.5	1	5.08	4.0	Clay-Like	103			326	0.95	3.1	33.7	0.90	0.320	1.0	0.064	0.055	**N/A**
13.35	43.8	1092	8	236.8	124.9	8	0.90	2.8	Clay-Like	41			1092	0.95	10.2	43.9	0.90	0.320	1.0	0.072	0.062	**N/A**
13.65	44.8	2758	18	242.2	127.4	22	0.72	2.4		27			2758	0.94	25.7	62.3	0.89	0.320	1.0	0.090	0.078	**0.24**
13.95	45.8	2250	27	247.7	129.9	17	1.34	2.6	Clay-Like	34			2250	0.94	20.8	57.6	0.89	0.319	1.0	0.085	0.073	**N/A**
14.25	46.8	661	17	253.1	132.4	4	4.23	3.5	Clay-Like	73			661	0.93	6.1	38.3	0.89	0.319	1.0	0.067	0.058	**N/A**
14.55	47.7	1877	6	258.5	134.9	14	0.36	2.5		30			1877	0.93	17.2	52.0	0.88	0.319	1.0	0.079	0.068	**0.21**
14.85	48.7	833	2	263.9	137.4	5	0.34	2.9	Clay-Like	45			833	0.92	7.6	40.5	0.88	0.318	1.0	0.069	0.059	**N/A**
15.15	49.7	632	5	269.3	139.8	3	1.32	3.3	Clay-Like	62			632	0.92	5.7	38.0	0.88	0.318	1.0	0.067	0.057	**N/A**
15.45	50.7	488	6	274.8	142.3	2	2.69	3.6	Clay-Like	78			488	0.91	4.4	35.9	0.87	0.317	1.0	0.065	0.056	**N/A**
15.75	51.7	431	8	280.2	144.8	1	5.08	3.9	Clay-Like	96			431	0.91	3.9	34.9	0.87	0.317	1.0	0.065	0.055	**N/A**
16.05	52.7	833	11	285.6	147.3	4	2.10	3.2	Clay-Like	58			833	0.91	7.5	40.4	0.86	0.316	1.0	0.069	0.059	**N/A**
16.35	53.6	3285	129	291.0	149.8	24	4.32	2.8	Clay-Like	41			3285	0.90	29.3	69.7	0.86	0.316	1.0	0.099	0.084	**N/A**
16.66	54.6	7948	50	296.5	152.2	62	0.65	2.0		17			7948	0.90	70.6	108.4	0.86	0.315	1.0	0.157	0.131	**0.42**
16.95	55.6	2337	98	301.9	154.7	16	4.80	3.0	Clay-Like	49			2337	0.89	20.7	58.2	0.85	0.314	1.0	0.086	0.073	**N/A**
17.25	56.6	1829	72	307.3	157.2	12	4.72	3.0	Clay-Like	49			1829	0.89	16.1	52.1	0.85	0.314	1.0	0.080	0.067	**N/A**
17.55	57.6	3141	130	312.8	159.7	22	4.60	2.8	Clay-Like	41			3141	0.89	27.6	67.3	0.85	0.313	1.0	0.096	0.081	**N/A**
17.85	58.6	15618	194	318.2	162.2	119	1.27	1.9		15			15618	0.88	136.5	181.2	0.84	0.312	0.9	0.556	0.438	**1.40**
18.16	59.6	6655	192	323.6	164.7	49	3.02	2.5		30			6655	0.88	57.9	106.4	0.84	0.311	0.9	0.153	0.127	**0.41**
18.45	60.5	8685	366	329.0	167.1	64	4.38	2.5		30			8685	0.88	75.3	129.6	0.84	0.311	0.9	0.202	0.165	**0.53**
18.76	61.5	4980	312	334.5	169.6	35	6.72	2.8	Clay-Like	41			4980	0.87	43.0	88.1	0.83	0.310	0.9	0.124	0.103	**N/A**
19.03	62.4	7345	381	339.4	171.9	53	5.44	2.6	Clay-Like	34			7345	0.87	63.2	114.4	0.83	0.309	0.9	0.168	0.138	**N/A**
19.30	63.3	15705	346	344.4	174.2	116	2.25	2.1		19			15705	0.87	134.7	194.8	0.83	0.308	0.9	0.906	0.686	**2.00**
19.60	64.3	24725	364	349.8	176.6	182	1.49	1.8		13			24725	0.86	211.2	257.2	0.82	0.307	0.8	2.000	1.457	**2.00**
19.91	65.3	27167	560	355.3	179.1	199	2.09	1.9		15			27167	0.86	231.2	295.0	0.82	0.307	0.8	2.000	1.450	**2.00**
20.20	66.3	20081	877	360.7	181.6	145	4.45	2.3		24			20081	0.86	170.3	250.9	0.82	0.306	0.8	2.000	1.443	**2.00**
20.51	67.3	21000	589	366.1	184.1	151	2.85	2.1		19			21000	0.85	177.5	249.2	0.81	0.305	0.8	2.000	1.436	**2.00**
20.80	68.2	20742	760	371.5	186.6	148	3.73	2.2		22			20742	0.85	174.7	251.9	0.81	0.304	0.8	2.000	1.429	**2.00**
21.10	69.2	32865	554	376.9	189.0	235	1.71	1.8		13			32865	0.85	275.8	331.7	0.81	0.303	0.8	2.000	1.422	**2.00**
21.41	70.2	37787	465	382.4	191.5	269	1.24	1.7		11			37787	0.84	316.0	358.0	0.80	0.302	0.8	2.000	1.415	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-13**

Test Boring Information:

Approx. ground elevation		7	ft	2.13 m
Approx. water table elevation		1	ft	0.30 m
Approx. depth to ground water table		6	ft	1.83 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	4319	18	2.3	2.3	280	0.42	1.3	Unsaturated	6			4319	1.70	72.7	72.8	1.00	0.189	1.1	0.103	0.099	**N/A**
0.45	1.5	9844	43	7.1	7.1	367	0.44	1.2	Unsaturated	4			9844	1.70	165.7	165.7	1.00	0.189	1.1	0.368	0.355	**N/A**
0.75	2.5	5899	19	11.8	11.8	170	0.33	1.4	Unsaturated	7			5899	1.70	99.3	100.4	1.00	0.189	1.1	0.143	0.138	**N/A**
1.05	3.4	2193	5	16.5	16.5	53	0.22	1.8	Unsaturated	13			2193	1.61	35.0	53.8	1.00	0.189	1.1	0.081	0.078	**N/A**
1.35	4.4	1810	6	21.2	21.2	39	0.32	2.0	Unsaturated	17			1810	1.51	27.0	54.3	1.00	0.188	1.1	0.082	0.079	**N/A**
1.65	5.4	2021	7	25.9	25.9	39	0.34	2.0	Unsaturated	17			2021	1.43	28.6	56.3	1.00	0.188	1.1	0.084	0.081	**N/A**
1.95	6.4	1752	2	31.0	29.8	31	0.11	2.0		17			1752	1.38	23.9	50.5	1.00	0.195	1.1	0.078	0.074	**0.38**
2.23	7.3	2365	34	35.9	32.0	41	1.44	2.3		24			2365	1.35	31.7	68.8	0.99	0.210	1.1	0.098	0.094	**0.45**
2.50	8.2	479	31	40.9	34.3	7	7.00	3.3	Clay-Like	62			479	1.33	6.3	38.7	0.99	0.223	1.1	0.068	0.063	**N/A**
2.80	9.2	144	6	46.3	36.8	2	5.90	3.8	Clay-Like	90			144	1.52	2.2	32.7	0.99	0.235	1.1	0.063	0.059	**N/A**
3.10	10.2	124	4	51.7	39.3	1	5.27	3.9	Clay-Like	96			124	1.53	1.9	32.2	0.99	0.246	1.1	0.063	0.058	**N/A**
3.40	11.2	124	5	57.1	41.7	1	7.11	4.0	Clay-Like	103			124	1.49	1.8	32.0	0.99	0.255	1.1	0.063	0.058	**N/A**
3.70	12.1	153	5	62.6	44.2	1	5.28	3.9	Clay-Like	96			153	1.39	2.1	32.5	0.98	0.263	1.0	0.063	0.058	**N/A**
4.03	13.2	134	5	68.5	46.9	1	7.30	4.0	Clay-Like	103			134	1.39	1.8	32.1	0.98	0.270	1.0	0.063	0.057	**N/A**
4.35	14.3	124	2	74.3	49.6	1	3.82	3.9	Clay-Like	96			124	1.38	1.7	32.0	0.98	0.277	1.0	0.063	0.057	**N/A**
4.65	15.3	153	4	79.8	52.1	1	5.22	4.0	Clay-Like	103			153	1.30	2.0	32.2	0.98	0.282	1.0	0.063	0.057	**N/A**
4.95	16.2	144	3	85.2	54.6	1	4.92	4.0	Clay-Like	103			144	1.29	1.8	32.1	0.98	0.287	1.0	0.063	0.057	**N/A**
5.25	17.2	153	4	90.6	57.0	1	6.12	4.0	Clay-Like	103			153	1.26	1.9	32.1	0.97	0.291	1.0	0.063	0.057	**N/A**
5.55	18.2	153	2	96.1	59.5	1	3.35	3.9	Clay-Like	96			153	1.23	1.9	32.2	0.97	0.295	1.0	0.063	0.057	**N/A**
5.85	19.2	144	3	101.5	62.0	1	6.81	4.0	Clay-Like	103			144	1.22	1.7	31.9	0.97	0.299	1.0	0.063	0.056	**N/A**
6.15	20.2	134	3	106.9	64.5	1	10.58	4.1	Clay-Like	110			134	1.21	1.6	31.7	0.97	0.302	1.0	0.062	0.056	**N/A**
6.45	21.2	153	3	112.3	67.0	1	7.02	4.0	Clay-Like	103			153	1.18	1.8	32.0	0.96	0.305	1.0	0.063	0.056	**N/A**
6.75	22.2	172	4	117.8	69.5	1	7.02	4.0	Clay-Like	103			172	1.15	2.0	32.2	0.96	0.307	1.0	0.063	0.056	**N/A**
7.05	23.1	172	2	123.2	71.9	1	3.89	3.9	Clay-Like	96			172	1.13	1.9	32.3	0.96	0.309	1.0	0.063	0.056	**N/A**
7.35	24.1	153	2	128.6	74.4	1	7.77	4.1	Clay-Like	110			153	1.13	1.7	31.8	0.96	0.311	1.0	0.062	0.056	**N/A**
7.65	25.1	153	1	134.0	76.9	1	4.99	4.0	Clay-Like	103			153	1.11	1.7	31.9	0.95	0.313	1.0	0.063	0.056	**N/A**
7.95	26.1	172	2	139.4	79.4	1	5.81	4.0	Clay-Like	103			172	1.09	1.9	32.1	0.95	0.315	1.0	0.063	0.056	**N/A**
8.25	27.1	144	1	144.9	81.9	1	0.10	3.5	Clay-Like	73			144	1.09	1.6	32.2	0.95	0.316	1.0	0.063	0.056	**N/A**
8.55	28.1	134	2	150.3	84.3	1	0.10	3.5	Clay-Like	73			134	1.08	1.4	32.0	0.95	0.317	1.0	0.063	0.055	**N/A**
8.85	29.0	134	2	155.7	86.8	1	0.10	3.5	Clay-Like	73			134	1.07	1.4	32.0	0.94	0.319	1.0	0.063	0.055	**N/A**
9.15	30.0	163	2	161.1	89.3	1	116.24	4.8	Clay-Like	165			163	1.05	1.7	31.2	0.94	0.319	1.0	0.062	0.055	**N/A**
9.45	31.0	144	2	166.5	91.8	1	0.10	3.5	Clay-Like	73			144	1.04	1.5	32.1	0.94	0.320	1.0	0.063	0.055	**N/A**
9.75	32.0	230	3	172.0	94.3	1	4.97	4.0	Clay-Like	103			230	1.02	2.3	32.7	0.93	0.321	1.0	0.063	0.056	**N/A**
10.05	33.0	287	3	177.4	96.7	1	2.61	3.8	Clay-Like	90			287	1.01	2.9	33.6	0.93	0.322	1.0	0.064	0.056	**N/A**
10.35	34.0	144	1	182.9	99.2	1	0.10	3.5	Clay-Like	73			144	1.01	1.4	32.0	0.93	0.322	1.0	0.063	0.055	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	172	3	188.3	101.7	1	0.10	3.5	Clay-Like	73			172	1.00	1.7	32.4	0.92	0.323	1.0	0.063	0.055	**N/A**
10.95	35.9	163	2	193.7	104.2	1	0.10	3.5	Clay-Like	73			163	0.99	1.6	32.2	0.92	0.323	1.0	0.063	0.055	**N/A**
11.25	36.9	182	2	199.1	106.7	1	0.10	3.5	Clay-Like	73			182	0.98	1.8	32.4	0.92	0.323	1.0	0.063	0.055	**N/A**
11.55	37.9	153	2	204.5	109.1	1	0.10	3.5	Clay-Like	73			153	0.97	1.5	32.0	0.91	0.323	1.0	0.063	0.055	**N/A**
11.85	38.9	172	3	210.0	111.6	1	0.10	3.5	Clay-Like	73			172	0.96	1.6	32.3	0.91	0.323	1.0	0.063	0.055	**N/A**
12.15	39.9	192	3	215.4	114.1	1	0.10	3.5	Clay-Like	73			192	0.96	1.8	32.5	0.91	0.323	1.0	0.063	0.055	**N/A**
12.45	40.9	153	1	220.8	116.6	1	0.10	3.5	Clay-Like	73			153	0.94	1.4	32.0	0.91	0.323	1.0	0.063	0.054	**N/A**
12.75	41.8	163	2	226.2	119.1	1	0.10	3.5	Clay-Like	73			163	0.94	1.5	32.1	0.90	0.323	1.0	0.063	0.054	**N/A**
13.05	42.8	163	2	231.6	121.5	1	0.10	3.5	Clay-Like	73			163	0.93	1.5	32.1	0.90	0.323	1.0	0.063	0.054	**N/A**
13.35	43.8	211	1	237.1	124.0	1	0.10	3.5	Clay-Like	73			211	0.94	2.0	32.7	0.90	0.323	1.0	0.063	0.055	**N/A**
13.65	44.8	4539	22	242.5	126.5	38	0.51	2.1		19			4539	0.94	42.3	77.3	0.89	0.322	1.0	0.109	0.094	**0.29**
13.95	45.8	5200	26	248.0	129.0	43	0.52	2.1		19			5200	0.94	48.3	84.9	0.89	0.322	1.0	0.119	0.102	**0.32**
14.25	46.8	5382	46	253.4	131.5	44	0.90	2.2		22			5382	0.93	49.7	90.0	0.89	0.322	1.0	0.127	0.108	**0.34**
14.55	47.7	3275	28	258.8	134.0	26	0.92	2.4		27			3275	0.93	30.1	68.2	0.88	0.321	1.0	0.097	0.083	**0.26**
14.85	48.7	1609	17	264.2	136.4	11	1.28	2.8	Clay-Like	41			1609	0.92	14.7	50.0	0.88	0.321	1.0	0.077	0.066	**N/A**
15.15	49.7	508	2	269.6	138.9	2	0.80	3.4	Clay-Like	67			508	0.92	4.6	36.4	0.88	0.320	1.0	0.066	0.056	**N/A**
15.45	50.7	469	3	275.1	141.4	2	1.48	3.5	Clay-Like	73			469	0.92	4.3	35.8	0.87	0.320	1.0	0.065	0.056	**N/A**
15.75	51.7	393	3	280.5	143.9	1	2.56	3.8	Clay-Like	90			393	0.91	3.5	34.5	0.87	0.319	1.0	0.064	0.055	**N/A**
16.05	52.7	192	3	285.9	146.4	1	0.10	3.5	Clay-Like	73			192	0.88	1.7	32.3	0.86	0.318	1.0	0.063	0.054	**N/A**
16.35	53.6	172	2	291.3	148.8	1	0.10	3.5	Clay-Like	73			172	0.87	1.5	32.1	0.86	0.318	1.0	0.063	0.054	**N/A**
16.66	54.6	316	3	296.8	151.3	1	14.94	4.2	Clay-Like	117			316	0.90	2.8	33.2	0.86	0.317	1.0	0.063	0.054	**N/A**
16.95	55.6	259	6	302.2	153.8	1	0.10	3.5	Clay-Like	73			259	0.89	2.3	33.1	0.85	0.316	1.0	0.063	0.054	**N/A**
17.25	56.6	278	7	307.6	156.3	1	0.10	3.5	Clay-Like	73			278	0.89	2.5	33.4	0.85	0.316	1.0	0.064	0.054	**N/A**
17.55	57.6	268	5	313.0	158.8	1	0.10	3.5	Clay-Like	73			268	0.89	2.4	33.2	0.85	0.315	1.0	0.063	0.054	**N/A**
17.85	58.6	402	12	318.4	161.2	1	14.86	4.2	Clay-Like	117			402	0.88	3.5	34.1	0.84	0.314	1.0	0.064	0.055	**N/A**
18.16	59.6	211	11	323.9	163.7	1	0.10	3.5	Clay-Like	73			211	0.86	1.8	32.5	0.84	0.313	1.0	0.063	0.054	**N/A**
18.45	60.5	316	8	329.3	166.2	1	0.10	3.5	Clay-Like	73			316	0.88	2.7	33.8	0.84	0.313	1.0	0.064	0.054	**N/A**
18.76	61.5	8896	62	334.8	168.7	65	0.73	2.0		17			8896	0.87	76.9	116.2	0.83	0.312	0.9	0.172	0.141	**0.45**
19.03	62.4	24898	125	339.7	171.0	187	0.51	1.5		8			24898	0.87	214.5	221.7	0.83	0.311	0.8	2.000	1.475	**2.00**
19.30	63.3	32645	156	344.7	173.2	244	0.48	1.4		7			32645	0.87	280.3	282.5	0.83	0.310	0.8	2.000	1.468	**2.00**
19.60	64.3	25731	192	350.1	175.7	190	0.76	1.6		10			25731	0.86	220.1	237.9	0.82	0.309	0.8	2.000	1.460	**2.00**
19.91	65.3	21776	259	355.5	178.2	159	1.21	1.8		13			21776	0.86	185.6	227.6	0.82	0.308	0.8	2.000	1.453	**2.00**
20.20	66.3	36255	399	360.9	180.7	265	1.11	1.6		10			36255	0.86	307.9	330.8	0.82	0.308	0.8	2.000	1.446	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-14**

Test Boring Information:

Approx. ground elevation		11	ft	3.35 m
Approx. water table elevation		3	ft	0.91 m
Approx. depth to ground water table		8	ft	2.44 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	6598	26	2.3	2.3	428	0.39	1.2	Unsaturated	4			6598	1.70	111.1	111.1	1.00	0.189	1.1	0.162	0.156	**N/A**
0.45	1.5	5861	34	7.1	7.1	218	0.59	1.5	Unsaturated	8			5861	1.70	98.6	103.0	1.00	0.189	1.1	0.148	0.142	**N/A**
0.75	2.5	6311	32	11.8	11.8	182	0.50	1.5	Unsaturated	8			6311	1.70	106.2	110.8	1.00	0.189	1.1	0.161	0.155	**N/A**
1.05	3.4	5698	40	16.5	16.5	139	0.71	1.7	Unsaturated	11			5698	1.61	91.0	109.5	1.00	0.189	1.1	0.159	0.153	**N/A**
1.35	4.4	4980	56	21.2	21.2	107	1.14	1.9	Unsaturated	15			4980	1.51	74.4	106.7	1.00	0.188	1.1	0.154	0.148	**N/A**
1.65	5.4	4769	46	25.9	25.9	93	0.97	1.9	Unsaturated	15			4769	1.43	67.6	98.5	1.00	0.188	1.1	0.140	0.135	**N/A**
1.95	6.4	3936	40	30.7	30.7	70	1.03	2.0	Unsaturated	17			3936	1.37	53.4	87.0	1.00	0.188	1.1	0.122	0.118	**N/A**
2.23	7.3	4625	24	35.0	35.0	77	0.52	1.8	Unsaturated	13			4625	1.32	60.6	83.3	0.99	0.187	1.1	0.117	0.113	**N/A**
2.50	8.2	7479	80	39.4	38.8	119	1.08	1.9		15			7479	1.29	95.3	131.8	0.99	0.190	1.1	0.208	0.200	**1.05**
2.80	9.2	5564	115	44.9	41.3	85	2.08	2.2		22			5564	1.27	69.7	115.9	0.99	0.203	1.1	0.171	0.165	**0.81**
3.10	10.2	2748	42	50.3	43.8	40	1.56	2.3		24			2748	1.25	33.9	71.7	0.99	0.214	1.1	0.102	0.095	**0.45**
3.40	11.2	1762	25	55.7	46.3	25	1.46	2.5		30			1762	1.23	21.4	57.7	0.99	0.224	1.1	0.085	0.079	**0.35**
3.70	12.1	2126	33	61.2	48.8	29	1.58	2.5		30			2126	1.21	25.5	63.1	0.98	0.233	1.1	0.091	0.085	**0.36**
4.03	13.2	2327	44	67.1	51.5	31	1.95	2.5		30			2327	1.19	27.5	65.8	0.98	0.241	1.1	0.095	0.087	**0.36**
4.35	14.3	15647	349	72.9	54.1	210	2.24	1.9		15			15647	1.18	182.6	236.6	0.98	0.249	1.1	2.000	1.927	**2.00**
4.65	15.3	6521	126	78.4	56.6	85	1.96	2.2		22			6521	1.16	75.2	123.0	0.98	0.255	1.1	0.186	0.175	**0.69**
4.95	16.2	9653	54	83.8	59.1	124	0.56	1.7		11			9653	1.15	110.1	130.6	0.98	0.261	1.1	0.205	0.192	**0.74**
5.25	17.2	6205	48	89.2	61.6	77	0.78	1.9		15			6205	1.14	70.0	101.4	0.97	0.266	1.1	0.145	0.134	**0.50**
5.55	18.2	3313	34	94.6	64.1	40	1.07	2.2		22			3313	1.13	37.0	73.5	0.97	0.270	1.0	0.104	0.095	**0.35**
5.85	19.2	4989	70	100.0	66.5	60	1.43	2.2		22			4989	1.12	55.1	97.0	0.97	0.274	1.0	0.138	0.126	**0.46**
6.15	20.2	4616	48	105.5	69.0	54	1.06	2.1		19			4616	1.11	50.5	87.7	0.97	0.278	1.0	0.124	0.112	**0.40**
6.45	21.2	6406	121	110.9	71.5	74	1.92	2.2		22			6406	1.10	69.5	115.6	0.96	0.282	1.0	0.171	0.156	**0.55**
6.75	22.2	12430	181	116.3	74.0	142	1.47	1.9		15			12430	1.09	133.6	177.8	0.96	0.285	1.1	0.501	0.467	**1.64**
7.05	23.1	9844	101	121.7	76.5	110	1.03	1.9		15			9844	1.08	104.9	143.3	0.96	0.288	1.0	0.244	0.223	**0.77**
7.35	24.1	9203	73	127.1	79.0	101	0.80	1.8		13			9203	1.07	97.2	125.6	0.96	0.290	1.0	0.192	0.174	**0.60**
7.65	25.1	5219	33	132.6	81.4	56	0.64	2.0		17			5219	1.06	54.7	88.6	0.95	0.293	1.0	0.125	0.112	**0.38**
7.95	26.1	1331	19	138.0	83.9	13	1.61	2.8	Clay-Like	41			1331	1.05	13.8	48.8	0.95	0.295	1.0	0.076	0.068	**N/A**
8.25	27.1	967	7	143.4	86.4	9	0.81	2.8	Clay-Like	41			967	1.04	10.0	43.6	0.95	0.297	1.0	0.072	0.063	**N/A**
8.55	28.1	843	8	148.8	88.9	7	1.10	2.9	Clay-Like	45			843	1.03	8.6	41.9	0.95	0.298	1.0	0.070	0.062	**N/A**
8.85	29.0	852	10	154.3	91.4	7	1.37	2.9	Clay-Like	45			852	1.03	8.7	42.0	0.94	0.300	1.0	0.070	0.062	**N/A**
9.15	30.0	795	8	159.7	93.8	7	1.21	3.0	Clay-Like	49			795	1.02	8.0	41.2	0.94	0.301	1.0	0.070	0.061	**N/A**
9.45	31.0	555	4	165.1	96.3	4	0.98	3.1	Clay-Like	53			555	1.01	5.6	37.8	0.94	0.303	1.0	0.067	0.059	**N/A**
9.75	32.0	689	6	170.6	98.8	5	1.11	3.0	Clay-Like	49			689	1.01	6.9	39.6	0.93	0.304	1.0	0.068	0.060	**N/A**
10.05	33.0	728	4	176.0	101.3	5	0.69	2.9	Clay-Like	45			728	1.00	7.2	40.0	0.93	0.305	1.0	0.069	0.060	**N/A**
10.35	34.0	613	6	181.4	103.8	4	1.33	3.1	Clay-Like	53			613	0.99	6.0	38.5	0.93	0.306	1.0	0.067	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	642	7	186.8	106.2	4	1.47	3.2	Clay-Like	58			642	0.99	6.3	38.7	0.92	0.306	1.0	0.068	0.059	**N/A**
10.95	35.9	757	8	192.2	108.7	5	1.36	3.1	Clay-Like	53			757	0.98	7.3	40.2	0.92	0.307	1.0	0.069	0.060	**N/A**
11.25	36.9	795	6	197.7	111.2	6	0.96	3.0	Clay-Like	49			795	0.97	7.7	40.7	0.92	0.308	1.0	0.069	0.060	**N/A**
11.55	37.9	670	5	203.1	113.7	4	1.02	3.1	Clay-Like	53			670	0.97	6.4	39.0	0.91	0.308	1.0	0.068	0.059	**N/A**
11.85	38.9	833	10	208.5	116.2	6	1.53	3.1	Clay-Like	53			833	0.96	7.9	41.1	0.91	0.308	1.0	0.069	0.060	**N/A**
12.15	39.9	862	10	213.9	118.7	6	1.48	3.0	Clay-Like	49			862	0.96	8.2	41.4	0.91	0.309	1.0	0.070	0.060	**N/A**
12.45	40.9	1053	6	219.4	121.1	8	0.69	2.8	Clay-Like	41			1053	0.95	9.9	43.6	0.91	0.309	1.0	0.072	0.062	**N/A**
12.75	41.8	881	5	224.8	123.6	6	0.73	2.9	Clay-Like	45			881	0.95	8.3	41.4	0.90	0.309	1.0	0.070	0.060	**N/A**
13.05	42.8	1159	8	230.2	126.1	8	0.83	2.8	Clay-Like	41			1159	0.94	10.8	44.7	0.90	0.309	1.0	0.073	0.063	**N/A**
13.35	43.8	517	6	235.7	128.6	2	2.04	3.4	Clay-Like	67			517	0.94	4.8	36.6	0.90	0.309	1.0	0.066	0.057	**N/A**
13.65	44.8	565	9	241.1	131.1	3	2.66	3.4	Clay-Like	67			565	0.93	5.2	37.2	0.89	0.309	1.0	0.066	0.057	**N/A**
13.95	45.8	1934	12	246.5	133.5	15	0.74	2.6	Clay-Like	34			1934	0.93	17.8	53.4	0.89	0.309	1.0	0.081	0.069	**N/A**
14.25	46.8	1111	14	251.9	136.0	7	1.67	3.0	Clay-Like	49			1111	0.92	10.2	44.1	0.89	0.309	1.0	0.072	0.062	**N/A**
14.55	47.7	871	3	257.4	138.5	5	0.47	2.9	Clay-Like	45			871	0.92	7.9	41.0	0.88	0.309	1.0	0.069	0.060	**N/A**
14.85	48.7	6876	30	262.8	141.0	55	0.45	1.9		15			6876	0.92	62.3	92.2	0.88	0.309	1.0	0.130	0.110	**0.36**
15.15	49.7	5439	59	268.2	143.5	43	1.15	2.2		22			5439	0.91	49.1	89.2	0.88	0.308	1.0	0.126	0.106	**0.34**
15.45	50.7	3754	41	273.6	146.0	29	1.18	2.4		27			3754	0.91	33.7	73.0	0.87	0.308	1.0	0.103	0.088	**0.28**
15.75	51.7	8293	152	279.0	148.4	65	1.90	2.2		22			8293	0.90	74.2	121.7	0.87	0.308	1.0	0.183	0.153	**0.50**
16.05	52.7	18022	120	284.5	150.9	143	0.67	1.7		11			18022	0.90	160.5	186.3	0.86	0.307	0.9	0.657	0.523	**1.70**
16.35	53.6	18108	210	289.9	153.4	143	1.18	1.8		13			18108	0.90	160.6	198.7	0.86	0.307	0.9	1.072	0.837	**2.00**
16.66	54.6	12162	344	295.3	155.9	94	2.90	2.3		24			12162	0.89	107.4	168.2	0.86	0.306	0.9	0.390	0.314	**1.02**
16.95	55.6	11127	403	300.7	158.4	85	3.72	2.4		27			11127	0.89	97.8	158.1	0.85	0.306	0.9	0.314	0.254	**0.83**
17.25	56.6	14948	430	306.1	160.8	115	2.94	2.2		22			14948	0.88	130.9	195.2	0.85	0.305	0.9	0.923	0.715	**2.00**
17.55	57.6	20828	465	311.6	163.3	160	2.27	2.0		17			20828	0.88	181.7	246.1	0.85	0.305	0.9	2.000	1.499	**2.00**
17.85	58.6	23567	385	317.0	165.8	179	1.66	1.9		15			23567	0.88	204.7	263.2	0.84	0.304	0.9	2.000	1.491	**2.00**
18.16	59.6	30040	418	322.5	168.3	228	1.41	1.8		13			30040	0.87	259.9	313.4	0.84	0.304	0.8	2.000	1.483	**2.00**
18.45	60.5	31917	352	327.9	170.8	240	1.12	1.7		11			31917	0.87	275.1	312.9	0.84	0.303	0.8	2.000	1.475	**2.00**
18.76	61.5	33372	384	333.3	173.3	249	1.16	1.7		11			33372	0.87	286.6	325.5	0.83	0.302	0.8	2.000	1.468	**2.00**
19.03	62.4	38697	361	338.3	175.5	288	0.94	1.6		10			38697	0.86	331.2	355.4	0.83	0.302	0.8	2.000	1.461	**2.00**
19.30	63.3	35153	338	343.2	177.8	259	0.97	1.6		10			35153	0.86	299.8	322.2	0.83	0.301	0.8	2.000	1.454	**2.00**
19.60	64.3	9365	187	348.6	180.3	67	2.07	2.3		24			9365	0.86	79.6	131.7	0.82	0.300	0.9	0.207	0.167	**0.56**
19.91	65.3	5114	268	354.1	182.8	35	5.63	2.8	Clay-Like	41			5114	0.86	43.3	88.5	0.82	0.300	0.9	0.125	0.103	**N/A**
20.20	66.3	7105	305	359.5	185.2	49	4.53	2.6	Clay-Like	34			7105	0.85	59.9	110.0	0.82	0.299	0.9	0.160	0.130	**N/A**
20.51	67.3	8580	282	365.0	187.7	60	3.44	2.4		27			8580	0.85	72.1	124.0	0.81	0.298	0.9	0.188	0.152	**0.51**
20.80	68.2	6990	330	370.4	190.2	48	4.99	2.6	Clay-Like	34			6990	0.85	58.6	108.2	0.81	0.297	0.9	0.157	0.127	**N/A**
21.10	69.2	24898	478	375.8	192.7	176	1.95	1.9		15			24898	0.84	207.9	267.0	0.81	0.296	0.8	2.000	1.412	**2.00**
21.41	70.2	19861	493	381.2	195.2	139	2.53	2.1		19			19861	0.84	165.3	233.7	0.80	0.296	0.8	2.000	1.405	**2.00**
21.70	71.2	11855	385	386.6	197.6	81	3.36	2.3		24			11855	0.84	98.3	156.3	0.80	0.295	0.9	0.304	0.236	**0.80**
22.01	72.2	9021	391	392.1	200.1	61	4.53	2.5		30			9021	0.83	74.6	128.7	0.80	0.294	0.9	0.200	0.159	**0.54**
22.30	73.2	7383	458	397.5	202.6	49	6.55	2.7	Clay-Like	37			7383	0.83	60.8	111.8	0.79	0.293	0.9	0.163	0.131	**N/A**
22.61	74.2	11089	577	402.9	205.1	74	5.40	2.5		30			11089	0.83	91.1	150.7	0.79	0.292	0.9	0.275	0.213	**0.73**
22.91	75.1	13655	375	408.3	207.6	91	2.83	2.3		24			13655	0.83	111.8	174.0	0.79	0.292	0.9	0.452	0.339	**1.16**
23.20	76.1	4903	155	413.7	210.0	31	3.46	2.6	Clay-Like	34			4903	0.82	40.0	83.3	0.78	0.291	0.9	0.117	0.096	**N/A**
23.51	77.1	5573	241	419.2	212.5	35	4.68	2.7	Clay-Like	37			5573	0.82	45.3	91.0	0.78	0.290	0.9	0.128	0.104	**N/A**
23.80	78.1	12219	444	424.6	215.0	80	3.77	2.4		27			12219	0.82	99.1	159.8	0.78	0.289	0.9	0.324	0.247	**0.85**
24.11	79.1	41598	474	430.0	217.5	277	1.15	1.6		10			41598	0.82	336.4	361.0	0.77	0.288	0.8	2.000	1.348	**2.00**
24.41	80.1	26583	423	435.5	220.0	175	1.62	1.9		15			26583	0.81	214.3	274.7	0.77	0.287	0.8	2.000	1.342	**2.00**
24.71	81.0	4654	106	440.9	222.5	28	2.52	2.6	Clay-Like	34			4654	0.81	37.4	79.8	0.77	0.287	0.9	0.112	0.091	**N/A**
25.01	82.0	3802	77	446.3	224.9	22	2.28	2.6	Clay-Like	34			3802	0.81	30.5	70.5	0.76	0.286	0.9	0.100	0.082	**N/A**
25.30	83.0	3572	67	451.7	227.4	21	2.15	2.7	Clay-Like	37			3572	0.81	28.5	68.4	0.76	0.285	0.9	0.098	0.080	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
25.61	84.0	3064	57	457.2	229.9	17	2.20	2.7	Clay-Like	37			3064	0.80	24.4	62.8	0.76	0.284	0.9	0.091	0.075	**N/A**
25.91	85.0	2605	50	462.6	232.4	14	2.32	2.8	Clay-Like	41			2605	0.80	20.7	58.1	0.75	0.283	0.9	0.086	0.070	**N/A**
26.21	86.0	2423	51	468.0	234.9	13	2.60	2.9	Clay-Like	45			2423	0.80	19.2	56.2	0.75	0.282	0.9	0.084	0.069	**N/A**
26.51	86.9	2672	51	473.4	237.3	14	2.31	2.8	Clay-Like	41			2672	0.80	21.1	58.6	0.75	0.281	0.9	0.086	0.071	**N/A**
26.81	87.9	2518	46	478.9	239.8	13	2.25	2.8	Clay-Like	41			2518	0.80	19.8	56.9	0.75	0.281	0.9	0.085	0.069	**N/A**
27.11	88.9	2270	38	484.3	242.3	11	2.15	2.9	Clay-Like	45			2270	0.79	17.8	54.4	0.74	0.280	0.9	0.082	0.067	**N/A**
27.41	89.9	2202	36	489.7	244.8	11	2.12	2.9	Clay-Like	45			2202	0.79	17.3	53.6	0.74	0.279	0.9	0.081	0.066	**N/A**
27.71	90.9	2164	34	495.1	247.3	11	2.01	2.9	Clay-Like	45			2164	0.79	16.9	53.1	0.74	0.278	0.9	0.081	0.066	**N/A**
28.01	91.9	2241	40	500.5	249.7	11	2.31	2.9	Clay-Like	45			2241	0.79	17.5	53.9	0.73	0.277	0.9	0.081	0.066	**N/A**
28.31	92.9	3170	43	506.0	252.2	17	1.62	2.7	Clay-Like	37			3170	0.79	24.7	63.1	0.73	0.277	0.9	0.091	0.074	**N/A**
28.61	93.8	2902	56	511.4	254.7	15	2.36	2.8	Clay-Like	41			2902	0.78	22.5	60.5	0.73	0.276	0.9	0.088	0.072	**N/A**
28.91	94.8	3074	124	516.9	257.2	16	4.87	3.0	Clay-Like	49			3074	0.78	23.8	62.4	0.73	0.275	0.9	0.091	0.073	**N/A**
29.21	95.8	3945	151	522.3	259.7	21	4.42	2.8	Clay-Like	41			3945	0.78	30.4	71.2	0.72	0.274	0.9	0.101	0.081	**N/A**
29.51	96.8	5525	150	527.7	262.1	31	3.01	2.6	Clay-Like	34			5525	0.78	42.5	86.7	0.72	0.274	0.9	0.122	0.097	**N/A**
29.81	97.8	7287	214	533.1	264.6	41	3.16	2.5		30			7287	0.78	56.0	103.8	0.72	0.273	0.9	0.149	0.117	**0.43**
30.11	98.8	6531	217	538.5	267.1	36	3.63	2.6	Clay-Like	34			6531	0.77	50.0	96.7	0.72	0.272	0.9	0.137	0.108	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-15**

Test Boring Information:

Approx. ground elevation		11.7	ft	3.57 m
Approx. water table elevation		4	ft	1.22 m
Approx. depth to ground water table		7.7	ft	2.35 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	1408	33	2.3	2.3	91	2.32	2.2	Unsaturated	22			1408	1.70	23.7	56.3	1.00	0.189	1.1	0.084	0.081	**N/A**
0.45	1.5	1915	44	7.1	7.1	71	2.31	2.3	Unsaturated	24			1915	1.70	32.2	69.5	1.00	0.189	1.1	0.099	0.095	**N/A**
0.75	2.5	2921	90	11.8	11.8	84	3.09	2.3	Unsaturated	24			2921	1.70	49.2	91.7	1.00	0.189	1.1	0.129	0.125	**N/A**
1.05	3.4	1408	43	16.5	16.5	34	3.10	2.6	Unsaturated	34			1408	1.61	22.5	59.7	1.00	0.189	1.1	0.088	0.084	**N/A**
1.35	4.4	938	47	21.2	21.2	20	5.12	2.9	Unsaturated	45			938	1.51	14.0	49.2	1.00	0.188	1.1	0.077	0.074	**N/A**
1.65	5.4	804	44	25.9	25.9	15	5.66	3.0	Unsaturated	49			804	1.43	11.4	45.7	1.00	0.188	1.1	0.073	0.070	**N/A**
1.95	6.4	3438	74	30.7	30.7	61	2.16	2.3	Unsaturated	24			3438	1.37	46.6	88.4	1.00	0.188	1.1	0.124	0.120	**N/A**
2.23	7.3	6990	157	35.0	35.0	117	2.26	2.1	Unsaturated	19			6990	1.32	91.5	139.9	0.99	0.187	1.1	0.232	0.224	**N/A**
2.50	8.2	2633	72	39.7	38.2	42	2.77	2.5		30			2633	1.29	33.7	74.1	0.99	0.194	1.1	0.105	0.099	**0.51**
2.80	9.2	220	1	45.1	40.7	3	0.55	3.2	Clay-Like	58			220	1.32	2.9	34.2	0.99	0.207	1.1	0.064	0.059	**N/A**
3.10	10.2	105	1	50.5	43.1	1	1.75	3.8	Clay-Like	90			105	1.51	1.6	31.9	0.99	0.218	1.1	0.063	0.058	**N/A**
3.40	11.2	201	4	55.9	45.6	2	2.64	3.5	Clay-Like	73			201	1.30	2.6	33.5	0.99	0.228	1.0	0.064	0.059	**N/A**
3.70	12.1	13138	207	61.4	48.1	187	1.58	1.9		15			13138	1.22	158.2	207.3	0.98	0.237	1.1	1.637	1.578	**2.00**
4.03	13.2	7029	59	67.3	50.8	97	0.85	1.9		15			7029	1.20	83.4	117.5	0.98	0.245	1.1	0.174	0.166	**0.67**
4.35	14.3	1523	19	73.1	53.5	20	1.32	2.6	Clay-Like	34			1523	1.18	17.8	53.5	0.98	0.253	1.0	0.081	0.074	**N/A**
4.65	15.3	306	3	78.6	56.0	3	1.26	3.3	Clay-Like	62			306	1.17	3.5	35.0	0.98	0.259	1.0	0.065	0.059	**N/A**
4.95	16.2	412	3	84.0	58.4	4	0.88	3.1	Clay-Like	53			412	1.16	4.7	36.7	0.98	0.264	1.0	0.066	0.060	**N/A**
5.25	17.2	354	3	89.4	60.9	3	1.08	3.2	Clay-Like	58			354	1.14	4.0	35.7	0.97	0.269	1.0	0.065	0.059	**N/A**
5.55	18.2	249	3	94.8	63.4	2	1.86	3.5	Clay-Like	73			249	1.13	2.8	33.8	0.97	0.274	1.0	0.064	0.058	**N/A**
5.85	19.2	249	3	100.2	65.9	2	1.93	3.5	Clay-Like	73			249	1.12	2.8	33.8	0.97	0.278	1.0	0.064	0.057	**N/A**
6.15	20.2	306	5	105.7	68.4	2	2.39	3.5	Clay-Like	73			306	1.11	3.4	34.6	0.97	0.282	1.0	0.064	0.058	**N/A**
6.45	21.2	268	5	111.1	70.8	2	3.05	3.6	Clay-Like	78			268	1.10	2.9	33.9	0.96	0.285	1.0	0.064	0.057	**N/A**
6.75	22.2	373	5	116.5	73.3	3	1.86	3.3	Clay-Like	62			373	1.09	4.0	35.7	0.96	0.288	1.0	0.065	0.058	**N/A**
7.05	23.1	306	3	121.9	75.8	2	1.56	3.4	Clay-Like	67			306	1.08	3.3	34.6	0.96	0.291	1.0	0.064	0.057	**N/A**
7.35	24.1	278	3	127.3	78.3	2	1.91	3.6	Clay-Like	78			278	1.07	2.9	33.9	0.96	0.293	1.0	0.064	0.057	**N/A**
7.65	25.1	306	7	132.8	80.8	2	3.86	3.7	Clay-Like	84			306	1.06	3.2	34.2	0.95	0.296	1.0	0.064	0.057	**N/A**
7.95	26.1	354	6	138.2	83.2	2	2.66	3.5	Clay-Like	73			354	1.05	3.7	35.0	0.95	0.298	1.0	0.065	0.057	**N/A**
8.25	27.1	287	3	143.7	85.7	2	2.00	3.6	Clay-Like	78			287	1.04	3.0	34.0	0.95	0.299	1.0	0.064	0.057	**N/A**
8.55	28.1	230	4	149.1	88.2	1	4.74	4.0	Clay-Like	103			230	1.04	2.4	32.8	0.95	0.301	1.0	0.063	0.056	**N/A**
8.85	29.0	306	3	154.5	90.7	2	1.89	3.6	Clay-Like	78			306	1.03	3.1	34.2	0.94	0.303	1.0	0.064	0.057	**N/A**
9.15	30.0	278	4	159.9	93.2	1	3.25	3.8	Clay-Like	90			278	1.02	2.8	33.6	0.94	0.304	1.0	0.064	0.056	**N/A**
9.45	31.0	297	4	165.3	95.6	1	2.91	3.7	Clay-Like	84			297	1.01	3.0	33.9	0.94	0.305	1.0	0.064	0.056	**N/A**
9.75	32.0	345	4	170.8	98.1	2	2.20	3.6	Clay-Like	78			345	1.01	3.4	34.6	0.93	0.306	1.0	0.064	0.057	**N/A**
10.05	33.0	335	5	176.2	100.6	2	3.01	3.7	Clay-Like	84			335	1.00	3.3	34.3	0.93	0.307	1.0	0.064	0.056	**N/A**
10.35	34.0	297	3	181.6	103.1	1	2.49	3.8	Clay-Like	90			297	0.99	2.9	33.7	0.93	0.308	1.0	0.064	0.056	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	345	4	187.0	105.6	2	2.43	3.7	Clay-Like	84			345	0.99	3.4	34.4	0.92	0.309	1.0	0.064	0.056	**N/A**
10.95	35.9	326	3	192.4	108.0	1	2.16	3.7	Clay-Like	84			326	0.98	3.2	34.1	0.92	0.309	1.0	0.064	0.056	**N/A**
11.25	36.9	383	4	197.9	110.5	2	2.07	3.6	Clay-Like	78			383	0.98	3.7	35.0	0.92	0.310	1.0	0.065	0.056	**N/A**
11.55	37.9	335	3	203.3	113.0	1	2.18	3.7	Clay-Like	84			335	0.97	3.2	34.2	0.91	0.310	1.0	0.064	0.056	**N/A**
11.85	38.9	412	4	208.8	115.5	2	1.89	3.5	Clay-Like	73			412	0.97	3.9	35.4	0.91	0.311	1.0	0.065	0.056	**N/A**
12.15	39.9	364	5	214.2	118.0	1	3.20	3.8	Clay-Like	90			364	0.96	3.5	34.4	0.91	0.311	1.0	0.064	0.056	**N/A**
12.45	40.9	450	3	219.6	120.5	2	1.25	3.4	Clay-Like	67			450	0.95	4.3	35.9	0.91	0.311	1.0	0.065	0.057	**N/A**
12.75	41.8	728	3	225.0	122.9	5	0.57	3.0	Clay-Like	49			728	0.95	6.8	39.6	0.90	0.311	1.0	0.068	0.059	**N/A**
13.05	42.8	431	1	230.4	125.4	2	0.48	3.3	Clay-Like	62			431	0.94	4.0	35.7	0.90	0.311	1.0	0.065	0.056	**N/A**
13.35	43.8	440	2	235.9	127.9	2	0.94	3.4	Clay-Like	67			440	0.94	4.1	35.7	0.90	0.311	1.0	0.065	0.056	**N/A**
13.65	44.8	479	3	241.3	130.4	2	1.21	3.4	Clay-Like	67			479	0.93	4.4	36.1	0.89	0.311	1.0	0.066	0.057	**N/A**
13.95	45.8	661	3	246.7	132.9	4	0.69	3.1	Clay-Like	53			661	0.93	6.1	38.5	0.89	0.311	1.0	0.067	0.058	**N/A**
14.25	46.8	498	2	252.1	135.3	2	0.78	3.3	Clay-Like	62			498	0.93	4.6	36.4	0.89	0.311	1.0	0.066	0.057	**N/A**
14.55	47.7	2748	6	257.6	137.8	21	0.23	2.2		22			2748	0.92	25.1	58.1	0.88	0.311	1.0	0.086	0.073	**0.24**
14.85	48.7	7699	61	263.0	140.3	62	0.82	2.0		17			7699	0.92	69.9	107.5	0.88	0.310	1.0	0.155	0.131	**0.42**
15.15	49.7	3639	122	268.4	142.8	28	3.61	2.7	Clay-Like	37			3639	0.91	32.9	74.2	0.88	0.310	1.0	0.105	0.089	**N/A**
15.45	50.7	2202	108	273.8	145.3	16	5.61	3.0	Clay-Like	49			2202	0.91	19.8	57.1	0.87	0.310	1.0	0.085	0.072	**N/A**
15.75	51.7	2557	142	279.2	147.7	19	6.22	3.0	Clay-Like	49			2557	0.90	22.9	61.2	0.87	0.309	1.0	0.089	0.076	**N/A**
16.05	52.7	3093	160	284.7	150.2	23	5.69	2.9	Clay-Like	45			3093	0.90	27.6	67.5	0.86	0.309	1.0	0.097	0.082	**N/A**
16.35	53.6	8034	266	290.1	152.7	62	3.44	2.4		27			8034	0.90	71.3	122.9	0.86	0.308	0.9	0.186	0.154	**0.50**
16.66	54.6	3371	144	295.6	155.2	25	4.67	2.8	Clay-Like	41			3371	0.89	29.8	70.3	0.86	0.308	1.0	0.100	0.084	**N/A**
16.95	55.6	5037	179	301.0	157.7	37	3.78	2.6	Clay-Like	34			5037	0.89	44.3	89.1	0.85	0.307	1.0	0.126	0.105	**N/A**
17.25	56.6	14804	208	306.4	160.1	114	1.43	2.0		17			14804	0.89	129.8	181.7	0.85	0.307	0.9	0.565	0.446	**1.45**
17.55	57.6	11625	93	311.8	162.6	88	0.82	1.9		15			11625	0.88	101.5	139.2	0.85	0.306	0.9	0.230	0.187	**0.61**
17.85	58.6	14307	177	317.2	165.1	108	1.27	2.0		17			14307	0.88	124.4	175.1	0.84	0.306	0.9	0.465	0.367	**1.20**
18.16	59.6	36695	426	322.7	167.6	279	1.17	1.6		10			36695	0.87	317.9	341.3	0.84	0.305	0.8	2.000	1.485	**2.00**
18.45	60.5	31237	349	328.1	170.1	235	1.13	1.7		11			31237	0.87	269.5	306.7	0.84	0.304	0.8	2.000	1.477	**2.00**
18.76	61.5	29111	308	333.5	172.6	218	1.07	1.7		11			29111	0.87	250.2	285.4	0.83	0.304	0.8	2.000	1.470	**2.00**
19.03	62.4	17237	424	338.5	174.8	127	2.51	2.1		19			17237	0.87	147.7	211.3	0.83	0.303	0.8	2.000	1.463	**2.00**
19.30	63.3	3524	169	343.5	177.1	24	5.30	2.9	Clay-Like	45			3524	0.86	30.1	70.9	0.83	0.302	1.0	0.101	0.084	**N/A**
19.60	64.3	2451	63	348.9	179.6	16	3.01	2.8	Clay-Like	41			2451	0.86	20.9	58.3	0.82	0.302	1.0	0.086	0.072	**N/A**
19.91	65.3	4711	225	354.3	182.1	32	5.16	2.8	Clay-Like	41			4711	0.86	39.9	84.0	0.82	0.301	0.9	0.118	0.098	**N/A**
20.20	66.3	11261	508	359.7	184.5	80	4.66	2.5		30			11261	0.85	95.1	156.1	0.82	0.300	0.9	0.302	0.238	**0.79**
20.51	67.3	20349	486	365.2	187.0	145	2.43	2.1		19			20349	0.85	171.2	241.3	0.81	0.299	0.8	2.000	1.427	**2.00**
20.80	68.2	18041	361	370.6	189.5	128	2.04	2.1		19			18041	0.85	151.3	215.9	0.81	0.298	0.8	2.000	1.420	**2.00**
21.10	69.2	8408	375	376.0	192.0	58	4.67	2.5		30			8408	0.84	70.3	122.9	0.81	0.298	0.9	0.186	0.150	**0.50**
21.41	70.2	8542	274	381.4	194.5	58	3.36	2.4		27			8542	0.84	71.1	122.6	0.80	0.297	0.9	0.185	0.149	**0.50**
21.70	71.2	10926	525	386.8	196.9	75	4.98	2.5		30			10926	0.84	90.7	150.2	0.80	0.296	0.9	0.272	0.213	**0.72**
22.01	72.2	12631	627	392.3	199.4	86	5.13	2.5		30			12631	0.84	104.5	168.7	0.80	0.295	0.9	0.394	0.301	**1.02**
22.30	73.2	14594	637	397.7	201.9	99	4.49	2.4		27			14594	0.83	120.4	187.9	0.79	0.294	0.8	0.696	0.513	**1.74**
22.61	74.2	12286	508	403.1	204.4	83	4.28	2.4		27			12286	0.83	101.0	162.3	0.79	0.294	0.9	0.342	0.262	**0.89**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-16**

Test Boring Information:

Approx. ground elevation		12	ft	3.66 m
Approx. water table elevation		3	ft	0.91 m
Approx. depth to ground water table		9	ft	2.74 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	3955	13	2.3	2.3	256	0.34	1.3	Unsaturated	6			3955	1.70	66.6	66.7	1.00	0.189	1.1	0.096	0.092	**N/A**
0.45	1.5	4606	55	7.1	7.1	172	1.19	1.8	Unsaturated	13			4606	1.70	77.5	102.8	1.00	0.189	1.1	0.147	0.142	**N/A**
0.75	2.5	5315	39	11.8	11.8	153	0.74	1.7	Unsaturated	11			5315	1.70	89.5	107.8	1.00	0.189	1.1	0.156	0.150	**N/A**
1.05	3.4	3601	11	16.5	16.5	88	0.29	1.7	Unsaturated	11			3601	1.61	57.5	72.5	1.00	0.189	1.1	0.103	0.099	**N/A**
1.35	4.4	2969	23	21.2	21.2	64	0.78	2.0	Unsaturated	17			2969	1.51	44.4	75.8	1.00	0.188	1.1	0.107	0.103	**N/A**
1.65	5.4	1915	2	25.9	25.9	37	0.10	1.9	Unsaturated	15			1915	1.43	27.1	49.9	1.00	0.188	1.1	0.077	0.074	**N/A**
1.95	6.4	2949	8	30.7	30.7	52	0.26	1.9	Unsaturated	15			2949	1.37	40.0	65.4	1.00	0.188	1.1	0.094	0.090	**N/A**
2.23	7.3	2969	12	35.0	35.0	49	0.42	2.0	Unsaturated	17			2969	1.32	38.9	69.0	0.99	0.187	1.1	0.098	0.094	**N/A**
2.50	8.2	3514	11	39.3	39.3	55	0.30	1.9	Unsaturated	15			3514	1.28	44.6	70.9	0.99	0.187	1.1	0.101	0.095	**N/A**
2.80	9.2	3562	11	44.2	43.6	53	0.30	1.9		15			3562	1.25	44.0	70.2	0.99	0.189	1.1	0.100	0.094	**0.49**
3.10	10.2	4300	26	49.6	46.1	62	0.61	2.0		17			4300	1.23	52.4	85.7	0.99	0.201	1.1	0.121	0.114	**0.57**
3.40	11.2	5468	34	55.0	48.6	77	0.62	1.9		15			5468	1.21	65.7	96.2	0.99	0.211	1.1	0.136	0.129	**0.61**
3.70	12.1	5688	32	60.4	51.0	78	0.56	1.9		15			5688	1.20	67.4	98.3	0.98	0.220	1.1	0.140	0.131	**0.60**
4.03	13.2	4970	34	66.3	53.7	66	0.68	2.0		17			4970	1.18	58.1	92.8	0.98	0.229	1.1	0.131	0.122	**0.53**
4.35	14.3	5573	54	72.2	56.4	73	0.97	2.0		17			5573	1.17	64.3	100.6	0.98	0.236	1.1	0.143	0.133	**0.56**
4.65	15.3	3562	16	77.6	58.9	45	0.47	2.0		17			3562	1.15	40.7	71.2	0.98	0.243	1.0	0.101	0.093	**0.38**
4.95	16.2	2681	25	83.0	61.4	33	0.96	2.3		24			2681	1.14	30.3	66.9	0.98	0.249	1.0	0.096	0.087	**0.35**
5.25	17.2	4252	33	88.4	63.9	52	0.78	2.1		19			4252	1.13	47.5	83.9	0.97	0.254	1.0	0.118	0.108	**0.42**
5.55	18.2	3553	40	93.9	66.4	42	1.16	2.2		22			3553	1.12	39.3	76.5	0.97	0.259	1.0	0.108	0.098	**0.38**
5.85	19.2	3811	53	99.3	68.8	44	1.42	2.3		24			3811	1.11	41.8	82.0	0.97	0.263	1.0	0.115	0.105	**0.40**
6.15	20.2	6109	131	104.8	71.3	71	2.18	2.2		22			6109	1.10	66.3	111.5	0.97	0.268	1.0	0.163	0.148	**0.55**
6.45	21.2	6540	55	110.2	73.8	74	0.85	2.0		17			6540	1.09	70.3	108.0	0.96	0.271	1.0	0.156	0.142	**0.52**
6.75	22.2	4453	22	115.6	76.3	49	0.51	2.0		17			4453	1.08	47.5	79.6	0.96	0.275	1.0	0.112	0.101	**0.37**
7.05	23.1	6042	49	121.0	78.8	66	0.82	2.0		17			6042	1.07	63.9	100.0	0.96	0.278	1.0	0.143	0.128	**0.46**
7.35	24.1	7986	109	126.4	81.2	87	1.39	2.1		19			7986	1.06	83.8	130.0	0.96	0.280	1.0	0.203	0.183	**0.65**
7.65	25.1	7488	49	131.9	83.7	80	0.66	1.9		15			7488	1.05	77.9	110.9	0.95	0.283	1.0	0.162	0.145	**0.51**
7.95	26.1	1685	10	137.3	86.2	17	0.62	2.5		30			1685	1.04	17.4	52.3	0.95	0.285	1.0	0.080	0.071	**0.25**
8.25	27.1	3802	18	142.7	88.7	39	0.50	2.1		19			3802	1.03	39.0	73.0	0.95	0.288	1.0	0.103	0.092	**0.32**
8.55	28.1	8216	45	148.1	91.2	84	0.56	1.8		13			8216	1.03	83.6	109.8	0.95	0.289	1.0	0.159	0.141	**0.49**
8.85	29.0	14699	52	153.6	93.6	149	0.36	1.5		8			14699	1.02	148.5	154.0	0.94	0.291	1.0	0.291	0.258	**0.89**
9.15	30.0	8906	23	159.0	96.1	89	0.26	1.7		11			8906	1.01	89.3	107.7	0.94	0.293	1.0	0.156	0.137	**0.47**
9.45	31.0	3926	47	164.4	98.6	38	1.25	2.3		24			3926	1.01	39.1	78.5	0.94	0.294	1.0	0.111	0.097	**0.33**
9.75	32.0	1609	11	169.8	101.1	14	0.73	2.6	Clay-Like	34			1609	1.00	15.9	50.9	0.93	0.296	1.0	0.078	0.069	**N/A**
10.05	33.0	1436	9	175.2	103.6	12	0.68	2.6	Clay-Like	34			1436	0.99	14.1	48.5	0.93	0.297	1.0	0.076	0.067	**N/A**
10.35	34.0	1561	8	180.7	106.1	13	0.56	2.5		30			1561	0.99	15.3	49.4	0.93	0.298	1.0	0.077	0.067	**0.23**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	1456	9	186.1	108.5	12	0.68	2.6	Clay-Like	34			1456	0.98	14.1	48.5	0.92	0.299	1.0	0.076	0.066	**N/A**
10.95	35.9	1456	10	191.5	111.0	12	0.76	2.6	Clay-Like	34			1456	0.98	14.1	48.4	0.92	0.300	1.0	0.076	0.066	**N/A**
11.25	36.9	1456	10	197.0	113.5	12	0.76	2.6	Clay-Like	34			1456	0.97	14.0	48.3	0.92	0.300	1.0	0.076	0.066	**N/A**
11.55	37.9	1436	10	202.4	116.0	11	0.78	2.7	Clay-Like	37			1436	0.96	13.7	48.4	0.91	0.301	1.0	0.076	0.066	**N/A**
11.85	38.9	1331	10	207.8	118.5	10	0.85	2.7	Clay-Like	37			1331	0.96	12.6	46.9	0.91	0.302	1.0	0.075	0.065	**N/A**
12.15	39.9	1408	9	213.2	120.9	11	0.72	2.7	Clay-Like	37			1408	0.95	13.3	47.8	0.91	0.302	1.0	0.075	0.065	**N/A**
12.45	40.9	1350	9	218.7	123.4	10	0.76	2.7	Clay-Like	37			1350	0.95	12.7	47.0	0.91	0.302	1.0	0.075	0.064	**N/A**
12.75	41.8	1513	9	224.1	125.9	11	0.67	2.6	Clay-Like	34			1513	0.94	14.1	48.5	0.90	0.303	1.0	0.076	0.066	**N/A**
13.05	42.8	2586	26	229.5	128.4	21	1.10	2.5		30			2586	0.94	24.0	61.1	0.90	0.303	1.0	0.089	0.077	**0.25**
13.35	43.8	1714	12	234.9	130.9	13	0.84	2.6	Clay-Like	34			1714	0.93	15.9	50.8	0.90	0.303	1.0	0.078	0.067	**N/A**
13.65	44.8	1130	5	240.3	133.3	8	0.54	2.8	Clay-Like	41			1130	0.93	10.4	44.2	0.89	0.303	1.0	0.072	0.062	**N/A**
13.95	45.8	1149	10	245.8	135.8	8	1.06	2.9	Clay-Like	45			1149	0.92	10.5	44.5	0.89	0.303	1.0	0.072	0.062	**N/A**
14.25	46.8	1207	7	251.2	138.3	8	0.70	2.8	Clay-Like	41			1207	0.92	11.0	45.0	0.89	0.303	1.0	0.073	0.062	**N/A**
14.55	47.7	1331	12	256.7	140.8	9	1.16	2.8	Clay-Like	41			1331	0.92	12.1	46.4	0.88	0.303	1.0	0.074	0.063	**N/A**
14.85	48.7	5631	107	262.1	143.3	45	2.00	2.4		27			5631	0.91	50.8	95.7	0.88	0.303	1.0	0.136	0.115	**0.38**
15.15	49.7	7421	127	267.5	145.7	59	1.78	2.2		22			7421	0.91	66.7	112.0	0.88	0.303	1.0	0.164	0.137	**0.45**
15.45	50.7	4673	98	272.9	148.2	36	2.22	2.5		30			4673	0.90	41.8	84.9	0.87	0.303	1.0	0.119	0.101	**0.33**
15.75	51.7	3926	93	278.3	150.7	30	2.55	2.6	Clay-Like	34			3926	0.90	35.0	76.5	0.87	0.302	1.0	0.108	0.091	**N/A**
16.05	52.7	15494	198	283.8	153.2	122	1.30	1.9		15			15494	0.90	137.4	182.4	0.86	0.302	0.9	0.577	0.460	**1.52**
16.35	53.6	45917	284	289.2	155.7	363	0.62	1.4		7			45917	0.89	405.6	408.4	0.86	0.302	0.9	2.000	1.524	**2.00**
16.66	54.6	60195	389	294.6	158.2	473	0.65	1.3		6			60195	0.89	529.5	529.9	0.86	0.301	0.9	2.000	1.516	**2.00**
16.95	55.6	63834	417	300.0	160.6	498	0.66	1.3		6			63834	0.88	559.2	559.6	0.85	0.301	0.9	2.000	1.507	**2.00**
17.25	56.6	40353	382	305.4	163.1	312	0.95	1.5		8			40353	0.88	352.1	362.4	0.85	0.300	0.9	2.000	1.499	**2.00**
17.55	57.6	38227	500	310.9	165.6	293	1.32	1.7		11			38227	0.88	332.2	375.9	0.85	0.300	0.9	2.000	1.491	**2.00**
17.85	58.6	50791	479	316.3	168.1	387	0.95	1.5		8			50791	0.87	439.7	452.1	0.84	0.299	0.8	2.000	1.484	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-22**

Test Boring Information:

Approx. ground elevation		6	ft	1.83 m
Approx. water table elevation		1.5	ft	0.46 m
Approx. depth to ground water table		4.5	ft	1.37 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	12401	124	2.3	2.3	804	1.00	1.3	Unsaturated	6			12401	1.70	208.7	208.9	1.00	0.189	1.1	1.784	1.719	**N/A**
0.45	1.5	6588	88	7.1	7.1	246	1.34	1.7	Unsaturated	11			6588	1.70	110.9	131.5	1.00	0.189	1.1	0.207	0.199	**N/A**
0.75	2.5	3792	43	11.8	11.8	109	1.14	1.9	Unsaturated	15			3792	1.70	63.8	94.0	1.00	0.189	1.1	0.133	0.128	**N/A**
1.05	3.4	1025	26	16.5	16.5	25	2.56	2.6	Unsaturated	34			1025	1.61	16.4	51.5	1.00	0.189	1.1	0.079	0.076	**N/A**
1.35	4.4	2049	49	21.2	21.2	44	2.41	2.4	Unsaturated	27			2049	1.51	30.6	68.9	1.00	0.188	1.1	0.098	0.095	**N/A**
1.65	5.4	728	13	26.6	23.9	14	1.91	2.8	Clay-Like	41			728	1.46	10.5	44.4	1.00	0.209	1.1	0.072	0.069	**N/A**
1.95	6.4	1321	53	32.0	26.4	25	4.08	2.8	Clay-Like	41			1321	1.43	18.6	55.3	1.00	0.228	1.1	0.083	0.080	**N/A**
2.23	7.3	2949	65	37.0	28.6	54	2.24	2.3		24			2949	1.39	40.7	80.6	0.99	0.242	1.1	0.113	0.109	**0.45**
2.50	8.2	3294	74	42.0	30.9	58	2.27	2.3		24			3294	1.37	44.6	85.7	0.99	0.254	1.1	0.121	0.116	**0.46**
2.80	9.2	1417	41	47.4	33.4	24	3.01	2.7	Clay-Like	37			1417	1.34	18.8	55.2	0.99	0.265	1.1	0.083	0.078	**N/A**
3.10	10.2	1925	46	52.8	35.9	31	2.46	2.6	Clay-Like	34			1925	1.31	25.0	63.2	0.99	0.275	1.1	0.091	0.087	**N/A**
3.40	11.2	1341	14	58.2	38.3	21	1.12	2.5		30			1341	1.29	17.1	51.9	0.99	0.283	1.1	0.079	0.074	**0.26**
3.70	12.1	1494	33	63.7	40.8	22	2.28	2.6	Clay-Like	34			1494	1.27	18.8	54.8	0.98	0.290	1.1	0.082	0.077	**N/A**
4.03	13.2	2040	54	69.6	43.5	30	2.72	2.6	Clay-Like	34			2040	1.25	25.2	63.4	0.98	0.296	1.1	0.092	0.086	**N/A**
4.35	14.3	1025	28	75.4	46.2	14	2.93	2.9	Clay-Like	45			1025	1.23	12.5	47.1	0.98	0.302	1.1	0.075	0.069	**N/A**
4.65	15.3	8896	40	80.9	48.7	126	0.46	1.6		10			8896	1.21	106.8	118.0	0.98	0.306	1.1	0.175	0.167	**0.55**
4.95	16.2	9902	47	86.3	51.2	136	0.48	1.6		10			9902	1.20	117.3	129.1	0.98	0.310	1.1	0.201	0.192	**0.62**
5.25	17.2	6445	14	91.7	53.6	86	0.23	1.6		10			6445	1.18	75.4	84.8	0.97	0.314	1.1	0.119	0.111	**0.35**
5.55	18.2	4922	5	97.1	56.1	64	0.10	1.7		11			4922	1.17	56.9	71.9	0.97	0.317	1.1	0.102	0.094	**0.30**
5.85	19.2	1934	5	102.5	58.6	24	0.26	2.2		22			1934	1.15	22.1	54.2	0.97	0.320	1.0	0.082	0.074	**0.23**
6.15	20.2	1494	6	108.0	61.1	18	0.41	2.4		27			1494	1.14	16.9	50.6	0.97	0.322	1.0	0.078	0.071	**0.22**
6.45	21.2	1561	4	113.4	63.6	18	0.26	2.3		24			1561	1.13	17.5	50.1	0.96	0.324	1.0	0.078	0.070	**0.22**
6.75	22.2	1369	2	118.8	66.1	15	0.15	2.3		24			1369	1.12	15.2	47.0	0.96	0.326	1.0	0.075	0.067	**0.21**
7.05	23.1	1436	2	124.2	68.5	16	0.15	2.3		24			1436	1.11	15.8	47.8	0.96	0.328	1.0	0.075	0.068	**0.21**
7.35	24.1	1436	1	129.6	71.0	15	0.10	2.3		24			1436	1.10	15.6	47.6	0.96	0.329	1.0	0.075	0.068	**0.21**
7.65	25.1	1436	1	135.1	73.5	15	0.10	2.3		24			1436	1.09	15.5	47.4	0.95	0.330	1.0	0.075	0.067	**0.20**
7.95	26.1	1484	1	140.5	76.0	15	0.10	2.3		24			1484	1.08	15.8	47.9	0.95	0.331	1.0	0.076	0.067	**0.20**
8.25	27.1	1446	1	146.0	78.5	15	0.10	2.3		24			1446	1.07	15.3	47.2	0.95	0.332	1.0	0.075	0.067	**0.20**
8.55	28.1	1513	1	151.4	80.9	15	0.10	2.3		24			1513	1.06	15.9	48.0	0.95	0.333	1.0	0.076	0.067	**0.20**
8.85	29.0	1542	1	156.8	83.4	15	0.10	2.3		24			1542	1.05	16.1	48.2	0.94	0.334	1.0	0.076	0.067	**0.20**
9.15	30.0	1417	1	162.2	85.9	13	0.10	2.4		27			1417	1.04	14.6	47.7	0.94	0.334	1.0	0.075	0.067	**0.20**
9.45	31.0	1456	1	167.6	88.4	14	0.10	2.3		24			1456	1.04	14.9	46.7	0.94	0.335	1.0	0.074	0.066	**0.20**
9.75	32.0	1523	1	173.1	90.9	14	0.10	2.3		24			1523	1.03	15.5	47.5	0.93	0.335	1.0	0.075	0.066	**0.20**
10.05	33.0	1475	1	178.5	93.3	13	0.10	2.4		27			1475	1.02	14.9	48.0	0.93	0.335	1.0	0.076	0.067	**0.20**
10.35	34.0	1523	1	183.9	95.8	14	0.10	2.3		24			1523	1.01	15.3	47.2	0.93	0.336	1.0	0.075	0.066	**0.20**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	1484	1	189.3	98.3	13	0.10	2.4		27			1484	1.01	14.8	47.9	0.92	0.336	1.0	0.075	0.066	**0.20**
10.95	35.9	1551	1	194.7	100.8	13	0.10	2.4		27			1551	1.00	15.4	48.6	0.92	0.336	1.0	0.076	0.067	**0.20**
11.25	36.9	1561	1	200.2	103.3	13	0.10	2.4		27			1561	0.99	15.4	48.6	0.92	0.336	1.0	0.076	0.067	**0.20**
11.55	37.9	2710	5	205.6	105.7	24	0.19	2.1		19			2710	0.99	26.5	57.2	0.91	0.335	1.0	0.085	0.074	**0.22**
11.85	38.9	6004	12	211.1	108.2	55	0.21	1.8		13			6004	0.98	58.4	80.7	0.91	0.335	1.0	0.114	0.099	**0.30**
12.15	39.9	9250	7	216.5	110.7	85	0.10	1.6		10			9250	0.98	89.4	99.6	0.91	0.335	1.0	0.142	0.123	**0.37**
12.45	40.9	2289	6	221.9	113.2	19	0.28	2.3		24			2289	0.97	22.0	56.0	0.91	0.335	1.0	0.084	0.073	**0.22**
12.75	41.8	3045	3	227.3	115.7	26	0.10	2.1		19			3045	0.96	29.1	60.5	0.90	0.334	1.0	0.088	0.077	**0.23**
13.05	42.8	8705	9	232.7	118.1	77	0.10	1.6		10			8705	0.96	82.7	92.5	0.90	0.334	1.0	0.131	0.113	**0.34**
13.35	43.8	9346	5	238.2	120.6	82	0.10	1.6		10			9346	0.95	88.3	98.4	0.90	0.333	1.0	0.140	0.120	**0.36**
13.65	44.8	14872	38	243.6	123.1	131	0.26	1.5		8			14872	0.95	139.8	145.1	0.89	0.333	1.0	0.251	0.213	**0.64**
13.95	45.8	18530	131	249.0	125.6	162	0.72	1.7		11			18530	0.94	173.2	200.3	0.89	0.332	0.9	1.155	0.953	**2.00**
14.25	46.8	42067	503	254.4	128.1	367	1.20	1.6		10			42067	0.94	391.2	418.9	0.89	0.332	0.9	2.000	1.627	**2.00**
14.55	47.7	34579	346	259.9	130.6	298	1.01	1.6		10			34579	0.93	319.9	343.5	0.88	0.331	0.9	2.000	1.617	**2.00**
14.85	48.7	43035	418	265.3	133.0	368	0.98	1.5		8			43035	0.93	396.2	407.6	0.88	0.330	0.9	2.000	1.607	**2.00**
15.15	49.7	47727	533	270.7	135.5	405	1.12	1.5		8			47727	0.93	437.3	449.7	0.88	0.330	0.9	2.000	1.597	**2.00**
15.45	50.7	43054	435	276.1	138.0	362	1.02	1.5		8			43054	0.92	392.6	403.9	0.87	0.329	0.9	2.000	1.587	**2.00**
15.75	51.7	41876	434	281.5	140.5	349	1.04	1.5		8			41876	0.92	380.1	391.1	0.87	0.328	0.9	2.000	1.578	**2.00**
16.05	52.7	52553	631	287.0	143.0	434	1.21	1.5		8			52553	0.91	474.7	488.0	0.86	0.327	0.9	2.000	1.569	**2.00**
16.35	53.6	45888	529	292.4	145.4	376	1.16	1.6		10			45888	0.91	412.7	441.6	0.86	0.326	0.9	2.000	1.560	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-23**

Test Boring Information:

Approx. ground elevation		16 ft	4.88 m
Approx. water table elevation		4.3 ft	1.31 m
Approx. depth to ground water table		11.7 ft	3.57 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	4280	48	2.3	2.3	277	1.12	1.6	Unsaturated	10			4280	1.70	72.0	81.2	1.00	0.189	1.1	0.114	0.110	**N/A**
0.45	1.5	18386	312	7.1	7.1	686	1.70	1.6	Unsaturated	10			18386	1.70	309.5	332.4	1.00	0.189	1.1	2.000	1.927	**N/A**
0.75	2.5	14125	489	11.8	11.8	408	3.47	2.0	Unsaturated	17			14125	1.70	237.7	315.6	1.00	0.189	1.1	2.000	1.927	**N/A**
1.05	3.4	8685	253	16.5	16.5	212	2.92	2.0	Unsaturated	17			8685	1.61	138.7	192.8	1.00	0.189	1.1	0.837	0.806	**N/A**
1.35	4.4	2586	57	21.2	21.2	55	2.24	2.3	Unsaturated	24			2586	1.51	38.6	77.9	1.00	0.188	1.1	0.110	0.106	**N/A**
1.65	5.4	10122	146	25.9	25.9	197	1.44	1.8	Unsaturated	13			10122	1.43	143.5	178.9	1.00	0.188	1.1	0.519	0.500	**N/A**
1.95	6.4	4462	149	30.7	30.7	80	3.37	2.3	Unsaturated	24			4462	1.37	60.5	106.6	1.00	0.188	1.1	0.154	0.148	**N/A**
2.23	7.3	2538	67	35.0	35.0	42	2.68	2.5	Unsaturated	30			2538	1.32	33.2	73.4	0.99	0.187	1.1	0.104	0.099	**N/A**
2.50	8.2	1906	102	39.3	39.3	30	5.49	2.8	Unsaturated	41			1906	1.28	24.2	62.8	0.99	0.187	1.1	0.091	0.086	**N/A**
2.80	9.2	1456	115	44.0	44.0	21	8.14	3.0	Unsaturated	49			1456	1.24	17.9	54.5	0.99	0.187	1.1	0.082	0.076	**N/A**
3.10	10.2	1417	34	48.7	48.7	19	2.52	2.7	Unsaturated	37			1417	1.21	17.0	52.8	0.99	0.186	1.1	0.080	0.074	**N/A**
3.40	11.2	1647	27	53.4	53.4	22	1.68	2.6	Unsaturated	34			1647	1.18	19.3	55.5	0.99	0.186	1.0	0.083	0.076	**N/A**
3.70	12.1	1149	33	58.5	57.2	14	2.99	2.9	Clay-Like	45			1149	1.16	13.2	48.1	0.98	0.190	1.0	0.076	0.069	**N/A**
4.03	13.2	316	12	64.4	59.9	3	4.95	3.5	Clay-Like	73			316	1.15	3.6	34.9	0.98	0.199	1.0	0.065	0.058	**N/A**
4.35	14.3	316	7	70.2	62.6	3	2.73	3.4	Clay-Like	67			316	1.13	3.6	34.9	0.98	0.207	1.0	0.065	0.058	**N/A**
4.65	15.3	354	6	75.7	65.0	3	2.06	3.3	Clay-Like	62			354	1.12	3.9	35.5	0.98	0.215	1.0	0.065	0.059	**N/A**
4.95	16.2	421	8	81.1	67.5	4	2.25	3.3	Clay-Like	62			421	1.11	4.6	36.5	0.98	0.221	1.0	0.066	0.059	**N/A**
5.25	17.2	421	6	86.5	70.0	4	1.72	3.2	Clay-Like	58			421	1.10	4.6	36.5	0.97	0.227	1.0	0.066	0.059	**N/A**
5.55	18.2	383	7	92.0	72.5	3	2.30	3.3	Clay-Like	62			383	1.09	4.1	35.8	0.97	0.232	1.0	0.065	0.058	**N/A**
5.85	19.2	642	9	97.4	75.0	6	1.58	3.0	Clay-Like	49			642	1.08	6.9	39.6	0.97	0.237	1.0	0.068	0.061	**N/A**
6.15	20.2	488	7	102.8	77.5	4	1.74	3.2	Clay-Like	58			488	1.07	5.2	37.3	0.97	0.242	1.0	0.066	0.059	**N/A**
6.45	21.2	1628	19	108.2	79.9	17	1.26	2.6	Clay-Like	34			1628	1.06	17.1	52.6	0.96	0.246	1.0	0.080	0.071	**N/A**
6.75	22.2	804	10	113.7	82.4	8	1.39	2.9	Clay-Like	45			804	1.06	8.4	41.6	0.96	0.250	1.0	0.070	0.062	**N/A**
7.05	23.1	517	7	119.1	84.9	4	1.68	3.2	Clay-Like	58			517	1.05	5.4	37.5	0.96	0.253	1.0	0.067	0.059	**N/A**
7.35	24.1	2059	16	124.5	87.4	21	0.84	2.4		27			2059	1.04	21.2	56.3	0.96	0.257	1.0	0.084	0.074	**0.29**
7.65	25.1	5813	39	129.9	89.9	60	0.69	2.0		17			5813	1.03	59.4	94.4	0.95	0.260	1.0	0.134	0.118	**0.46**
7.95	26.1	10610	87	135.3	92.3	108	0.83	1.8		13			10610	1.02	107.6	137.5	0.95	0.263	1.0	0.224	0.199	**0.76**
8.25	27.1	10955	93	140.8	94.8	110	0.86	1.8		13			10955	1.02	110.3	140.6	0.95	0.265	1.0	0.235	0.207	**0.78**
8.55	28.1	10333	77	146.2	97.3	103	0.75	1.8		13			10333	1.01	103.3	132.6	0.95	0.268	1.0	0.210	0.185	**0.69**
8.85	29.0	6071	104	151.6	99.8	59	1.76	2.2		22			6071	1.00	60.3	103.7	0.94	0.270	1.0	0.149	0.130	**0.48**
9.15	30.0	4912	190	157.0	102.3	47	3.99	2.6	Clay-Like	34			4912	1.00	48.5	94.6	0.94	0.272	1.0	0.134	0.117	**N/A**
9.45	31.0	3457	104	162.4	104.7	32	3.17	2.6	Clay-Like	34			3457	0.99	33.9	75.1	0.94	0.274	1.0	0.106	0.093	**N/A**
9.75	32.0	7527	238	167.9	107.2	71	3.24	2.4		27			7527	0.98	73.4	125.6	0.93	0.276	1.0	0.192	0.167	**0.61**
10.05	33.0	19592	715	173.3	109.7	184	3.68	2.2		22			19592	0.98	189.8	271.6	0.93	0.277	1.0	2.000	1.708	**2.00**
10.35	34.0	30490	888	178.8	112.2	284	2.93	2.0		17			30490	0.97	293.6	385.0	0.93	0.279	1.0	2.000	1.696	**2.00**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	35297	948	184.2	114.7	326	2.70	1.9		15			35297	0.97	338.0	423.2	0.92	0.280	1.0	2.000	1.685	**2.00**
10.95	35.9	40305	857	189.6	117.1	368	2.14	1.8		13			40305	0.96	383.8	456.3	0.92	0.281	1.0	2.000	1.674	**2.00**
11.25	36.9	41799	982	195.0	119.6	378	2.36	1.8		13			41799	0.96	395.8	470.2	0.92	0.282	0.9	2.000	1.663	**2.00**
11.55	37.9	14929	479	200.4	122.1	132	3.25	2.2		22			14929	0.95	140.6	207.8	0.91	0.283	0.9	1.679	1.390	**2.00**
11.85	38.9	7163	343	205.9	124.6	62	4.93	2.5		30			7163	0.95	67.1	118.7	0.91	0.284	1.0	0.177	0.151	**0.53**
12.15	39.9	13512	665	211.3	127.1	117	5.00	2.4		27			13512	0.94	125.9	195.3	0.91	0.285	0.9	0.927	0.765	**2.00**
12.45	40.9	15867	689	216.7	129.6	137	4.40	2.3		24			15867	0.94	147.1	220.4	0.91	0.285	0.9	2.000	1.621	**2.00**
12.75	41.8	20148	773	222.1	132.0	172	3.88	2.2		22			20148	0.93	185.9	266.5	0.90	0.286	0.9	2.000	1.611	**2.00**
13.05	42.8	30701	782	227.5	134.5	261	2.57	1.9		15			30701	0.93	281.8	355.8	0.90	0.287	0.9	2.000	1.601	**2.00**
13.35	43.8	36571	939	233.0	137.0	308	2.59	1.9		15			36571	0.92	334.1	418.6	0.90	0.287	0.9	2.000	1.591	**2.00**
13.65	44.8	33813	884	238.4	139.5	282	2.63	1.9		15			33813	0.92	307.5	386.6	0.89	0.287	0.9	2.000	1.582	**2.00**
13.95	45.8	36389	890	243.9	142.0	301	2.46	1.9		15			36389	0.91	329.3	412.8	0.89	0.288	0.9	2.000	1.572	**2.00**
14.25	46.8	36513	899	249.3	144.4	300	2.48	1.9		15			36513	0.91	329.0	412.4	0.89	0.288	0.9	2.000	1.563	**2.00**
14.55	47.7	28412	838	254.7	146.9	231	2.98	2.0		17			28412	0.91	254.8	336.8	0.88	0.288	0.9	2.000	1.554	**2.00**
14.85	48.7	19765	573	260.1	149.4	159	2.94	2.1		19			19765	0.90	176.5	248.0	0.88	0.288	0.9	2.000	1.546	**2.00**
15.15	49.7	16394	411	265.5	151.9	130	2.55	2.1		19			16394	0.90	145.8	208.9	0.88	0.288	0.9	1.781	1.374	**2.00**
15.45	50.7	2499	46	271.0	154.4	18	2.06	2.7	Clay-Like	37			2499	0.89	22.1	59.7	0.87	0.288	1.0	0.088	0.074	**N/A**
15.75	51.7	2949	58	276.4	156.8	21	2.19	2.7	Clay-Like	37			2949	0.89	26.0	64.9	0.87	0.288	1.0	0.093	0.079	**N/A**
16.05	52.7	4960	265	281.8	159.3	37	5.67	2.7	Clay-Like	37			4960	0.89	43.5	88.6	0.86	0.288	1.0	0.125	0.104	**N/A**
16.35	53.6	7230	393	287.2	161.8	54	5.66	2.6	Clay-Like	34			7230	0.88	63.2	114.4	0.86	0.288	0.9	0.168	0.139	**N/A**
16.66	54.6	7230	454	292.7	164.3	54	6.54	2.7	Clay-Like	37			7230	0.88	63.0	114.7	0.86	0.288	0.9	0.169	0.139	**N/A**
16.95	55.6	5765	406	298.1	166.8	42	7.43	2.8	Clay-Like	41			5765	0.88	50.0	97.6	0.85	0.288	0.9	0.139	0.115	**N/A**
17.25	56.6	5726	388	303.5	169.2	41	7.15	2.8	Clay-Like	41			5726	0.87	49.5	96.9	0.85	0.288	0.9	0.138	0.114	**N/A**
17.55	57.6	15178	651	308.9	171.7	113	4.38	2.3		24			15178	0.87	130.6	198.8	0.85	0.287	0.9	1.076	0.813	**2.00**
17.85	58.6	34167	917	314.3	174.2	255	2.71	2.0		17			34167	0.87	293.0	384.1	0.84	0.287	0.8	2.000	1.465	**2.00**
18.16	59.6	41493	1216	319.8	176.7	308	2.95	2.0		17			41493	0.86	354.5	460.4	0.84	0.287	0.8	2.000	1.457	**2.00**
18.45	60.5	30672	1041	325.2	179.2	225	3.43	2.1		19			30672	0.86	261.1	355.5	0.84	0.286	0.8	2.000	1.450	**2.00**
18.76	61.5	5937	353	330.7	181.7	41	6.30	2.7	Clay-Like	37			5937	0.86	50.3	97.7	0.83	0.286	0.9	0.139	0.114	**N/A**
19.03	62.4	23241	815	335.6	183.9	168	3.56	2.2		22			23241	0.85	196.5	280.2	0.83	0.286	0.8	2.000	1.436	**2.00**
19.30	63.3	48004	1343	340.6	186.2	347	2.82	1.9		15			48004	0.85	404.5	503.0	0.83	0.285	0.8	2.000	1.430	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-24**

Test Boring Information:

Approx. ground elevation		6	ft	1.83 m
Approx. water table elevation		1.5	ft	0.46 m
Approx. depth to ground water table		4.5	ft	1.37 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.50 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	6272	108	2.3	2.3	407	1.73	1.7	Unsaturated	11			6272	1.70	105.6	125.6	1.00	0.325	1.1	0.192	0.185	**N/A**
0.45	1.5	8992	322	7.1	7.1	335	3.58	2.0	Unsaturated	17			8992	1.70	151.3	208.5	1.00	0.325	1.1	1.743	1.679	**N/A**
0.75	2.5	5717	173	11.8	11.8	165	3.04	2.1	Unsaturated	19			5717	1.70	96.2	145.9	1.00	0.325	1.1	0.254	0.244	**N/A**
1.05	3.4	23988	664	16.5	16.5	587	2.77	1.8	Unsaturated	13			23988	1.61	383.1	455.6	1.00	0.325	1.1	2.000	1.927	**N/A**
1.35	4.4	9940	444	21.2	21.2	214	4.48	2.2	Unsaturated	22			9940	1.51	148.5	218.0	1.00	0.325	1.1	2.000	1.927	**N/A**
1.65	5.4	3227	161	26.6	23.9	65	5.03	2.5		30			3227	1.46	46.8	91.5	1.00	0.361	1.1	0.129	0.124	**0.34**
1.95	6.4	1436	102	32.0	26.4	27	7.30	2.9	Clay-Like	45			1436	1.43	20.3	57.6	1.00	0.393	1.1	0.085	0.082	**N/A**
2.23	7.3	1226	53	37.0	28.6	22	4.43	2.8	Clay-Like	41			1226	1.39	16.9	53.0	0.99	0.418	1.1	0.080	0.077	**N/A**
2.50	8.2	996	56	42.0	30.9	17	5.82	3.0	Clay-Like	49			996	1.37	13.5	48.5	0.99	0.438	1.1	0.076	0.072	**N/A**
2.80	9.2	1187	45	47.4	33.4	20	3.95	2.8	Clay-Like	41			1187	1.34	15.7	51.4	0.99	0.457	1.1	0.079	0.075	**N/A**
3.10	10.2	1216	29	52.8	35.9	19	2.47	2.7	Clay-Like	37			1216	1.31	15.8	51.2	0.99	0.473	1.1	0.079	0.074	**N/A**
3.40	11.2	1274	34	58.2	38.3	20	2.76	2.7	Clay-Like	37			1274	1.29	16.3	51.8	0.99	0.487	1.1	0.079	0.074	**N/A**
3.70	12.1	2777	27	63.7	40.8	42	0.99	2.2		22			2777	1.27	34.9	70.8	0.98	0.499	1.1	0.101	0.095	**0.19**
4.03	13.2	124	4	69.6	43.5	1	6.98	4.0	Clay-Like	103			124	1.46	1.8	32.0	0.98	0.510	1.1	0.063	0.058	**N/A**
4.35	14.3	268	7	75.4	46.2	3	3.48	3.5	Clay-Like	73			268	1.23	3.3	34.5	0.98	0.520	1.0	0.064	0.059	**N/A**
4.65	15.3	124	3	80.9	48.7	1	6.59	4.0	Clay-Like	103			124	1.39	1.7	31.9	0.98	0.528	1.0	0.063	0.057	**N/A**
4.95	16.2	201	6	86.3	51.2	2	5.00	3.8	Clay-Like	90			201	1.25	2.5	33.1	0.98	0.535	1.0	0.063	0.058	**N/A**
5.25	17.2	163	4	91.7	53.6	1	5.39	4.0	Clay-Like	103			163	1.27	2.1	32.3	0.97	0.541	1.0	0.063	0.057	**N/A**
5.55	18.2	153	2	97.1	56.1	1	3.41	3.9	Clay-Like	96			153	1.26	1.9	32.3	0.97	0.546	1.0	0.063	0.057	**N/A**
5.85	19.2	345	3	102.5	58.6	3	1.19	3.2	Clay-Like	58			345	1.15	3.9	35.6	0.97	0.551	1.0	0.065	0.059	**N/A**
6.15	20.2	718	5	108.0	61.1	8	0.78	2.8	Clay-Like	41			718	1.14	8.1	41.1	0.97	0.555	1.0	0.070	0.063	**N/A**
6.45	21.2	814	8	113.4	63.6	9	1.09	2.8	Clay-Like	41			814	1.13	9.1	42.4	0.96	0.559	1.0	0.071	0.064	**N/A**
6.75	22.2	220	4	118.8	66.1	1	3.78	3.8	Clay-Like	90			220	1.14	2.5	33.1	0.96	0.562	1.0	0.063	0.057	**N/A**
7.05	23.1	182	5	124.2	68.5	1	8.30	4.1	Clay-Like	110			182	1.15	2.1	32.3	0.96	0.565	1.0	0.063	0.056	**N/A**
7.35	24.1	1666	9	129.6	71.0	18	0.56	2.4		27			1666	1.10	18.1	52.3	0.96	0.567	1.0	0.080	0.072	**0.13**
7.65	25.1	8360	47	135.1	73.5	95	0.57	1.8		13			8360	1.09	90.0	117.2	0.95	0.570	1.0	0.174	0.158	**0.28**
7.95	26.1	13588	68	140.5	76.0	153	0.51	1.6		10			13588	1.08	145.0	158.5	0.95	0.571	1.0	0.316	0.291	**0.51**
8.25	27.1	10103	33	146.0	78.5	112	0.33	1.6		10			10103	1.07	106.9	118.1	0.95	0.573	1.0	0.176	0.159	**0.28**
8.55	28.1	4309	44	151.4	80.9	46	1.06	2.2		22			4309	1.06	45.2	84.2	0.95	0.574	1.0	0.118	0.106	**0.18**
8.85	29.0	3208	110	156.8	83.4	33	3.61	2.6	Clay-Like	34			3208	1.05	33.4	74.4	0.94	0.576	1.0	0.105	0.094	**N/A**
9.15	30.0	7364	96	162.2	85.9	77	1.33	2.1		19			7364	1.04	76.1	120.3	0.94	0.577	1.0	0.180	0.161	**0.28**
9.45	31.0	9739	278	167.6	88.4	101	2.90	2.2		22			9739	1.04	99.9	155.0	0.94	0.577	1.0	0.296	0.265	**0.46**
9.75	32.0	23002	714	173.1	90.9	238	3.13	2.0		17			23002	1.03	234.2	311.2	0.93	0.578	1.0	2.000	1.807	**2.00**
10.05	33.0	27311	626	178.5	93.3	279	2.31	1.9		15			27311	1.02	276.1	348.9	0.93	0.578	1.0	2.000	1.793	**2.00**
10.35	34.0	21814	482	183.9	95.8	220	2.23	1.9		15			21814	1.01	219.0	280.3	0.93	0.579	1.0	2.000	1.779	**2.00**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	21977	440	189.3	98.3	218	2.02	1.9		15			21977	1.01	219.2	280.5	0.92	0.579	1.0	2.000	1.766	**2.00**
10.95	35.9	45400	853	194.7	100.8	447	1.89	1.7		11			45400	1.00	449.8	505.8	0.92	0.579	1.0	2.000	1.753	**2.00**
11.25	36.9	30557	729	200.2	103.3	297	2.40	1.9		15			30557	0.99	300.8	378.5	0.92	0.578	1.0	2.000	1.740	**2.00**
11.55	37.9	9796	365	205.6	105.7	93	3.80	2.3		24			9796	0.99	95.8	153.0	0.91	0.578	1.0	0.286	0.249	**0.43**
11.85	38.9	13397	697	211.1	108.2	126	5.29	2.4		27			13397	0.98	130.2	201.1	0.91	0.578	1.0	1.195	1.028	**1.78**
12.15	39.9	14096	576	216.5	110.7	131	4.15	2.3		24			14096	0.98	136.2	206.1	0.91	0.577	1.0	1.536	1.310	**2.00**
12.45	40.9	16049	512	221.9	113.2	148	3.24	2.2		22			16049	0.97	154.2	225.4	0.91	0.577	1.0	2.000	1.692	**2.00**
12.75	41.8	14958	497	227.3	115.7	136	3.37	2.2		22			14958	0.96	142.9	210.8	0.90	0.576	1.0	1.980	1.664	**2.00**
13.05	42.8	32530	852	232.7	118.1	295	2.64	1.9		15			32530	0.96	309.0	388.4	0.90	0.575	1.0	2.000	1.669	**2.00**
13.35	43.8	44653	990	238.2	120.6	402	2.23	1.8		13			44653	0.95	421.9	500.3	0.90	0.575	0.9	2.000	1.658	**2.00**
13.65	44.8	42144	1113	243.6	123.1	375	2.66	1.9		15			42144	0.95	396.0	492.9	0.89	0.574	0.9	2.000	1.647	**2.00**
13.95	45.8	36475	829	249.0	125.6	321	2.29	1.9		15			36475	0.94	341.0	426.8	0.89	0.573	0.9	2.000	1.637	**2.00**
14.25	46.8	33631	818	254.4	128.1	293	2.45	1.9		15			33631	0.94	312.8	392.9	0.89	0.572	0.9	2.000	1.627	**2.00**
14.55	47.7	27780	801	259.9	130.6	239	2.91	2.0		17			27780	0.93	257.0	339.6	0.88	0.571	0.9	2.000	1.617	**2.00**
14.85	48.7	8120	164	265.3	133.0	68	2.08	2.2		22			8120	0.93	74.8	122.5	0.88	0.569	1.0	0.185	0.156	**0.27**
15.15	49.7	3256	67	270.7	135.5	25	2.25	2.6	Clay-Like	34			3256	0.93	29.8	69.6	0.88	0.568	1.0	0.099	0.085	**N/A**
15.45	50.7	2375	91	276.1	138.0	18	4.33	2.9	Clay-Like	45			2375	0.92	21.7	59.5	0.87	0.567	1.0	0.087	0.075	**N/A**
15.75	51.7	3715	199	281.5	140.5	29	5.80	2.8	Clay-Like	41			3715	0.92	33.7	75.6	0.87	0.566	1.0	0.107	0.091	**N/A**
16.05	52.7	6943	369	287.0	143.0	55	5.54	2.6	Clay-Like	34			6943	0.91	62.7	113.7	0.86	0.564	1.0	0.167	0.140	**N/A**
16.35	53.6	7814	425	292.4	145.4	62	5.65	2.6	Clay-Like	34			7814	0.91	70.3	123.9	0.86	0.563	1.0	0.188	0.157	**N/A**
16.66	54.6	11759	704	297.9	147.9	94	6.14	2.5		30			11759	0.90	105.3	169.7	0.86	0.561	0.9	0.404	0.328	**0.58**
16.95	55.6	4443	298	303.3	150.4	34	7.19	2.8	Clay-Like	41			4443	0.90	39.6	83.6	0.85	0.560	1.0	0.118	0.099	**N/A**
17.25	56.6	5066	288	308.7	152.9	38	6.06	2.8	Clay-Like	41			5066	0.90	45.0	90.8	0.85	0.558	1.0	0.128	0.108	**N/A**
17.55	57.6	14019	463	314.1	155.4	109	3.37	2.3		24			14019	0.89	123.9	189.9	0.85	0.557	0.9	0.748	0.589	**1.06**
17.85	58.6	19583	688	319.5	157.8	152	3.57	2.2		22			19583	0.89	172.3	248.9	0.84	0.555	0.9	2.000	1.517	**2.00**
18.16	59.6	35288	982	325.0	160.3	274	2.81	2.0		17			35288	0.89	309.3	404.4	0.84	0.554	0.9	2.000	1.508	**2.00**
18.45	60.5	25491	818	330.4	162.8	196	3.25	2.1		19			25491	0.88	222.5	306.5	0.84	0.552	0.9	2.000	1.500	**2.00**
18.76	61.5	5640	296	335.8	165.3	41	5.58	2.7	Clay-Like	37			5640	0.88	49.0	95.9	0.83	0.550	0.9	0.136	0.113	**N/A**
19.03	62.4	9490	457	340.8	167.6	70	4.99	2.5		30			9490	0.87	82.2	138.9	0.83	0.549	0.9	0.229	0.186	**0.34**
19.30	63.3	26774	727	345.8	169.8	201	2.75	2.0		17			26774	0.87	231.1	307.4	0.83	0.547	0.8	2.000	1.478	**2.00**
19.60	64.3	45247	886	351.2	172.3	340	1.97	1.8		13			45247	0.87	389.1	462.5	0.82	0.546	0.8	2.000	1.471	**2.00**
19.91	65.3	57312	1289	356.6	174.8	428	2.26	1.8		13			57312	0.87	491.0	580.1	0.82	0.544	0.8	2.000	1.463	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-25**

Test Boring Information:

Approx. ground elevation		16	ft	4.88 m
Approx. water table elevation		4.4	ft	1.34 m
Approx. depth to ground water table		11.6	ft	3.54 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	4338	41	2.3	2.3	281	0.95	1.6	Unsaturated	10			4338	1.70	73.0	82.3	1.00	0.189	1.1	0.116	0.112	**N/A**
0.45	1.5	2662	29	7.1	7.1	99	1.08	1.9	Unsaturated	15			2662	1.70	44.8	71.2	1.00	0.189	1.1	0.101	0.097	**N/A**
0.75	2.5	1695	15	11.8	11.8	49	0.91	2.1	Unsaturated	19			1695	1.70	28.5	59.8	1.00	0.189	1.1	0.088	0.084	**N/A**
1.05	3.4	1226	14	16.5	16.5	30	1.19	2.4	Unsaturated	27			1226	1.61	19.6	54.2	1.00	0.189	1.1	0.082	0.079	**N/A**
1.35	4.4	871	11	21.2	21.2	18	1.24	2.6	Unsaturated	34			871	1.51	13.0	47.0	1.00	0.188	1.1	0.075	0.072	**N/A**
1.65	5.4	1293	16	25.9	25.9	25	1.29	2.5	Unsaturated	30			1293	1.43	18.3	53.5	1.00	0.188	1.1	0.081	0.078	**N/A**
1.95	6.4	785	20	30.7	30.7	14	2.67	2.9	Unsaturated	45			785	1.37	10.6	44.6	1.00	0.188	1.1	0.073	0.069	**N/A**
2.23	7.3	1149	29	35.0	35.0	19	2.58	2.7	Unsaturated	37			1149	1.32	15.0	50.2	0.99	0.187	1.1	0.078	0.073	**N/A**
2.50	8.2	871	23	39.3	39.3	13	2.76	2.9	Unsaturated	45			871	1.28	11.1	45.2	0.99	0.187	1.1	0.073	0.068	**N/A**
2.80	9.2	1130	32	44.0	44.0	16	2.91	2.8	Unsaturated	41			1130	1.24	13.9	48.9	0.99	0.187	1.1	0.076	0.071	**N/A**
3.10	10.2	2834	127	48.7	48.7	40	4.57	2.7	Unsaturated	37			2834	1.21	34.0	75.7	0.99	0.186	1.1	0.107	0.100	**N/A**
3.40	11.2	5343	186	53.4	53.4	72	3.51	2.4	Unsaturated	27			5343	1.18	62.6	111.3	0.99	0.186	1.1	0.162	0.153	**N/A**
3.70	12.1	22695	631	58.6	57.0	298	2.79	1.9		15			22695	1.16	261.4	331.2	0.98	0.191	1.1	2.000	1.927	**2.00**
4.03	13.2	14182	505	64.5	59.7	182	3.57	2.1		19			14182	1.15	161.3	228.7	0.98	0.200	1.1	2.000	1.927	**2.00**
4.35	14.3	22427	440	70.3	62.3	281	1.97	1.8		13			22427	1.14	252.2	304.5	0.98	0.208	1.1	2.000	1.927	**2.00**
4.65	15.3	13560	127	75.8	64.8	166	0.94	1.7		11			13560	1.12	150.9	175.7	0.98	0.215	1.1	0.473	0.451	**2.00**
4.95	16.2	10285	527	81.2	67.3	124	5.16	2.4		27			10285	1.11	113.3	178.6	0.98	0.222	1.1	0.514	0.489	**2.00**
5.25	17.2	11357	448	86.6	69.8	134	3.98	2.3		24			11357	1.10	124.0	190.0	0.97	0.228	1.1	0.751	0.715	**2.00**
5.55	18.2	5717	94	92.0	72.3	66	1.67	2.2		22			5717	1.09	61.8	105.7	0.97	0.233	1.0	0.152	0.138	**0.59**
5.85	19.2	7747	292	97.4	74.7	88	3.82	2.4		27			7747	1.08	83.0	138.4	0.97	0.238	1.0	0.227	0.208	**0.87**
6.15	20.2	10601	150	102.9	77.2	119	1.43	2.0		17			10601	1.07	112.7	160.5	0.97	0.243	1.0	0.329	0.302	**1.24**
6.45	21.2	14163	316	108.3	79.7	156	2.25	2.0		17			14163	1.06	149.3	205.9	0.96	0.247	1.1	1.519	1.420	**2.00**
6.75	22.2	17294	275	113.7	82.2	188	1.60	1.9		15			17294	1.06	180.8	234.5	0.96	0.251	1.1	2.000	1.860	**2.00**
7.05	23.1	2930	130	119.1	84.7	30	4.63	2.7	Clay-Like	37			2930	1.05	30.4	70.8	0.96	0.254	1.0	0.101	0.089	**N/A**
7.35	24.1	1140	16	124.5	87.1	11	1.60	2.8	Clay-Like	41			1140	1.04	11.7	46.0	0.96	0.258	1.0	0.074	0.065	**N/A**
7.65	25.1	1073	13	130.0	89.6	10	1.42	2.8	Clay-Like	41			1073	1.03	11.0	44.9	0.95	0.261	1.0	0.073	0.064	**N/A**
7.95	26.1	1331	18	135.4	92.1	12	1.52	2.8	Clay-Like	41			1331	1.02	13.5	48.4	0.95	0.263	1.0	0.076	0.067	**N/A**
8.25	27.1	958	10	140.9	94.6	8	1.17	2.9	Clay-Like	45			958	1.02	9.6	43.3	0.95	0.266	1.0	0.071	0.063	**N/A**
8.55	28.1	1159	11	146.3	97.1	10	1.04	2.8	Clay-Like	41			1159	1.01	11.6	45.8	0.95	0.268	1.0	0.074	0.065	**N/A**
8.85	29.0	1599	16	151.7	99.6	14	1.12	2.6	Clay-Like	34			1599	1.00	15.9	50.9	0.94	0.271	1.0	0.078	0.069	**N/A**
9.15	30.0	1436	14	157.1	102.0	13	1.12	2.7	Clay-Like	37			1436	1.00	14.2	49.0	0.94	0.273	1.0	0.077	0.067	**N/A**
9.45	31.0	2547	23	162.5	104.5	23	0.96	2.4		27			2547	0.99	25.0	61.4	0.94	0.275	1.0	0.089	0.078	**0.28**
9.75	32.0	852	11	168.0	107.0	7	1.68	3.0	Clay-Like	49			852	0.98	8.3	41.5	0.93	0.276	1.0	0.070	0.061	**N/A**
10.05	33.0	1101	6	173.4	109.5	9	0.62	2.7	Clay-Like	37			1101	0.98	10.7	44.3	0.93	0.278	1.0	0.072	0.063	**N/A**
10.35	34.0	3390	18	178.8	112.0	30	0.57	2.2		22			3390	0.97	32.7	67.9	0.93	0.279	1.0	0.097	0.084	**0.30**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
10.65	34.9	8207	74	184.2	114.4	75	0.92	2.0		17			8207	0.97	78.6	118.3	0.92	0.281	1.0	0.176	0.152	**0.54**
10.95	35.9	14268	107	189.6	116.9	129	0.76	1.7		11			14268	0.96	135.9	159.1	0.92	0.282	1.0	0.321	0.274	**0.97**
11.25	36.9	11577	63	195.1	119.4	103	0.56	1.7		11			11577	0.96	109.7	130.2	0.92	0.283	1.0	0.203	0.174	**0.62**
11.55	37.9	9624	85	200.5	121.9	85	0.90	1.9		15			9624	0.95	90.7	126.2	0.91	0.284	1.0	0.194	0.165	**0.58**
11.85	38.9	6023	192	206.0	124.4	52	3.31	2.5		30			6023	0.95	56.5	104.4	0.91	0.285	1.0	0.150	0.128	**0.45**
12.15	39.9	5410	188	211.4	126.8	46	3.61	2.5		30			5410	0.94	50.4	96.4	0.91	0.285	1.0	0.137	0.117	**0.41**
12.45	40.9	8302	274	216.8	129.3	71	3.39	2.4		27			8302	0.94	77.0	130.4	0.91	0.286	1.0	0.204	0.173	**0.60**
12.75	41.8	11309	406	222.2	131.8	96	3.66	2.3		24			11309	0.93	104.4	164.3	0.90	0.287	1.0	0.357	0.297	**1.04**
13.05	42.8	24792	560	227.6	134.3	211	2.28	2.0		17			24792	0.93	227.7	303.2	0.90	0.287	0.9	2.000	1.602	**2.00**
13.35	43.8	30184	748	233.1	136.8	254	2.50	1.9		15			30184	0.92	275.9	348.6	0.90	0.288	0.9	2.000	1.592	**2.00**
13.65	44.8	34244	811	238.5	139.2	286	2.39	1.9		15			34244	0.92	311.5	391.4	0.89	0.288	0.9	2.000	1.583	**2.00**
13.95	45.8	38821	842	243.9	141.7	322	2.18	1.8		13			38821	0.91	351.5	419.1	0.89	0.288	0.9	2.000	1.573	**2.00**
14.25	46.8	10486	404	249.3	144.2	85	3.95	2.4		27			10486	0.91	94.5	153.6	0.89	0.289	0.9	0.289	0.238	**0.83**
14.55	47.7	10763	463	254.8	146.7	86	4.40	2.4		27			10763	0.91	96.6	156.4	0.88	0.289	0.9	0.304	0.249	**0.86**
14.85	48.7	13301	508	260.2	149.2	106	3.90	2.3		24			13301	0.90	118.8	183.2	0.88	0.289	0.9	0.593	0.475	**1.64**
15.15	49.7	15781	596	265.6	151.6	125	3.84	2.3		24			15781	0.90	140.4	211.6	0.88	0.289	0.9	2.000	1.538	**2.00**
15.45	50.7	22877	624	271.0	154.1	181	2.76	2.1		19			22877	0.89	202.6	281.2	0.87	0.289	0.9	2.000	1.529	**2.00**
15.75	51.7	25443	847	276.4	156.6	200	3.37	2.1		19			25443	0.89	224.4	308.9	0.87	0.289	0.9	2.000	1.521	**2.00**
16.05	52.7	33363	786	281.9	159.1	261	2.38	1.9		15			33363	0.89	293.0	369.2	0.86	0.289	0.9	2.000	1.512	**2.00**
16.35	53.6	37500	970	287.3	161.6	291	2.61	1.9		15			37500	0.88	328.0	411.2	0.86	0.289	0.9	2.000	1.504	**2.00**
16.66	54.6	37844	821	292.8	164.1	291	2.19	1.9		15			37844	0.88	329.7	413.2	0.86	0.289	0.9	2.000	1.496	**2.00**
16.95	55.6	39147	966	298.2	166.5	299	2.49	1.9		15			39147	0.88	339.7	425.2	0.85	0.288	0.8	2.000	1.488	**2.00**
17.25	56.6	30930	812	303.6	169.0	234	2.65	2.0		17			30930	0.87	267.4	352.4	0.85	0.288	0.8	2.000	1.481	**2.00**
17.55	57.6	22341	527	309.0	171.5	167	2.39	2.0		17			22341	0.87	192.4	259.3	0.85	0.288	0.8	2.000	1.473	**2.00**
17.85	58.6	26200	537	314.4	174.0	195	2.08	1.9		15			26200	0.87	224.7	287.2	0.84	0.288	0.8	2.000	1.465	**2.00**
18.16	59.6	9231	306	319.9	176.5	67	3.44	2.4		27			9231	0.86	78.9	132.9	0.84	0.287	0.9	0.211	0.170	**0.59**
18.45	60.5	2940	43	325.3	178.9	19	1.65	2.6	Clay-Like	34			2940	0.86	25.0	63.2	0.84	0.287	1.0	0.091	0.076	**N/A**
18.76	61.5	5477	161	330.7	181.4	38	3.13	2.6	Clay-Like	34			5477	0.86	46.5	91.9	0.83	0.286	0.9	0.130	0.107	**N/A**
19.03	62.4	16030	705	335.7	183.7	115	4.49	2.3		24			16030	0.85	135.5	205.2	0.83	0.286	0.8	1.466	1.069	**2.00**
19.30	63.3	16662	646	340.7	186.0	119	3.96	2.3		24			16662	0.85	140.4	211.6	0.83	0.286	0.8	2.000	1.430	**2.00**
19.60	64.3	12851	571	346.1	188.4	91	4.56	2.4		27			12851	0.85	107.9	171.5	0.82	0.285	0.9	0.423	0.325	**1.14**
19.91	65.3	12267	356	351.5	190.9	86	2.99	2.3		24			12267	0.85	102.7	162.0	0.82	0.285	0.9	0.340	0.264	**0.93**
20.20	66.3	7000	434	356.9	193.4	47	6.53	2.7	Clay-Like	37			7000	0.84	58.4	108.5	0.82	0.284	0.9	0.157	0.127	**N/A**
20.51	67.3	19047	704	362.4	195.9	133	3.77	2.2		22			19047	0.84	158.3	230.8	0.81	0.284	0.8	2.000	1.403	**2.00**
20.80	68.2	36877	918	367.8	198.4	258	2.52	1.9		15			36877	0.84	305.6	384.3	0.81	0.283	0.8	2.000	1.396	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-26B**

Test Boring Information:

Approx. ground elevation		16.2	ft	4.94 m
Approx. water table elevation		4.5	ft	1.37 m
Approx. depth to ground water table		11.7	ft	3.57 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.15	0.5	2586	119	2.3	2.3	167	4.60	2.3	Unsaturated	24			2586	1.70	43.5	84.3	1.00	0.189	1.1	0.119	0.114	**N/A**
0.45	1.5	4577	165	7.1	7.1	170	3.60	2.2	Unsaturated	22			4577	1.70	77.0	125.4	1.00	0.189	1.1	0.192	0.185	**N/A**
0.75	2.5	2337	92	11.8	11.8	67	3.95	2.4	Unsaturated	27			2337	1.70	39.3	80.4	1.00	0.189	1.1	0.113	0.109	**N/A**
1.05	3.4	1724	66	16.5	16.5	42	3.87	2.6	Unsaturated	34			1724	1.61	27.5	66.5	1.00	0.189	1.1	0.095	0.092	**N/A**
1.35	4.4	852	23	21.2	21.2	18	2.77	2.8	Unsaturated	41			852	1.51	12.7	47.3	1.00	0.188	1.1	0.075	0.072	**N/A**
1.65	5.4	565	31	25.9	25.9	11	5.68	3.1	Unsaturated	53			565	1.43	8.0	41.1	1.00	0.188	1.1	0.070	0.066	**N/A**
1.95	6.4	201	27	30.7	30.7	3	15.73	3.8	Unsaturated	90			201	1.48	2.9	33.7	1.00	0.188	1.1	0.064	0.060	**N/A**
2.23	7.3	1235	83	35.0	35.0	20	6.94	3.0	Unsaturated	49			1235	1.32	16.2	52.2	0.99	0.187	1.1	0.080	0.075	**N/A**
2.50	8.2	536	56	39.3	39.3	8	11.37	3.4	Unsaturated	67			536	1.28	6.8	39.3	0.99	0.187	1.1	0.068	0.063	**N/A**
2.80	9.2	3811	105	44.0	44.0	56	2.80	2.4	Unsaturated	27			3811	1.24	47.0	90.6	0.99	0.187	1.1	0.128	0.121	**N/A**
3.10	10.2	2461	143	48.7	48.7	34	5.91	2.8	Unsaturated	41			2461	1.21	29.5	70.0	0.99	0.186	1.1	0.100	0.093	**N/A**
3.40	11.2	3103	131	53.4	53.4	41	4.30	2.6	Unsaturated	34			3103	1.18	36.3	78.3	0.99	0.186	1.1	0.110	0.102	**N/A**
3.70	12.1	3926	172	58.5	57.2	51	4.46	2.6	Clay-Like	34			3926	1.16	45.2	90.2	0.98	0.190	1.1	0.127	0.118	**N/A**
4.03	13.2	30729	858	64.4	59.9	394	2.80	1.9		15			30729	1.15	349.2	436.7	0.98	0.199	1.1	2.000	1.927	**2.00**
4.35	14.3	23155	462	70.2	62.6	290	2.00	1.8		13			23155	1.13	260.1	313.6	0.98	0.207	1.1	2.000	1.927	**2.00**
4.65	15.3	3189	145	75.7	65.0	38	4.64	2.7	Clay-Like	37			3189	1.12	35.5	77.7	0.98	0.215	1.0	0.109	0.100	**N/A**
4.95	16.2	1542	205	81.1	67.5	18	14.03	3.2	Clay-Like	58			1542	1.11	17.0	53.2	0.98	0.221	1.0	0.081	0.073	**N/A**
5.25	17.2	14058	429	86.5	70.0	166	3.07	2.1		19			14058	1.10	153.3	218.5	0.97	0.227	1.1	2.000	1.927	**2.00**
5.55	18.2	13991	175	92.0	72.5	162	1.26	1.8		13			13991	1.09	151.2	187.9	0.97	0.232	1.1	0.694	0.654	**2.00**
5.85	19.2	12449	260	97.4	75.0	142	2.11	2.0		17			12449	1.08	133.3	186.2	0.97	0.237	1.1	0.654	0.611	**2.00**

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-52**

Test Boring Information:

Approx. ground elevation		2.3 ft	0.70 m
Approx. water table elevation		0 ft	0.00 m
Approx. depth to ground water table		2.3 ft	0.70 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	419	0.3	1.6	1.6	33	0.07	1.09	Unsaturated	4			419	1.70	7.1	7.1	1.00	0.189	1.1	0.051	0.049	**N/A**
0.2	0.7	498	2.7	3.1	3.1	28	0.54	1.62	Unsaturated	10			498	1.70	8.4	14.7	1.00	0.189	1.1	0.053	0.051	**N/A**
0.3	1.0	321	4.3	4.7	4.7	14	1.36	2.15	Unsaturated	20			321	1.70	5.4	31.5	1.00	0.189	1.1	0.062	0.060	**N/A**
0.4	1.3	162	1.9	6.3	6.3	6	1.23	2.47	Unsaturated	29			162	1.70	2.7	32.5	1.00	0.189	1.1	0.063	0.061	**N/A**
0.5	1.6	244	1.8	7.9	7.9	8	0.77	2.3	Unsaturated	24			244	1.70	4.1	32.5	1.00	0.189	1.1	0.063	0.061	**N/A**
0.6	2.0	445	3.1	9.4	9.4	14	0.70	2.13	Unsaturated	20			445	1.70	7.5	33.8	1.00	0.189	1.1	0.064	0.062	**N/A**
0.7	2.3	654	5.9	11.0	11.0	19	0.92	2.11	Unsaturated	20			654	1.70	11.0	37.8	1.00	0.189	1.1	0.067	0.064	**N/A**
0.8	2.6	595	7.7	12.8	11.8	17	1.32	2.28		24			595	1.70	10.0	40.0	1.00	0.204	1.1	0.069	0.066	**0.32**
0.9	3.0	694	6.8	14.6	12.7	19	1.00	2.2		22			694	1.70	11.7	40.7	1.00	0.218	1.1	0.069	0.067	**0.31**
1.0	3.3	793	7.5	16.4	13.5	21	0.96	2.18		21			793	1.70	13.4	42.5	1.00	0.229	1.1	0.071	0.068	**0.30**
1.1	3.6	679	7.0	18.2	14.3	17	1.06	2.3		24			679	1.67	11.3	41.9	1.00	0.240	1.1	0.070	0.068	**0.28**
1.2	3.9	561	6.5	20.0	15.1	14	1.20	2.43		28			561	1.65	9.2	40.7	1.00	0.249	1.1	0.069	0.067	**0.27**
1.3	4.3	350	5.3	21.8	16.0	8	1.60	2.71	Clay-Like	37			350	1.63	5.6	37.6	1.00	0.258	1.1	0.067	0.064	**N/A**
1.4	4.6	216	2.8	23.7	16.8	5	1.44	2.91	Clay-Like	45			216	1.70	3.6	35.2	1.00	0.265	1.1	0.065	0.063	**N/A**
1.5	4.9	158	1.7	25.5	17.6	3	1.30	3.05	Clay-Like	51			158	1.70	2.7	33.9	1.00	0.272	1.1	0.064	0.062	**N/A**
1.6	5.2	140	1.8	27.3	18.5	3	1.61	3.15	Clay-Like	55			140	1.70	2.4	33.5	1.00	0.278	1.1	0.064	0.061	**N/A**
1.7	5.6	186	3.1	29.1	19.3	4	1.95	3.08	Clay-Like	52			186	1.70	3.1	34.6	1.00	0.284	1.1	0.064	0.062	**N/A**
1.8	5.9	159	3.1	30.9	20.1	3	2.40	3.2	Clay-Like	58			159	1.70	2.7	33.9	1.00	0.289	1.1	0.064	0.062	**N/A**
1.9	6.2	193	1.5	32.7	20.9	3	0.96	2.94	Clay-Like	46			193	1.70	3.2	34.7	1.00	0.293	1.1	0.065	0.062	**N/A**
2.0	6.6	230	2.6	34.5	21.8	4	1.32	2.93	Clay-Like	46			230	1.56	3.6	35.1	1.00	0.298	1.1	0.065	0.062	**N/A**
2.1	6.9	239	5.3	36.3	22.6	4	2.59	3.06	Clay-Like	51			239	1.52	3.6	35.2	0.99	0.301	1.1	0.065	0.062	**N/A**
2.2	7.2	265	6.1	38.1	23.4	5	2.70	3.04	Clay-Like	50			265	1.47	3.9	35.5	0.99	0.305	1.1	0.065	0.062	**N/A**
2.3	7.5	246	5.1	39.9	24.2	4	2.47	3.06	Clay-Like	51			246	1.48	3.6	35.2	0.99	0.309	1.1	0.065	0.062	**N/A**
2.4	7.9	225	4.7	41.7	25.1	4	2.56	3.11	Clay-Like	53			225	1.51	3.4	34.9	0.99	0.312	1.1	0.065	0.062	**N/A**
2.5	8.2	215	4.7	43.5	25.9	3	2.74	3.15	Clay-Like	55			215	1.53	3.2	34.7	0.99	0.315	1.1	0.065	0.061	**N/A**
2.6	8.5	210	4.7	45.3	26.7	3	2.85	3.18	Clay-Like	57			210	1.52	3.2	34.6	0.99	0.317	1.1	0.064	0.061	**N/A**
2.7	8.9	217	4.8	47.2	27.5	3	2.81	3.17	Clay-Like	56			217	1.49	3.2	34.6	0.99	0.320	1.1	0.064	0.061	**N/A**
2.8	9.2	238	4.5	49.0	28.4	4	2.38	3.11	Clay-Like	53			238	1.43	3.4	34.9	0.99	0.322	1.1	0.065	0.061	**N/A**
2.9	9.5	235	4.7	50.8	29.2	3	2.55	3.14	Clay-Like	55			235	1.43	3.3	34.8	0.99	0.324	1.1	0.065	0.061	**N/A**
3.0	9.8	218	5.0	52.6	30.0	3	3.01	3.22	Clay-Like	59			218	1.45	3.1	34.5	0.99	0.327	1.1	0.064	0.061	**N/A**
3.1	10.2	208	4.5	54.4	30.9	3	2.93	3.24	Clay-Like	60			208	1.46	3.0	34.3	0.99	0.329	1.1	0.064	0.060	**N/A**
3.2	10.5	225	4.8	56.2	31.7	3	2.84	3.21	Clay-Like	58			225	1.41	3.1	34.5	0.99	0.330	1.1	0.064	0.060	**N/A**
3.3	10.8	238	5.3	58.0	32.5	3	2.93	3.2	Clay-Like	58			238	1.38	3.2	34.7	0.99	0.332	1.1	0.065	0.060	**N/A**
3.4	11.2	243	5.3	59.8	33.3	3	2.87	3.2	Clay-Like	58			243	1.36	3.3	34.7	0.99	0.334	1.1	0.065	0.060	**N/A**
3.5	11.5	237	5.1	61.6	34.2	3	2.90	3.22	Clay-Like	59			237	1.36	3.2	34.6	0.99	0.335	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	228	5.5	63.4	35.0	3	3.31	3.28	Clay-Like	61			228	1.37	3.1	34.4	0.99	0.337	1.1	0.064	0.060	**N/A**
3.7	12.1	222	4.8	65.2	35.8	3	3.05	3.28	Clay-Like	61			222	1.37	3.0	34.3	0.98	0.338	1.1	0.064	0.060	**N/A**
3.8	12.5	238	4.1	67.0	36.6	3	2.41	3.2	Clay-Like	58			238	1.33	3.1	34.5	0.98	0.339	1.1	0.064	0.060	**N/A**
3.9	12.8	237	4.1	68.9	37.5	3	2.45	3.21	Clay-Like	58			237	1.32	3.1	34.5	0.98	0.341	1.1	0.064	0.060	**N/A**
4.0	13.1	230	4.3	70.7	38.3	3	2.70	3.25	Clay-Like	60			230	1.33	3.0	34.3	0.98	0.342	1.1	0.064	0.060	**N/A**
4.1	13.5	237	4.4	72.5	39.1	3	2.68	3.25	Clay-Like	60			237	1.31	3.1	34.4	0.98	0.343	1.1	0.064	0.060	**N/A**
4.2	13.8	240	4.1	74.3	40.0	3	2.48	3.24	Clay-Like	60			240	1.30	3.1	34.4	0.98	0.344	1.1	0.064	0.060	**N/A**
4.3	14.1	195	5.6	76.1	40.8	2	4.74	3.48	Clay-Like	72			195	1.36	2.6	33.6	0.98	0.345	1.1	0.064	0.059	**N/A**
4.4	14.4	217	5.4	77.9	41.6	2	3.87	3.4	Clay-Like	67			217	1.31	2.8	33.9	0.98	0.346	1.1	0.064	0.059	**N/A**
4.5	14.8	246	3.8	79.7	42.4	3	2.31	3.24	Clay-Like	60			246	1.27	3.1	34.4	0.98	0.347	1.1	0.064	0.059	**N/A**
4.6	15.1	229	3.4	81.5	43.3	2	2.33	3.28	Clay-Like	61			229	1.28	2.9	34.2	0.98	0.348	1.1	0.064	0.059	**N/A**
4.7	15.4	242	5.1	83.3	44.1	2	3.19	3.33	Clay-Like	64			242	1.26	3.0	34.3	0.98	0.348	1.1	0.064	0.059	**N/A**
4.8	15.7	267	5.4	85.1	44.9	3	2.95	3.28	Clay-Like	61			267	1.24	3.3	34.7	0.98	0.349	1.0	0.065	0.059	**N/A**
4.9	16.1	253	5.1	86.9	45.7	2	3.05	3.31	Clay-Like	63			253	1.23	3.1	34.4	0.98	0.350	1.0	0.064	0.059	**N/A**
5.0	16.4	269	5.7	88.7	46.6	3	3.19	3.31	Clay-Like	63			269	1.23	3.3	34.6	0.98	0.350	1.0	0.064	0.059	**N/A**
5.1	16.7	282	5.7	90.5	47.4	3	2.99	3.28	Clay-Like	61			282	1.22	3.4	34.8	0.97	0.351	1.0	0.065	0.059	**N/A**
5.2	17.1	282	4.9	92.4	48.2	3	2.58	3.25	Clay-Like	60			282	1.22	3.4	34.8	0.97	0.352	1.0	0.065	0.059	**N/A**
5.3	17.4	284	5.3	94.2	49.0	3	2.77	3.27	Clay-Like	61			284	1.21	3.4	34.8	0.97	0.352	1.0	0.065	0.059	**N/A**
5.4	17.7	268	5.3	96.0	49.9	2	3.06	3.33	Clay-Like	64			268	1.20	3.2	34.5	0.97	0.353	1.0	0.064	0.059	**N/A**
5.5	18.0	261	4.3	97.8	50.7	2	2.63	3.31	Clay-Like	63			261	1.20	3.1	34.4	0.97	0.353	1.0	0.064	0.059	**N/A**
5.6	18.4	269	4.3	99.6	51.5	2	2.55	3.3	Clay-Like	62			269	1.19	3.2	34.5	0.97	0.354	1.0	0.064	0.059	**N/A**
5.7	18.7	259	4.4	101.4	52.4	2	2.80	3.34	Clay-Like	64			259	1.19	3.0	34.3	0.97	0.354	1.0	0.064	0.059	**N/A**
5.8	19.0	260	4.0	103.2	53.2	2	2.56	3.32	Clay-Like	63			260	1.18	3.1	34.3	0.97	0.355	1.0	0.064	0.059	**N/A**
5.9	19.4	272	3.8	105.0	54.0	2	2.29	3.28	Clay-Like	61			272	1.18	3.2	34.5	0.97	0.355	1.0	0.064	0.059	**N/A**
6.0	19.7	282	4.8	106.8	54.8	2	2.74	3.32	Clay-Like	63			282	1.17	3.3	34.6	0.97	0.355	1.0	0.064	0.059	**N/A**
6.1	20.0	289	5.3	108.6	55.7	2	2.92	3.33	Clay-Like	64			289	1.17	3.3	34.7	0.97	0.356	1.0	0.065	0.059	**N/A**
6.2	20.3	295	4.1	110.4	56.5	2	2.23	3.27	Clay-Like	61			295	1.17	3.4	34.8	0.97	0.356	1.0	0.065	0.059	**N/A**
6.3	20.7	267	3.0	112.2	57.3	2	1.92	3.29	Clay-Like	62			267	1.16	3.1	34.4	0.97	0.356	1.0	0.064	0.058	**N/A**
6.4	21.0	239	4.2	114.0	58.1	2	3.36	3.45	Clay-Like	70			239	1.17	2.8	33.8	0.96	0.357	1.0	0.064	0.058	**N/A**
6.5	21.3	282	4.4	115.9	59.0	2	2.64	3.33	Clay-Like	64			282	1.15	3.2	34.5	0.96	0.357	1.0	0.064	0.058	**N/A**
6.6	21.7	303	5.0	117.7	59.8	2	2.69	3.32	Clay-Like	63			303	1.15	3.4	34.9	0.96	0.357	1.0	0.065	0.058	**N/A**
6.7	22.0	285	4.8	119.5	60.6	2	2.89	3.37	Clay-Like	66			285	1.14	3.2	34.5	0.96	0.357	1.0	0.064	0.058	**N/A**
6.8	22.3	289	4.3	121.3	61.4	2	2.57	3.34	Clay-Like	64			289	1.14	3.3	34.6	0.96	0.357	1.0	0.064	0.058	**N/A**
6.9	22.6	298	4.5	123.1	62.3	2	2.57	3.33	Clay-Like	64			298	1.14	3.4	34.7	0.96	0.358	1.0	0.065	0.058	**N/A**
7.0	23.0	328	4.5	124.9	63.1	3	2.21	3.26	Clay-Like	60			328	1.13	3.7	35.2	0.96	0.358	1.0	0.065	0.059	**N/A**
7.1	23.3	338	5.3	126.7	63.9	3	2.50	3.28	Clay-Like	61			338	1.13	3.8	35.3	0.96	0.358	1.0	0.065	0.059	**N/A**
7.2	23.6	350	5.4	128.5	64.8	3	2.42	3.26	Clay-Like	60			350	1.12	3.9	35.5	0.96	0.358	1.0	0.065	0.059	**N/A**
7.3	24.0	332	4.6	130.3	65.6	2	2.28	3.28	Clay-Like	61			332	1.12	3.7	35.2	0.96	0.358	1.0	0.065	0.058	**N/A**
7.4	24.3	323	5.0	132.1	66.4	2	2.61	3.32	Clay-Like	63			323	1.12	3.6	35.0	0.96	0.358	1.0	0.065	0.058	**N/A**
7.5	24.6	326	4.6	133.9	67.2	2	2.40	3.31	Clay-Like	63			326	1.11	3.6	35.1	0.95	0.358	1.0	0.065	0.058	**N/A**
7.6	24.9	339	4.7	135.7	68.1	2	2.30	3.29	Clay-Like	62			339	1.11	3.7	35.3	0.95	0.359	1.0	0.065	0.058	**N/A**
7.7	25.3	354	5.6	137.5	68.9	3	2.57	3.3	Clay-Like	62			354	1.11	3.9	35.5	0.95	0.359	1.0	0.065	0.058	**N/A**
7.8	25.6	367	5.5	139.4	69.7	3	2.40	3.27	Clay-Like	61			367	1.10	4.0	35.6	0.95	0.359	1.0	0.065	0.058	**N/A**
7.9	25.9	368	6.1	141.2	70.5	3	2.70	3.3	Clay-Like	62			368	1.10	4.0	35.6	0.95	0.359	1.0	0.065	0.058	**N/A**
8	26.2	360	5.4	143.0	71.4	3	2.47	3.3	Clay-Like	62			360	1.10	3.9	35.5	0.95	0.359	1.0	0.065	0.058	**N/A**
8.1	26.6	349	5.2	144.8	72.2	2	2.54	3.32	Clay-Like	63			349	1.09	3.8	35.3	0.95	0.359	1.0	0.065	0.058	**N/A**
8.2	26.9	344	5.0	146.6	73.0	2	2.52	3.33	Clay-Like	64			344	1.09	3.7	35.2	0.95	0.359	1.0	0.065	0.058	**N/A**
8.3	27.2	344	4.6	148.4	73.8	2	2.35	3.32	Clay-Like	63			344	1.09	3.7	35.2	0.95	0.359	1.0	0.065	0.058	**N/A**
8.4	27.6	347	5.2	150.2	74.7	2	2.63	3.35	Clay-Like	65			347	1.08	3.7	35.2	0.95	0.359	1.0	0.065	0.058	**N/A**
8.5	27.9	383	5.9	152.0	75.5	3	2.57	3.31	Clay-Like	63			383	1.08	4.1	35.7	0.95	0.359	1.0	0.065	0.058	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
8.6	28.2	372	6.4	153.8	76.3	2	2.94	3.36	Clay-Like	65			372	1.08	4.0	35.5	0.94	0.359	1.0	0.065	0.058	**N/A**
8.7	28.5	370	5.8	155.6	77.2	2	2.73	3.34	Clay-Like	64			370	1.07	3.9	35.5	0.94	0.359	1.0	0.065	0.058	**N/A**
8.8	28.9	374	6.0	157.4	78.0	2	2.78	3.35	Clay-Like	65			374	1.07	4.0	35.5	0.94	0.359	1.0	0.065	0.058	**N/A**
8.9	29.2	367	5.6	159.2	78.8	2	2.68	3.35	Clay-Like	65			367	1.07	3.9	35.4	0.94	0.359	1.0	0.065	0.058	**N/A**
9	29.5	369	4.7	161.0	79.6	2	2.26	3.32	Clay-Like	63			369	1.06	3.9	35.5	0.94	0.359	1.0	0.065	0.058	**N/A**
9.1	29.9	358	5.0	162.9	80.5	2	2.55	3.36	Clay-Like	65			358	1.06	3.8	35.3	0.94	0.359	1.0	0.065	0.058	**N/A**
9.2	30.2	360	5.1	164.7	81.3	2	2.60	3.36	Clay-Like	65			360	1.06	3.8	35.3	0.94	0.358	1.0	0.065	0.058	**N/A**
9.3	30.5	366	4.6	166.5	82.1	2	2.30	3.34	Clay-Like	64			366	1.06	3.8	35.4	0.94	0.358	1.0	0.065	0.058	**N/A**
9.4	30.8	380	5.4	168.3	82.9	2	2.54	3.34	Clay-Like	64			380	1.05	4.0	35.5	0.94	0.358	1.0	0.065	0.058	**N/A**
9.5	31.2	393	5.5	170.1	83.8	2	2.45	3.33	Clay-Like	64			393	1.05	4.1	35.7	0.94	0.358	1.0	0.065	0.058	**N/A**
9.6	31.5	399	5.6	171.9	84.6	2	2.49	3.33	Clay-Like	64			399	1.05	4.1	35.8	0.93	0.358	1.0	0.065	0.058	**N/A**
9.7	31.8	402	6.3	173.7	85.4	2	2.77	3.35	Clay-Like	65			402	1.05	4.2	35.8	0.93	0.358	1.0	0.065	0.058	**N/A**
9.8	32.2	404	6.1	175.5	86.3	2	2.69	3.34	Clay-Like	64			404	1.04	4.2	35.8	0.93	0.358	1.0	0.065	0.058	**N/A**
9.9	32.5	419	6.2	177.3	87.1	3	2.57	3.32	Clay-Like	63			419	1.04	4.3	36.0	0.93	0.358	1.0	0.066	0.058	**N/A**
10	32.8	420	6.8	179.1	87.9	3	2.82	3.34	Clay-Like	64			420	1.04	4.3	36.0	0.93	0.358	1.0	0.066	0.058	**N/A**
10.1	33.1	421	6.6	180.9	88.7	3	2.75	3.34	Clay-Like	64			421	1.03	4.3	36.0	0.93	0.357	1.0	0.066	0.058	**N/A**
10.2	33.5	408	6.3	182.7	89.6	2	2.80	3.36	Clay-Like	65			408	1.03	4.2	35.8	0.93	0.357	1.0	0.065	0.058	**N/A**
10.3	33.8	410	6.4	184.5	90.4	2	2.85	3.37	Clay-Like	66			410	1.03	4.2	35.8	0.93	0.357	1.0	0.065	0.058	**N/A**
10.4	34.1	424	6.9	186.4	91.2	2	2.90	3.36	Clay-Like	65			424	1.03	4.3	36.0	0.93	0.357	1.0	0.065	0.058	**N/A**
10.5	34.4	428	7.0	188.2	92.0	2	2.91	3.36	Clay-Like	65			428	1.02	4.3	36.0	0.93	0.357	1.0	0.066	0.058	**N/A**
10.6	34.8	430	6.1	190.0	92.9	2	2.55	3.34	Clay-Like	64			430	1.02	4.4	36.1	0.92	0.357	1.0	0.066	0.058	**N/A**
10.7	35.1	438	5.9	191.8	93.7	3	2.42	3.32	Clay-Like	63			438	1.02	4.4	36.2	0.92	0.356	1.0	0.066	0.058	**N/A**
10.8	35.4	442	6.7	193.6	94.5	3	2.70	3.34	Clay-Like	64			442	1.02	4.5	36.2	0.92	0.356	1.0	0.066	0.058	**N/A**
10.9	35.8	442	6.2	195.4	95.3	3	2.52	3.33	Clay-Like	64			442	1.02	4.4	36.2	0.92	0.356	1.0	0.066	0.058	**N/A**
11	36.1	436	5.4	197.2	96.2	2	2.25	3.32	Clay-Like	63			436	1.01	4.4	36.1	0.92	0.356	1.0	0.066	0.058	**N/A**
11.1	36.4	481	4.7	199.0	97.0	3	1.67	3.22	Clay-Like	59			481	1.01	4.8	36.8	0.92	0.356	1.0	0.066	0.058	**N/A**
11.2	36.7	585	5.8	200.8	97.8	4	1.52	3.12	Clay-Like	54			585	1.01	5.8	38.2	0.92	0.355	1.0	0.067	0.059	**N/A**
11.3	37.1	539	5.8	202.6	98.7	3	1.73	3.18	Clay-Like	57			539	1.01	5.4	37.5	0.92	0.355	1.0	0.067	0.058	**N/A**
11.4	37.4	482	4.2	204.4	99.5	3	1.52	3.21	Clay-Like	58			482	1.00	4.8	36.8	0.92	0.355	1.0	0.066	0.058	**N/A**
11.5	37.7	511	4.9	206.2	100.3	3	1.60	3.2	Clay-Like	58			511	1.00	5.1	37.1	0.92	0.355	1.0	0.066	0.058	**N/A**
11.6	38.1	531	5.9	208.1	101.1	3	1.84	3.22	Clay-Like	59			531	1.00	5.3	37.4	0.91	0.355	1.0	0.067	0.058	**N/A**
11.7	38.4	474	6.5	209.9	102.0	3	2.46	3.32	Clay-Like	63			474	1.00	4.7	36.5	0.91	0.354	1.0	0.066	0.058	**N/A**
11.8	38.7	489	5.6	211.7	102.8	3	2.04	3.27	Clay-Like	61			489	1.00	4.8	36.7	0.91	0.354	1.0	0.066	0.058	**N/A**
11.9	39.0	483	5.8	213.5	103.6	3	2.17	3.29	Clay-Like	62			483	0.99	4.7	36.6	0.91	0.354	1.0	0.066	0.058	**N/A**
12	39.4	501	6.4	215.3	104.4	3	2.25	3.29	Clay-Like	62			501	0.99	4.9	36.9	0.91	0.354	1.0	0.066	0.058	**N/A**
12.1	39.7	501	7.2	217.1	105.3	3	2.53	3.32	Clay-Like	63			501	0.99	4.9	36.8	0.91	0.353	1.0	0.066	0.058	**N/A**
12.2	40.0	497	5.5	218.9	106.1	3	1.96	3.27	Clay-Like	61			497	0.99	4.9	36.8	0.91	0.353	1.0	0.066	0.058	**N/A**
12.3	40.4	492	5.4	220.7	106.9	3	1.98	3.28	Clay-Like	61			492	0.99	4.8	36.7	0.91	0.353	1.0	0.066	0.058	**N/A**
12.4	40.7	590	8.8	222.5	107.7	4	2.40	3.23	Clay-Like	59			590	0.98	5.7	38.0	0.91	0.353	1.0	0.067	0.058	**N/A**
12.5	41.0	3142	26.4	224.3	108.6	28	0.91	2.35		26			3142	0.98	30.5	68.0	0.90	0.352	1.0	0.097	0.085	**0.24**
12.6	41.3	8553	58.4	226.1	109.4	79	0.70	1.92		15			8553	0.98	82.9	118.4	0.90	0.352	1.0	0.176	0.153	**0.43**
12.7	41.7	8465	78.6	227.9	110.2	78	0.95	2		17			8465	0.98	81.9	122.3	0.90	0.352	1.0	0.185	0.160	**0.45**
12.8	42.0	5468	73.4	229.7	111.1	49	1.40	2.26		23			5468	0.98	52.8	95.6	0.90	0.352	1.0	0.135	0.117	**0.33**
12.9	42.3	2178	38.7	231.6	111.9	18	1.99	2.69	Clay-Like	37			2178	0.97	21.0	58.1	0.90	0.351	1.0	0.086	0.075	**N/A**
13	42.7	804	11.9	233.4	112.7	5	2.08	3.11	Clay-Like	53			804	0.97	7.7	40.8	0.90	0.351	1.0	0.069	0.060	**N/A**
13.1	43.0	565	4.1	235.2	113.5	3	1.25	3.15	Clay-Like	55			565	0.97	5.4	37.6	0.90	0.351	1.0	0.067	0.058	**N/A**
13.2	43.3	836	6.3	237.0	114.4	6	1.06	2.95	Clay-Like	47			836	0.97	8.0	41.1	0.90	0.350	1.0	0.070	0.060	**N/A**
13.3	43.6	1655	10.6	238.8	115.2	13	0.75	2.6	Clay-Like	34			1655	0.97	15.8	50.8	0.90	0.350	1.0	0.078	0.068	**N/A**
13.4	44.0	2081	13.0	240.6	116.0	17	0.71	2.5		30			2081	0.96	19.9	55.6	0.89	0.350	1.0	0.083	0.072	**0.21**
13.5	44.3	1610	8.8	242.4	116.8	13	0.64	2.6	Clay-Like	34			1610	0.96	15.3	50.2	0.89	0.350	1.0	0.078	0.067	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
13.6	44.6	869	6.9	244.2	117.7	6	1.10	2.96	Clay-Like	47			869	0.96	8.3	41.5	0.89	0.349	1.0	0.070	0.061	**N/A**
13.7	44.9	826	5.4	246.0	118.5	5	0.93	2.95	Clay-Like	47			826	0.96	7.8	40.9	0.89	0.349	1.0	0.069	0.060	**N/A**
13.8	45.3	978	13.7	247.8	119.3	7	1.88	3	Clay-Like	49			978	0.96	9.3	42.8	0.89	0.349	1.0	0.071	0.061	**N/A**
13.9	45.6	5650	60.1	249.6	120.2	49	1.11	2.22		22			5650	0.96	53.4	95.4	0.89	0.348	1.0	0.135	0.116	**0.33**
14	45.9	4873	122.6	251.4	121.0	42	2.65	2.51		31			4873	0.95	46.0	90.6	0.89	0.348	1.0	0.128	0.110	**0.32**
14.1	46.3	1968	83.3	253.2	121.8	15	4.86	3	Clay-Like	49			1968	0.95	18.5	55.4	0.89	0.348	1.0	0.083	0.072	**N/A**
14.2	46.6	1339	30.8	255.1	122.6	10	2.84	3	Clay-Like	49			1339	0.95	12.6	47.3	0.89	0.347	1.0	0.075	0.065	**N/A**
14.3	46.9	715	14.3	256.9	123.5	4	3.12	3.27	Clay-Like	61			715	0.95	6.7	39.3	0.88	0.347	1.0	0.068	0.059	**N/A**
14.4	47.2	1932	34.9	258.7	124.3	15	2.08	2.78	Clay-Like	40			1932	0.95	18.1	54.5	0.88	0.347	1.0	0.082	0.071	**N/A**
14.5	47.6	2628	77.3	260.5	125.1	21	3.26	2.79	Clay-Like	40			2628	0.95	24.6	63.3	0.88	0.346	1.0	0.092	0.079	**N/A**
14.6	47.9	1013	47.7	262.3	125.9	7	6.36	3.34	Clay-Like	64			1013	0.94	9.5	43.0	0.88	0.346	1.0	0.071	0.061	**N/A**
14.7	48.2	723	14.2	264.1	126.8	4	3.09	3.3	Clay-Like	62			723	0.94	6.7	39.3	0.88	0.346	1.0	0.068	0.059	**N/A**
14.8	48.6	754	11.0	265.9	127.6	4	2.26	3.2	Clay-Like	58			754	0.94	7.0	39.8	0.88	0.345	1.0	0.068	0.059	**N/A**
14.9	48.9	627	10.7	267.7	128.4	3	2.98	3.34	Clay-Like	64			627	0.94	5.8	38.1	0.88	0.345	1.0	0.067	0.058	**N/A**
15	49.2	568	8.8	269.5	129.2	3	2.95	3.37	Clay-Like	66			568	0.94	5.3	37.3	0.88	0.345	1.0	0.066	0.057	**N/A**
15.1	49.5	558	9.3	271.3	130.1	2	3.24	3.41	Clay-Like	68			558	0.94	5.2	37.1	0.88	0.344	1.0	0.066	0.057	**N/A**
15.2	49.9	556	9.7	273.1	130.9	2	3.42	3.42	Clay-Like	68			556	0.93	5.1	37.1	0.87	0.344	1.0	0.066	0.057	**N/A**
15.3	50.2	566	9.4	274.9	131.7	3	3.22	3.41	Clay-Like	68			566	0.93	5.2	37.2	0.87	0.344	1.0	0.066	0.057	**N/A**
15.4	50.5	555	8.8	276.7	132.6	2	3.17	3.42	Clay-Like	68			555	0.93	5.1	37.0	0.87	0.343	1.0	0.066	0.057	**N/A**
15.5	50.9	559	8.4	278.6	133.4	2	3.01	3.41	Clay-Like	68			559	0.93	5.1	37.1	0.87	0.343	1.0	0.066	0.057	**N/A**
15.6	51.2	564	8.6	280.4	134.2	2	3.04	3.41	Clay-Like	68			564	0.93	5.2	37.1	0.87	0.343	1.0	0.066	0.057	**N/A**
15.7	51.5	562	8.4	282.2	135.0	2	3.01	3.41	Clay-Like	68			562	0.93	5.2	37.1	0.87	0.342	1.0	0.066	0.057	**N/A**
15.8	51.8	571	7.5	284.0	135.9	2	2.60	3.37	Clay-Like	66			571	0.92	5.2	37.2	0.87	0.342	1.0	0.066	0.057	**N/A**
15.9	52.2	516	6.0	285.8	136.7	2	2.62	3.43	Clay-Like	69			516	0.92	4.7	36.5	0.87	0.342	1.0	0.066	0.057	**N/A**
16	52.5	532	7.9	287.6	137.5	2	3.25	3.46	Clay-Like	71			532	0.92	4.9	36.6	0.87	0.341	1.0	0.066	0.057	**N/A**
16.1	52.8	604	8.6	289.4	138.3	3	2.74	3.37	Clay-Like	66			604	0.92	5.5	37.6	0.86	0.341	1.0	0.067	0.057	**N/A**
16.2	53.2	593	7.7	291.2	139.2	3	2.54	3.37	Clay-Like	66			593	0.92	5.4	37.4	0.86	0.340	1.0	0.067	0.057	**N/A**
16.3	53.5	559	8.3	293.0	140.0	2	3.14	3.44	Clay-Like	70			559	0.92	5.1	37.0	0.86	0.340	1.0	0.066	0.057	**N/A**
16.4	53.8	589	8.8	294.8	140.8	2	3.00	3.42	Clay-Like	68			589	0.92	5.3	37.3	0.86	0.340	1.0	0.067	0.057	**N/A**
16.5	54.1	576	8.5	296.6	141.6	2	3.05	3.43	Clay-Like	69			576	0.91	5.2	37.2	0.86	0.339	1.0	0.066	0.057	**N/A**
16.6	54.5	573	8.8	298.4	142.5	2	3.21	3.45	Clay-Like	70			573	0.91	5.2	37.1	0.86	0.339	1.0	0.066	0.057	**N/A**
16.7	54.8	574	9.0	300.2	143.3	2	3.29	3.45	Clay-Like	70			574	0.91	5.2	37.1	0.86	0.339	1.0	0.066	0.057	**N/A**
16.8	55.1	591	9.3	302.1	144.1	2	3.22	3.44	Clay-Like	70			591	0.91	5.3	37.3	0.86	0.338	1.0	0.066	0.057	**N/A**
16.9	55.4	610	9.6	303.9	145.0	3	3.13	3.42	Clay-Like	68			610	0.91	5.5	37.5	0.85	0.338	1.0	0.067	0.057	**N/A**
17	55.8	630	9.8	305.7	145.8	3	3.01	3.4	Clay-Like	67			630	0.91	5.7	37.8	0.85	0.337	1.0	0.067	0.057	**N/A**
17.1	56.1	648	10.6	307.5	146.6	3	3.13	3.4	Clay-Like	67			648	0.91	5.8	38.0	0.85	0.337	1.0	0.067	0.057	**N/A**
17.2	56.4	641	11.2	309.3	147.4	3	3.38	3.42	Clay-Like	68			641	0.91	5.7	37.9	0.85	0.337	1.0	0.067	0.057	**N/A**
17.3	56.8	627	11.6	311.1	148.3	3	3.66	3.46	Clay-Like	71			627	0.90	5.6	37.7	0.85	0.336	1.0	0.067	0.057	**N/A**
17.4	57.1	634	11.5	312.9	149.1	3	3.58	3.45	Clay-Like	70			634	0.90	5.7	37.7	0.85	0.336	1.0	0.067	0.057	**N/A**
17.5	57.4	624	11.5	314.7	149.9	3	3.72	3.47	Clay-Like	71			624	0.90	5.6	37.6	0.85	0.336	1.0	0.067	0.057	**N/A**
17.6	57.7	638	12.0	316.5	150.7	3	3.72	3.46	Clay-Like	71			638	0.90	5.7	37.8	0.85	0.335	1.0	0.067	0.057	**N/A**
17.7	58.1	652	11.7	318.3	151.6	3	3.50	3.44	Clay-Like	70			652	0.90	5.8	37.9	0.85	0.335	1.0	0.067	0.057	**N/A**
17.8	58.4	631	11.4	320.1	152.4	3	3.67	3.47	Clay-Like	71			631	0.90	5.6	37.6	0.84	0.334	1.0	0.067	0.057	**N/A**
17.9	58.7	617	10.6	321.9	153.2	2	3.60	3.48	Clay-Like	72			617	0.90	5.5	37.5	0.84	0.334	1.0	0.067	0.057	**N/A**
18	59.1	615	10.2	323.8	154.0	2	3.49	3.48	Clay-Like	72			615	0.89	5.4	37.4	0.84	0.334	1.0	0.067	0.057	**N/A**
18.1	59.4	624	12.5	325.6	154.9	2	4.21	3.52	Clay-Like	74			624	0.89	5.5	37.5	0.84	0.333	1.0	0.067	0.057	**N/A**
18.2	59.7	619	13.6	327.4	155.7	2	4.66	3.55	Clay-Like	75			619	0.89	5.5	37.4	0.84	0.333	1.0	0.067	0.057	**N/A**
18.3	60.0	634	16.5	329.2	156.5	2	5.41	3.58	Clay-Like	77			634	0.89	5.6	37.5	0.84	0.332	1.0	0.067	0.057	**N/A**
18.4	60.4	645	15.1	331.0	157.4	2	4.82	3.55	Clay-Like	75			645	0.89	5.7	37.7	0.84	0.332	1.0	0.067	0.057	**N/A**
18.5	60.7	637	13.0	332.8	158.2	2	4.27	3.52	Clay-Like	74			637	0.89	5.6	37.6	0.84	0.332	1.0	0.067	0.057	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
18.6	61.0	656	14.5	334.6	159.0	3	4.50	3.52	Clay-Like	74			656	0.89	5.8	37.8	0.84	0.331	1.0	0.067	0.057	**N/A**
18.7	61.4	694	16.3	336.4	159.8	3	4.55	3.5	Clay-Like	73			694	0.89	6.1	38.3	0.83	0.331	1.0	0.067	0.057	**N/A**
18.8	61.7	711	16.4	338.2	160.7	3	4.39	3.48	Clay-Like	72			711	0.88	6.2	38.5	0.83	0.331	1.0	0.067	0.057	**N/A**
18.9	62.0	846	24.6	340.0	161.5	4	4.87	3.41	Clay-Like	68			846	0.88	7.4	40.1	0.83	0.330	1.0	0.069	0.058	**N/A**
19	62.3	992	42.7	341.8	162.3	5	6.56	3.44	Clay-Like	70			992	0.88	8.7	41.8	0.83	0.330	1.0	0.070	0.059	**N/A**
19.1	62.7	909	38.3	343.6	163.1	4	6.77	3.49	Clay-Like	72			909	0.88	7.9	40.8	0.83	0.329	1.0	0.069	0.059	**N/A**
19.2	63.0	1032	28.7	345.4	164.0	5	4.18	3.32	Clay-Like	63			1032	0.88	9.0	42.3	0.83	0.329	1.0	0.071	0.060	**N/A**
19.3	63.3	992	32.6	347.3	164.8	5	5.05	3.39	Clay-Like	67			992	0.88	8.6	41.8	0.83	0.329	1.0	0.070	0.059	**N/A**
19.4	63.6	989	59.7	349.1	165.6	5	9.33	3.55	Clay-Like	75			989	0.88	8.6	41.6	0.83	0.328	1.0	0.070	0.059	**N/A**
19.5	64.0	2611	74.3	350.9	166.5	17	3.29	2.9	Clay-Like	45			2611	0.88	22.7	60.9	0.82	0.328	1.0	0.089	0.075	**N/A**
19.6	64.3	3763	87.3	352.7	167.3	26	2.56	2.7	Clay-Like	37			3763	0.88	32.6	73.8	0.82	0.327	1.0	0.104	0.087	**N/A**
19.7	64.6	4478	107.3	354.5	168.1	32	2.60	2.64	Clay-Like	35			4478	0.87	38.8	81.8	0.82	0.327	1.0	0.115	0.096	**N/A**
19.8	65.0	6123	137.0	356.3	168.9	44	2.38	2.51		31			6123	0.87	52.9	99.8	0.82	0.327	0.9	0.142	0.118	**0.36**
19.9	65.3	7388	169.7	358.1	169.8	54	2.41	2.45		29			7388	0.87	63.8	113.6	0.82	0.326	0.9	0.167	0.137	**0.42**
20	65.6	7987	185.1	359.9	170.6	58	2.43	2.42		28			7987	0.87	68.9	119.9	0.82	0.326	0.9	0.179	0.147	**0.45**
20.1	65.9	8944	211.3	361.7	171.4	65	2.46	2.39		27			8944	0.87	77.0	130.2	0.82	0.325	0.9	0.204	0.166	**0.51**
20.2	66.3	12703	247.3	363.5	172.2	93	2.00	2.22		22			12703	0.87	109.2	168.0	0.82	0.325	0.9	0.388	0.306	**0.94**
20.3	66.6	17205	225.9	365.3	173.1	127	1.34	2		17			17205	0.87	147.8	204.1	0.82	0.325	0.9	1.383	1.031	**2.00**
20.4	66.9	20542	353.6	367.1	173.9	152	1.75	2.03		18			20542	0.87	176.2	242.0	0.81	0.324	0.8	2.000	1.466	**2.00**
20.5	67.3	22958	504.0	368.9	174.7	170	2.23	2.08		19			22958	0.87	196.7	272.1	0.81	0.324	0.8	2.000	1.463	**2.00**
20.6	67.6	23732	407.1	370.8	175.5	175	1.74	1.99		17			23732	0.86	203.1	271.6	0.81	0.323	0.8	2.000	1.461	**2.00**
20.7	67.9	23411	249.3	372.6	176.4	172	1.08	1.85		14			23411	0.86	200.1	251.2	0.81	0.323	0.8	2.000	1.458	**2.00**
20.8	68.2	22421	427.0	374.4	177.2	165	1.94	2.04		18			22421	0.86	191.4	261.9	0.81	0.323	0.8	2.000	1.456	**2.00**
20.9	68.6	19429	427.8	376.2	178.0	142	2.25	2.13		20			19429	0.86	165.6	236.2	0.81	0.322	0.8	2.000	1.453	**2.00**
21	68.9	18023	339.8	378.0	178.9	131	1.93	2.11		20			18023	0.86	153.5	219.3	0.81	0.322	0.8	2.000	1.451	**2.00**
21.1	69.2	14396	316.3	379.8	179.7	104	2.26	2.23		23			14396	0.86	122.4	185.5	0.81	0.321	0.9	0.639	0.488	**1.52**
21.2	69.6	7313	254.7	381.6	180.5	51	3.67	2.6	Clay-Like	34			7313	0.86	62.1	113.0	0.81	0.321	0.9	0.165	0.135	**N/A**
21.3	69.9	2999	151.1	383.4	181.3	19	5.78	3.02	Clay-Like	50			2999	0.86	25.4	64.7	0.80	0.321	1.0	0.093	0.078	**N/A**
21.4	70.2	1998	126.9	385.2	182.2	12	7.87	3.23	Clay-Like	59			1998	0.86	16.9	53.1	0.80	0.320	1.0	0.081	0.068	**N/A**
21.5	70.5	2426	81.2	387.0	183.0	15	3.98	2.97	Clay-Like	47			2426	0.85	20.5	58.0	0.80	0.320	1.0	0.086	0.072	**N/A**
21.6	70.9	2309	76.0	388.8	183.8	14	3.96	3	Clay-Like	49			2309	0.85	19.5	56.7	0.80	0.319	1.0	0.084	0.070	**N/A**
21.7	71.2	2250	78.6	390.6	184.6	14	4.23	3.04	Clay-Like	50			2250	0.85	19.0	56.0	0.80	0.319	1.0	0.084	0.070	**N/A**
21.8	71.5	2120	86.2	392.4	185.5	13	4.99	3.12	Clay-Like	54			2120	0.85	17.9	54.5	0.80	0.319	1.0	0.082	0.069	**N/A**
21.9	71.9	2001	82.9	394.3	186.3	12	5.16	3.15	Clay-Like	55			2001	0.85	16.9	53.1	0.80	0.318	1.0	0.081	0.067	**N/A**
22	72.2	1890	72.7	396.1	187.1	11	4.87	3.15	Clay-Like	55			1890	0.85	15.9	51.8	0.80	0.318	1.0	0.079	0.066	**N/A**
22.1	72.5	1992	72.8	397.9	187.9	12	4.56	3.11	Clay-Like	53			1992	0.85	16.7	52.9	0.80	0.317	1.0	0.080	0.067	**N/A**
22.2	72.8	2090	78.1	399.7	188.8	12	4.62	3.1	Clay-Like	53			2090	0.85	17.5	54.0	0.79	0.317	1.0	0.081	0.068	**N/A**
22.3	73.2	1948	75.0	401.5	189.6	11	4.85	3.15	Clay-Like	55			1948	0.85	16.3	52.4	0.79	0.317	1.0	0.080	0.067	**N/A**
22.4	73.5	1794	74.2	403.3	190.4	10	5.34	3.21	Clay-Like	58			1794	0.85	15.0	50.6	0.79	0.316	1.0	0.078	0.065	**N/A**
22.5	73.8	1943	72.0	405.1	191.3	11	4.68	3.13	Clay-Like	54			1943	0.84	16.3	52.3	0.79	0.316	1.0	0.080	0.067	**N/A**
22.6	74.1	2170	82.7	406.9	192.1	13	4.69	3.1	Clay-Like	53			2170	0.84	18.1	54.8	0.79	0.315	1.0	0.082	0.069	**N/A**
22.7	74.5	2085	87.9	408.7	192.9	12	5.24	3.14	Clay-Like	55			2085	0.84	17.4	53.8	0.79	0.315	1.0	0.081	0.068	**N/A**
22.8	74.8	1820	73.7	410.5	193.7	10	5.23	3.19	Clay-Like	57			1820	0.84	15.2	50.8	0.79	0.315	1.0	0.078	0.065	**N/A**
22.9	75.1	1662	54.2	412.3	194.6	9	4.34	3.16	Clay-Like	56			1662	0.84	13.8	49.0	0.79	0.314	1.0	0.077	0.064	**N/A**
23	75.5	1614	47.3	414.1	195.4	9	3.94	3.15	Clay-Like	55			1614	0.84	13.4	48.4	0.79	0.314	1.0	0.076	0.063	**N/A**
23.1	75.8	1597	49.7	415.9	196.2	8	4.21	3.17	Clay-Like	56			1597	0.84	13.3	48.2	0.78	0.313	1.0	0.076	0.063	**N/A**
23.2	76.1	1644	57.6	417.8	197.0	9	4.69	3.2	Clay-Like	58			1644	0.84	13.6	48.7	0.78	0.313	1.0	0.076	0.064	**N/A**
23.3	76.4	1581	54.7	419.6	197.9	8	4.71	3.22	Clay-Like	59			1581	0.84	13.1	48.0	0.78	0.313	1.0	0.076	0.063	**N/A**
23.4	76.8	1461	48.9	421.4	198.7	7	4.71	3.24	Clay-Like	60			1461	0.84	12.1	46.6	0.78	0.312	1.0	0.074	0.062	**N/A**
23.5	77.1	1456	46.3	423.2	199.5	7	4.48	3.24	Clay-Like	60			1456	0.84	12.0	46.5	0.78	0.312	1.0	0.074	0.062	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
23.6	77.4	1450	46.1	425.0	200.4	7	4.49	3.24	Clay-Like	60			1450	0.83	12.0	46.4	0.78	0.311	1.0	0.074	0.062	**N/A**
23.7	77.8	1452	46.2	426.8	201.2	7	4.50	3.24	Clay-Like	60			1452	0.83	12.0	46.4	0.78	0.311	1.0	0.074	0.062	**N/A**
23.8	78.1	1441	42.2	428.6	202.0	7	4.17	3.22	Clay-Like	59			1441	0.83	11.9	46.3	0.78	0.311	1.0	0.074	0.062	**N/A**
23.9	78.4	1456	38.9	430.4	202.8	7	3.79	3.2	Clay-Like	58			1456	0.83	12.0	46.5	0.78	0.310	1.0	0.074	0.062	**N/A**
24	78.7	1453	40.9	432.2	203.7	7	4.01	3.22	Clay-Like	59			1453	0.83	12.0	46.4	0.77	0.310	1.0	0.074	0.062	**N/A**
24.1	79.1	1376	41.8	434.0	204.5	7	4.44	3.27	Clay-Like	61			1376	0.83	11.3	45.5	0.77	0.309	1.0	0.073	0.061	**N/A**
24.2	79.4	1294	36.4	435.8	205.3	6	4.24	3.29	Clay-Like	62			1294	0.83	10.6	44.6	0.77	0.309	1.0	0.072	0.060	**N/A**
24.3	79.7	1260	31.6	437.6	206.1	6	3.84	3.27	Clay-Like	61			1260	0.83	10.3	44.2	0.77	0.309	1.0	0.072	0.060	**N/A**
24.4	80.1	1264	31.8	439.4	207.0	6	3.86	3.27	Clay-Like	61			1264	0.83	10.4	44.2	0.77	0.308	1.0	0.072	0.060	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-53**

Test Boring Information:

Approx. ground elevation		7	ft	2.13 m
Approx. water table elevation		1	ft	0.30 m
Approx. depth to ground water table		6	ft	1.83 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	237	4	1.6	1.6	19	1.63	1.95	Unsaturated	16			237	1.70	4.0	24.0	1.00	0.189	1.1	0.058	0.056	**N/A**
0.2	0.7	194	8	3.1	3.1	11	4.30	2.52	Unsaturated	31			194	1.70	3.3	33.5	1.00	0.189	1.1	0.064	0.061	**N/A**
0.3	1.0	313	16	4.7	4.7	14	5.28	2.56	Unsaturated	32			313	1.70	5.3	36.4	1.00	0.189	1.1	0.066	0.063	**N/A**
0.4	1.3	210	16	6.3	6.3	8	8.03	2.88	Unsaturated	44			210	1.70	3.5	35.0	1.00	0.189	1.1	0.065	0.062	**N/A**
0.5	1.6	210	14	7.9	7.9	7	6.82	2.89	Unsaturated	44			210	1.70	3.5	35.0	1.00	0.189	1.1	0.065	0.062	**N/A**
0.6	2.0	140	11	9.4	9.4	4	8.12	3.11	Unsaturated	53			140	1.70	2.4	33.5	1.00	0.189	1.1	0.064	0.061	**N/A**
0.7	2.3	113	8	11.0	11.0	3	8.00	3.21	Unsaturated	58			113	1.70	1.9	32.8	1.00	0.189	1.1	0.063	0.061	**N/A**
0.8	2.6	145	7	12.6	12.6	4	4.92	3.03	Unsaturated	50			145	1.70	2.4	33.6	1.00	0.189	1.1	0.064	0.061	**N/A**
0.9	3.0	137	8	14.1	14.1	3	6.72	3.17	Unsaturated	56			137	1.70	2.3	33.4	1.00	0.189	1.1	0.064	0.061	**N/A**
1.0	3.3	212	11	15.7	15.7	5	5.86	3.03	Unsaturated	50			212	1.70	3.6	35.1	1.00	0.189	1.1	0.065	0.062	**N/A**
1.1	3.6	320	14	17.3	17.3	7	4.52	2.87	Unsaturated	43			320	1.59	5.0	37.1	1.00	0.189	1.1	0.066	0.064	**N/A**
1.2	3.9	181	11	18.9	18.9	4	6.86	3.2	Unsaturated	58			181	1.70	3.0	34.4	1.00	0.188	1.1	0.064	0.062	**N/A**
1.3	4.3	122	18	20.4	20.4	2	17.54	3.62	Unsaturated	79			122	1.70	2.1	32.7	1.00	0.188	1.1	0.063	0.061	**N/A**
1.4	4.6	340	41	22.0	22.0	7	12.76	3.23	Unsaturated	59			340	1.49	5.0	37.1	1.00	0.188	1.1	0.066	0.064	**N/A**
1.5	4.9	211	22	23.6	23.6	4	11.93	3.37	Unsaturated	66			211	1.58	3.3	34.6	1.00	0.188	1.1	0.064	0.062	**N/A**
1.6	5.2	178	11	25.2	25.2	3	7.15	3.29	Unsaturated	62			178	1.65	2.9	34.2	1.00	0.188	1.1	0.064	0.061	**N/A**
1.7	5.6	240	12	26.7	26.7	4	5.83	3.15	Unsaturated	55			240	1.45	3.5	35.0	1.00	0.188	1.1	0.065	0.061	**N/A**
1.8	5.9	180	15	28.3	28.3	3	9.73	3.38	Unsaturated	66			180	1.58	2.8	33.9	1.00	0.188	1.1	0.064	0.060	**N/A**
1.9	6.2	302	17	30.0	29.3	5	6.41	3.12	Clay-Like	54			302	1.39	4.1	35.9	1.00	0.192	1.1	0.065	0.062	**N/A**
2.0	6.6	162	14	31.8	30.2	2	10.41	3.46	Clay-Like	71			162	1.59	2.6	33.5	1.00	0.198	1.1	0.064	0.060	**N/A**
2.1	6.9	113	9	33.7	31.0	1	11.61	3.61	Clay-Like	79			113	1.70	1.9	32.5	0.99	0.204	1.1	0.063	0.059	**N/A**
2.2	7.2	124	9	35.5	31.8	2	10.51	3.56	Clay-Like	76			124	1.68	2.1	32.8	0.99	0.209	1.1	0.063	0.059	**N/A**
2.3	7.5	182	12	37.3	32.6	3	8.03	3.36	Clay-Like	65			182	1.49	2.7	33.8	0.99	0.214	1.1	0.064	0.060	**N/A**
2.4	7.9	191	12	39.1	33.5	3	7.89	3.34	Clay-Like	64			191	1.46	2.8	33.9	0.99	0.219	1.1	0.064	0.060	**N/A**
2.5	8.2	259	11	40.9	34.3	4	5.10	3.13	Clay-Like	54			259	1.33	3.4	34.9	0.99	0.223	1.1	0.065	0.060	**N/A**
2.6	8.5	626	7	42.7	35.1	10	1.21	2.47		29			626	1.32	8.2	39.8	0.99	0.227	1.1	0.068	0.064	**0.28**
2.7	8.9	698	4	44.5	36.0	11	0.62	2.31		25			698	1.31	9.1	39.2	0.99	0.231	1.1	0.068	0.063	**0.27**
2.8	9.2	452	6	46.3	36.8	7	1.49	2.67	Clay-Like	36			452	1.31	5.8	37.7	0.99	0.235	1.1	0.067	0.062	**N/A**
2.9	9.5	241	4	48.1	37.6	3	2.28	3.03	Clay-Like	50			241	1.32	3.1	34.6	0.99	0.239	1.1	0.064	0.060	**N/A**
3.0	9.8	138	3	49.9	38.4	1	3.14	3.31	Clay-Like	63			138	1.50	2.1	33.0	0.99	0.242	1.1	0.063	0.059	**N/A**
3.1	10.2	111	3	51.7	39.3	1	4.52	3.48	Clay-Like	72			111	1.57	1.7	32.4	0.99	0.246	1.1	0.063	0.058	**N/A**
3.2	10.5	140	3	53.5	40.1	1	3.86	3.35	Clay-Like	65			140	1.47	2.0	32.9	0.99	0.249	1.1	0.063	0.059	**N/A**
3.3	10.8	153	4	55.3	40.9	2	3.72	3.31	Clay-Like	63			153	1.43	2.2	33.1	0.99	0.252	1.1	0.063	0.059	**N/A**
3.4	11.2	160	4	57.2	41.7	2	4.08	3.32	Clay-Like	63			160	1.41	2.2	33.2	0.99	0.255	1.1	0.063	0.059	**N/A**
3.5	11.5	177	5	59.0	42.6	2	3.81	3.28	Clay-Like	61			177	1.37	2.4	33.5	0.99	0.257	1.1	0.064	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	200	5	60.8	43.4	2	3.72	3.23	Clay-Like	59			200	1.32	2.6	33.8	0.99	0.260	1.1	0.064	0.059	**N/A**
3.7	12.1	188	5	62.6	44.2	2	3.82	3.26	Clay-Like	60			188	1.33	2.5	33.6	0.98	0.263	1.1	0.064	0.059	**N/A**
3.8	12.5	200	5	64.4	45.1	2	3.96	3.26	Clay-Like	60			200	1.30	2.6	33.7	0.98	0.265	1.0	0.064	0.059	**N/A**
3.9	12.8	202	5	66.2	45.9	2	3.81	3.26	Clay-Like	60			202	1.29	2.6	33.7	0.98	0.267	1.0	0.064	0.059	**N/A**
4.0	13.1	195	4	68.0	46.7	2	3.16	3.23	Clay-Like	59			195	1.30	2.5	33.6	0.98	0.270	1.0	0.064	0.058	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-54**

Test Boring Information:

Approx. ground elevation		4	ft	1.22 m
Approx. water table elevation		0.5	ft	0.15 m
Approx. depth to ground water table		3.5	ft	1.07 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	409	4.2	1.6	1.6	32	1.03	1.66	Unsaturated	10			409	1.70	6.9	14.8	1.00	0.189	1.1	0.053	0.051	**N/A**
0.2	0.7	500	4.3	3.1	3.1	28	0.87	1.75	Unsaturated	12			500	1.70	8.4	20.7	1.00	0.189	1.1	0.056	0.054	**N/A**
0.3	1.0	374	5.0	4.7	4.7	17	1.35	2.1	Unsaturated	19			374	1.70	6.3	31.5	1.00	0.189	1.1	0.062	0.060	**N/A**
0.4	1.3	335	5.2	6.3	6.3	13	1.57	2.27	Unsaturated	24			335	1.70	5.6	34.1	1.00	0.189	1.1	0.064	0.062	**N/A**
0.5	1.6	455	5.7	7.9	7.9	16	1.29	2.19	Unsaturated	21			455	1.70	7.7	35.3	1.00	0.189	1.1	0.065	0.063	**N/A**
0.6	2.0	452	6.2	9.4	9.4	14	1.41	2.28	Unsaturated	24			452	1.70	7.6	36.8	1.00	0.189	1.1	0.066	0.064	**N/A**
0.7	2.3	395	4.5	11.0	11.0	12	1.17	2.34	Unsaturated	26			395	1.70	6.7	36.4	1.00	0.189	1.1	0.066	0.063	**N/A**
0.8	2.6	358	1.8	12.6	12.6	10	0.53	2.26	Unsaturated	23			358	1.70	6.0	34.4	1.00	0.189	1.1	0.064	0.062	**N/A**
0.9	3.0	366	4.1	14.1	14.1	9	1.17	2.46	Unsaturated	29			366	1.68	6.1	36.9	1.00	0.189	1.1	0.066	0.064	**N/A**
1.0	3.3	589	5.5	15.7	15.7	14	0.95	2.28	Unsaturated	24			589	1.63	9.5	39.3	1.00	0.189	1.1	0.068	0.066	**N/A**
1.1	3.6	406	4.8	17.4	17.0	9	1.23	2.52		31			406	1.60	6.4	37.8	1.00	0.192	1.1	0.067	0.064	**0.34**
1.2	3.9	229	3.7	19.2	17.9	5	1.78	2.85	Clay-Like	43			229	1.66	3.8	35.3	1.00	0.202	1.1	0.065	0.063	**N/A**
1.3	4.3	270	3.2	21.0	18.7	6	1.27	2.75	Clay-Like	39			270	1.56	4.2	35.7	1.00	0.211	1.1	0.065	0.063	**N/A**
1.4	4.6	294	3.1	22.8	19.5	6	1.13	2.72	Clay-Like	38			294	1.54	4.5	36.0	1.00	0.220	1.1	0.066	0.063	**N/A**
1.5	4.9	138	2.0	24.6	20.4	2	1.78	3.18	Clay-Like	57			138	1.70	2.3	33.4	1.00	0.227	1.1	0.064	0.061	**N/A**
1.6	5.2	114	1.4	26.4	21.2	2	1.64	3.27	Clay-Like	61			114	1.70	1.9	32.8	1.00	0.235	1.1	0.063	0.061	**N/A**
1.7	5.6	79	1.4	28.2	22.0	1	2.83	3.53	Clay-Like	74			79	1.70	1.3	31.8	1.00	0.241	1.1	0.063	0.060	**N/A**
1.8	5.9	109	1.1	30.0	22.8	2	1.33	3.25	Clay-Like	60			109	1.70	1.8	32.7	1.00	0.247	1.1	0.063	0.060	**N/A**
1.9	6.2	42	2.6	31.8	23.7	1	24.87	4.06	Clay-Like	107			42	1.70	0.7	30.5	1.00	0.253	1.1	0.062	0.059	**N/A**
2.0	6.6	106	3.3	33.6	24.5	1	4.53	3.53	Clay-Like	74			106	1.70	1.8	32.4	1.00	0.258	1.1	0.063	0.060	**N/A**
2.1	6.9	94	4.1	35.4	25.3	1	7.09	3.71	Clay-Like	85			94	1.70	1.6	32.0	0.99	0.263	1.1	0.063	0.059	**N/A**
2.2	7.2	85	3.5	37.3	26.1	1	7.37	3.76	Clay-Like	88			85	1.70	1.4	31.7	0.99	0.267	1.1	0.062	0.059	**N/A**
2.3	7.5	40	2.1	39.1	27.0	1	242.52	4.06	Clay-Like	107			40	1.70	0.7	30.4	0.99	0.271	1.1	0.062	0.058	**N/A**
2.4	7.9	18	2.1	40.9	27.8	1	0.10			0			18	1.70	0.3	0.3	0.99	0.275	1.0	0.050	0.045	**0.17**
2.5	8.2	79	3.2	42.7	28.6	1	8.72	3.81	Clay-Like	91			79	1.70	1.3	31.6	0.99	0.279	1.1	0.062	0.059	**N/A**
2.6	8.5	108	4.6	44.5	29.4	1	7.21	3.63	Clay-Like	80			108	1.70	1.8	32.4	0.99	0.282	1.1	0.063	0.059	**N/A**
2.7	8.9	119	4.4	46.3	30.3	1	6.04	3.55	Clay-Like	75			119	1.70	2.0	32.7	0.99	0.286	1.1	0.063	0.059	**N/A**
2.8	9.2	120	4.6	48.1	31.1	1	6.38	3.56	Clay-Like	76			120	1.70	2.0	32.7	0.99	0.289	1.1	0.063	0.059	**N/A**
2.9	9.5	119	5.6	49.9	31.9	1	8.15	3.61	Clay-Like	79			119	1.70	2.0	32.7	0.99	0.292	1.1	0.063	0.059	**N/A**
3.0	9.8	126	5.3	51.7	32.8	1	7.13	3.55	Clay-Like	75			126	1.65	2.1	32.8	0.99	0.294	1.1	0.063	0.059	**N/A**
3.1	10.2	128	5.1	53.5	33.6	1	6.86	3.54	Clay-Like	75			128	1.63	2.1	32.8	0.99	0.297	1.1	0.063	0.059	**N/A**
3.2	10.5	149	4.5	55.3	34.4	2	4.82	3.41	Clay-Like	68			149	1.55	2.3	33.2	0.99	0.300	1.1	0.063	0.059	**N/A**
3.3	10.8	177	4.7	57.1	35.2	2	3.91	3.31	Clay-Like	63			177	1.46	2.6	33.7	0.99	0.302	1.1	0.064	0.059	**N/A**
3.4	11.2	161	5.0	58.9	36.1	2	4.86	3.4	Clay-Like	67			161	1.49	2.4	33.4	0.99	0.304	1.1	0.064	0.059	**N/A**
3.5	11.5	153	4.5	60.8	36.9	2	4.87	3.42	Clay-Like	68			153	1.49	2.3	33.2	0.99	0.306	1.1	0.063	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	146	4.0	62.6	37.7	1	4.83	3.45	Clay-Like	70			146	1.50	2.2	33.0	0.99	0.308	1.1	0.063	0.059	**N/A**
3.7	12.1	132	4.0	64.4	38.5	1	5.93	3.54	Clay-Like	75			132	1.52	2.0	32.7	0.98	0.310	1.1	0.063	0.059	**N/A**
3.8	12.5	149	3.8	66.2	39.4	1	4.65	3.46	Clay-Like	71			149	1.47	2.2	33.0	0.98	0.312	1.1	0.063	0.059	**N/A**
3.9	12.8	155	3.8	68.0	40.2	1	4.40	3.44	Clay-Like	70			155	1.44	2.2	33.1	0.98	0.314	1.1	0.063	0.059	**N/A**
4.0	13.1	143	4.1	69.8	41.0	1	5.61	3.54	Clay-Like	75			143	1.45	2.1	32.8	0.98	0.315	1.1	0.063	0.058	**N/A**
4.1	13.5	164	4.4	71.6	41.9	1	4.76	3.45	Clay-Like	70			164	1.40	2.3	33.2	0.98	0.317	1.1	0.063	0.059	**N/A**
4.2	13.8	164	3.5	73.4	42.7	1	3.90	3.42	Clay-Like	68			164	1.39	2.3	33.2	0.98	0.318	1.1	0.063	0.058	**N/A**
4.3	14.1	155	3.2	75.2	43.5	1	3.96	3.45	Clay-Like	70			155	1.39	2.1	33.0	0.98	0.320	1.1	0.063	0.058	**N/A**
4.4	14.4	177	3.8	77.0	44.3	1	3.83	3.41	Clay-Like	68			177	1.35	2.4	33.3	0.98	0.321	1.1	0.064	0.058	**N/A**
4.5	14.8	160	4.1	78.8	45.2	1	5.10	3.51	Clay-Like	73			160	1.37	2.2	33.0	0.98	0.322	1.0	0.063	0.058	**N/A**
4.6	15.1	155	4.0	80.6	46.0	1	5.41	3.55	Clay-Like	75			155	1.36	2.1	32.8	0.98	0.323	1.0	0.063	0.058	**N/A**
4.7	15.4	149	3.8	82.5	46.8	1	5.79	3.58	Clay-Like	77			149	1.37	2.0	32.7	0.98	0.325	1.0	0.063	0.058	**N/A**
4.8	15.7	169	3.4	84.3	47.6	1	3.96	3.46	Clay-Like	71			169	1.32	2.2	33.1	0.98	0.326	1.0	0.063	0.058	**N/A**
4.9	16.1	185	2.3	86.1	48.5	1	2.32	3.33	Clay-Like	64			185	1.29	2.4	33.4	0.98	0.327	1.0	0.064	0.058	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-55**

Test Boring Information:

Approx. ground elevation		7 ft	2.13 m
Approx. water table elevation		1 ft	0.30 m
Approx. depth to ground water table		6 ft	1.83 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	366	6	1.6	1.6	29	1.76	1.85	Unsaturated	14			366	1.70	6.2	22.7	1.00	0.189	1.1	0.057	0.055	**N/A**
0.2	0.7	333	4	3.1	3.1	18	1.25	1.99	Unsaturated	17			333	1.70	5.6	27.4	1.00	0.189	1.1	0.060	0.057	**N/A**
0.3	1.0	1103	7	4.7	4.7	50	0.60	1.52	Unsaturated	8			1103	1.70	18.6	21.6	1.00	0.189	1.1	0.056	0.054	**N/A**
0.4	1.3	2202	15	6.3	6.3	87	0.68	1.44	Unsaturated	7			2202	1.70	37.1	38.4	1.00	0.189	1.1	0.067	0.065	**N/A**
0.5	1.6	2275	22	7.9	7.9	80	0.98	1.62	Unsaturated	10			2275	1.70	38.3	46.6	1.00	0.189	1.1	0.074	0.072	**N/A**
0.6	2.0	2172	27	9.4	9.4	70	1.23	1.76	Unsaturated	12			2172	1.70	36.6	53.1	1.00	0.189	1.1	0.081	0.078	**N/A**
0.7	2.3	2014	27	11.0	11.0	60	1.36	1.85	Unsaturated	14			2014	1.70	33.9	55.4	1.00	0.189	1.1	0.083	0.080	**N/A**
0.8	2.6	2013	25	12.6	12.6	56	1.27	1.87	Unsaturated	14			2013	1.70	33.9	56.4	1.00	0.189	1.1	0.084	0.081	**N/A**
0.9	3.0	2113	19	14.1	14.1	55	0.90	1.8	Unsaturated	13			2113	1.68	35.1	53.9	1.00	0.189	1.1	0.081	0.078	**N/A**
1.0	3.3	1979	17	15.7	15.7	49	0.88	1.85	Unsaturated	14			1979	1.63	32.0	53.1	1.00	0.189	1.1	0.081	0.078	**N/A**
1.1	3.6	1648	16	17.3	17.3	39	1.00	1.98	Unsaturated	17			1648	1.59	26.0	52.2	1.00	0.189	1.1	0.080	0.077	**N/A**
1.2	3.9	1212	16	18.9	18.9	27	1.32	2.19	Unsaturated	21			1212	1.56	18.7	49.6	1.00	0.188	1.1	0.077	0.074	**N/A**
1.3	4.3	849	14	20.4	20.4	18	1.68	2.4	Unsaturated	27			849	1.52	12.8	45.2	1.00	0.188	1.1	0.073	0.070	**N/A**
1.4	4.6	654	11	22.0	22.0	13	1.67	2.52	Unsaturated	31			654	1.49	9.7	42.1	1.00	0.188	1.1	0.070	0.068	**N/A**
1.5	4.9	529	8	23.6	23.6	10	1.67	2.63	Unsaturated	35			529	1.47	7.7	40.0	1.00	0.188	1.1	0.069	0.066	**N/A**
1.6	5.2	567	7	25.2	25.2	11	1.31	2.56	Unsaturated	32			567	1.44	8.1	40.2	1.00	0.188	1.1	0.069	0.066	**N/A**
1.7	5.6	583	7	26.7	26.7	11	1.22	2.54	Unsaturated	32			583	1.42	8.2	40.3	1.00	0.188	1.1	0.069	0.065	**N/A**
1.8	5.9	464	7	28.3	28.3	8	1.54	2.69	Unsaturated	37			464	1.40	6.4	38.5	1.00	0.188	1.1	0.067	0.064	**N/A**
1.9	6.2	534	5	30.0	29.3	9	0.95	2.54		32			534	1.39	7.3	39.1	1.00	0.192	1.1	0.068	0.064	**0.33**
2.0	6.6	553	5	31.8	30.2	9	0.96	2.54		32			553	1.38	7.5	39.4	1.00	0.198	1.1	0.068	0.064	**0.32**
2.1	6.9	398	3	33.7	31.0	7	0.89	2.67	Clay-Like	36			398	1.37	5.4	37.1	0.99	0.204	1.1	0.066	0.062	**N/A**
2.2	7.2	271	3	35.5	31.8	4	1.30	2.9	Clay-Like	45			271	1.36	3.6	35.2	0.99	0.209	1.1	0.065	0.061	**N/A**
2.3	7.5	196	5	37.3	32.6	3	3.13	3.21	Clay-Like	58			196	1.46	2.8	34.1	0.99	0.214	1.1	0.064	0.060	**N/A**
2.4	7.9	206	6	39.1	33.5	3	3.38	3.22	Clay-Like	59			206	1.43	2.9	34.2	0.99	0.219	1.1	0.064	0.060	**N/A**
2.5	8.2	208	5	40.9	34.3	3	3.15	3.21	Clay-Like	58			208	1.41	2.9	34.2	0.99	0.223	1.1	0.064	0.060	**N/A**
2.6	8.5	185	5	42.7	35.1	2	3.36	3.28	Clay-Like	61			185	1.45	2.7	33.8	0.99	0.227	1.1	0.064	0.060	**N/A**
2.7	8.9	188	5	44.5	36.0	2	3.60	3.3	Clay-Like	62			188	1.43	2.7	33.8	0.99	0.231	1.1	0.064	0.059	**N/A**
2.8	9.2	221	5	46.3	36.8	3	2.63	3.18	Clay-Like	57			221	1.36	3.0	34.3	0.99	0.235	1.1	0.064	0.060	**N/A**
2.9	9.5	187	4	48.1	37.6	2	3.17	3.29	Clay-Like	62			187	1.41	2.6	33.8	0.99	0.239	1.1	0.064	0.059	**N/A**
3.0	9.8	166	4	49.9	38.4	2	3.79	3.39	Clay-Like	67			166	1.44	2.4	33.3	0.99	0.242	1.1	0.064	0.059	**N/A**
3.1	10.2	176	4	51.7	39.3	2	3.54	3.36	Clay-Like	65			176	1.41	2.5	33.5	0.99	0.246	1.1	0.064	0.059	**N/A**
3.2	10.5	185	5	53.5	40.1	2	3.42	3.34	Clay-Like	64			185	1.38	2.5	33.6	0.99	0.249	1.1	0.064	0.059	**N/A**
3.3	10.8	187	4	55.3	40.9	2	3.34	3.34	Clay-Like	64			187	1.37	2.5	33.6	0.99	0.252	1.1	0.064	0.059	**N/A**
3.4	11.2	190	5	57.2	41.7	2	3.46	3.35	Clay-Like	65			190	1.35	2.5	33.6	0.99	0.255	1.1	0.064	0.059	**N/A**
3.5	11.5	201	5	59.0	42.6	2	3.51	3.34	Clay-Like	64			201	1.33	2.6	33.8	0.99	0.257	1.1	0.064	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	210	5	60.8	43.4	2	3.66	3.34	Clay-Like	64			210	1.31	2.7	33.9	0.99	0.260	1.1	0.064	0.059	**N/A**
3.7	12.1	198	5	62.6	44.2	2	4.03	3.4	Clay-Like	67			198	1.32	2.6	33.6	0.98	0.263	1.1	0.064	0.059	**N/A**
3.8	12.5	194	5	64.4	45.1	2	3.83	3.4	Clay-Like	67			194	1.31	2.5	33.6	0.98	0.265	1.0	0.064	0.059	**N/A**
3.9	12.8	217	5	66.2	45.9	2	3.31	3.33	Clay-Like	64			217	1.28	2.7	33.9	0.98	0.267	1.0	0.064	0.059	**N/A**
4.0	13.1	210	3	68.0	46.7	2	2.29	3.28	Clay-Like	61			210	1.28	2.7	33.8	0.98	0.270	1.0	0.064	0.059	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-56**

Test Boring Information:

Approx. ground elevation		2 ft	0.61	m
Approx. water table elevation		0.5 ft	0.15	m
Approx. depth to ground water table		1.5 ft	0.46	m
Moist unit weight of soil	γ_m	100 pcf	15.72	kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8	
Peak horizontal ground surface acceleration	a_{max}	0.29	g
Magnitude Scaling Factor	M_F	0.88	

Atomospheric pressure	P_a	101.3	kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	427	6	1.6	1.6	34	1.46	1.77	Unsaturated	12			427	1.70	7.2	20.2	1.00	0.189	1.1	0.056	0.054	**N/A**
0.2	0.7	159	5	3.1	3.1	9	2.96	2.49	Unsaturated	30			159	1.70	2.7	32.5	1.00	0.189	1.1	0.063	0.061	**N/A**
0.3	1.0	167	3	4.7	4.7	7	2.07	2.5	Unsaturated	30			167	1.70	2.8	32.8	1.00	0.189	1.1	0.063	0.061	**N/A**
0.4	1.3	239	4	6.3	6.3	9	1.73	2.43	Unsaturated	28			239	1.70	4.0	33.8	1.00	0.189	1.1	0.064	0.062	**N/A**
0.5	1.6	289	5	8.0	7.5	10	1.64	2.43		28			289	1.70	4.9	35.0	1.00	0.199	1.1	0.065	0.062	**0.31**
0.6	2.0	280	5	9.8	8.4	9	1.81	2.52		31			280	1.70	4.7	35.5	1.00	0.220	1.1	0.065	0.063	**0.28**
0.7	2.3	268	5	11.6	9.2	8	1.91	2.6	Clay-Like	34			268	1.70	4.5	35.6	1.00	0.237	1.1	0.065	0.063	**N/A**
0.8	2.6	285	5	13.4	10.0	9	1.87	2.62	Clay-Like	34			285	1.70	4.8	36.1	1.00	0.252	1.1	0.066	0.063	**N/A**
0.9	3.0	459	6	15.2	10.8	13	1.40	2.43		28			459	1.70	7.7	38.8	1.00	0.264	1.1	0.068	0.065	**0.25**
1.0	3.3	538	7	17.0	11.7	15	1.36	2.41		28			538	1.70	9.0	40.3	1.00	0.274	1.1	0.069	0.066	**0.24**
1.1	3.6	347	6	18.8	12.5	9	1.93	2.69	Clay-Like	37			347	1.70	5.8	37.8	1.00	0.284	1.1	0.067	0.064	**N/A**
1.2	3.9	250	5	20.6	13.3	6	2.17	2.87	Clay-Like	43			250	1.70	4.2	35.9	1.00	0.292	1.1	0.065	0.063	**N/A**
1.3	4.3	327	5	22.4	14.2	8	1.69	2.74	Clay-Like	38			327	1.68	5.4	37.4	1.00	0.298	1.1	0.067	0.064	**N/A**
1.4	4.6	304	5	24.2	15.0	7	1.92	2.83	Clay-Like	42			304	1.65	5.0	36.9	1.00	0.304	1.1	0.066	0.064	**N/A**
1.5	4.9	394	5	26.0	15.8	9	1.43	2.69	Clay-Like	37			394	1.63	6.4	38.5	1.00	0.310	1.1	0.067	0.065	**N/A**
1.6	5.2	373	4	27.8	16.6	8	1.05	2.66	Clay-Like	36			373	1.61	5.9	37.8	1.00	0.315	1.1	0.067	0.064	**N/A**
1.7	5.6	390	2	29.7	17.5	9	0.69	2.57		33			390	1.59	6.1	37.7	1.00	0.319	1.1	0.067	0.064	**0.20**
1.8	5.9	305	3	31.5	18.3	6	1.08	2.77	Clay-Like	40			305	1.57	4.7	36.5	1.00	0.323	1.1	0.066	0.063	**N/A**
1.9	6.2	166	4	33.3	19.1	3	2.96	3.22	Clay-Like	59			166	1.70	2.8	34.0	1.00	0.327	1.1	0.064	0.062	**N/A**
2.0	6.6	143	5	35.1	19.9	2	4.26	3.37	Clay-Like	66			143	1.70	2.4	33.4	1.00	0.330	1.1	0.064	0.061	**N/A**
2.1	6.9	150	5	36.9	20.8	2	4.13	3.36	Clay-Like	65			150	1.70	2.5	33.6	0.99	0.333	1.1	0.064	0.061	**N/A**
2.2	7.2	130	5	38.7	21.6	2	5.13	3.46	Clay-Like	71			130	1.70	2.2	33.0	0.99	0.336	1.1	0.063	0.061	**N/A**
2.3	7.5	131	5	40.5	22.4	2	4.96	3.46	Clay-Like	71			131	1.70	2.2	33.1	0.99	0.338	1.1	0.063	0.061	**N/A**
2.4	7.9	134	4	42.3	23.3	2	4.70	3.47	Clay-Like	71			134	1.70	2.3	33.1	0.99	0.341	1.1	0.063	0.060	**N/A**
2.5	8.2	117	4	44.1	24.1	1	5.49	3.56	Clay-Like	76			117	1.70	2.0	32.7	0.99	0.343	1.1	0.063	0.060	**N/A**
2.6	8.5	117	5	45.9	24.9	1	6.43	3.59	Clay-Like	78			117	1.70	2.0	32.6	0.99	0.345	1.1	0.063	0.060	**N/A**
2.7	8.9	120	5	47.7	25.7	1	7.01	3.61	Clay-Like	79			120	1.70	2.0	32.7	0.99	0.347	1.1	0.063	0.060	**N/A**
2.8	9.2	139	6	49.5	26.6	2	6.39	3.54	Clay-Like	75			139	1.70	2.3	33.2	0.99	0.348	1.1	0.063	0.060	**N/A**
2.9	9.5	160	6	51.3	27.4	2	5.13	3.45	Clay-Like	70			160	1.66	2.6	33.6	0.99	0.350	1.1	0.064	0.060	**N/A**
3.0	9.8	208	6	53.2	28.2	3	3.95	3.3	Clay-Like	62			208	1.50	3.1	34.4	0.99	0.351	1.1	0.064	0.061	**N/A**
3.1	10.2	221	7	55.0	29.0	3	3.92	3.28	Clay-Like	61			221	1.46	3.2	34.5	0.99	0.353	1.1	0.064	0.061	**N/A**
3.2	10.5	145	6	56.8	29.9	2	6.96	3.58	Clay-Like	77			145	1.65	2.4	33.2	0.99	0.354	1.1	0.063	0.060	**N/A**
3.3	10.8	136	5	58.6	30.7	1	6.20	3.58	Clay-Like	77			136	1.66	2.2	33.0	0.99	0.355	1.1	0.063	0.059	**N/A**
3.4	11.2	146	5	60.4	31.5	2	5.60	3.55	Clay-Like	75			146	1.61	2.3	33.2	0.99	0.356	1.1	0.063	0.059	**N/A**
3.5	11.5	175	6	62.2	32.3	2	5.08	3.47	Clay-Like	71			175	1.51	2.6	33.6	0.99	0.357	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	176	6	64.0	33.2	2	5.04	3.48	Clay-Like	72			176	1.50	2.6	33.6	0.99	0.358	1.1	0.064	0.060	**N/A**
3.7	12.1	173	5	65.8	34.0	2	4.81	3.48	Clay-Like	72			173	1.49	2.6	33.5	0.98	0.359	1.1	0.064	0.059	**N/A**
3.8	12.5	164	5	67.6	34.8	2	5.36	3.54	Clay-Like	75			164	1.50	2.4	33.3	0.98	0.360	1.1	0.064	0.059	**N/A**
3.9	12.8	153	5	69.4	35.7	1	5.95	3.59	Clay-Like	78			153	1.51	2.3	33.1	0.98	0.361	1.1	0.063	0.059	**N/A**
4.0	13.1	143	4	71.2	36.5	1	6.00	3.62	Clay-Like	79			143	1.53	2.2	32.9	0.98	0.362	1.1	0.063	0.059	**N/A**
4.1	13.5	172	5	73.0	37.3	2	4.62	3.5	Clay-Like	73			172	1.44	2.5	33.4	0.98	0.362	1.1	0.064	0.059	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-57**

Test Boring Information:

Approx. ground elevation		1.5	ft	0.46 m
Approx. water table elevation		0.5	ft	0.15 m
Approx. depth to ground water table		1	ft	0.30 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	416	5	1.6	1.6	33	1.22	1.7	Unsaturated	11			416	1.70	7.0	16.8	1.00	0.189	1.1	0.054	0.052	**N/A**
0.2	0.7	646	7	3.1	3.1	36	1.09	1.74	Unsaturated	12			646	1.70	10.9	23.0	1.00	0.189	1.1	0.057	0.055	**N/A**
0.3	1.0	794	9	4.7	4.7	36	1.09	1.81	Unsaturated	13			794	1.70	13.4	29.3	1.00	0.189	1.1	0.061	0.059	**N/A**
0.4	1.3	1217	12	6.5	5.6	51	0.97	1.73		12			1217	1.70	20.5	33.2	1.00	0.220	1.1	0.064	0.061	**0.28**
0.5	1.6	969	12	8.3	6.4	38	1.30	1.96		16			969	1.70	16.3	39.5	1.00	0.245	1.1	0.068	0.066	**0.27**
0.6	2.0	834	11	10.1	7.2	30	1.33	2.07		19			834	1.70	14.0	40.5	1.00	0.264	1.1	0.069	0.066	**0.25**
0.7	2.3	899	12	11.9	8.1	31	1.35	2.1		19			899	1.70	15.1	42.7	1.00	0.279	1.1	0.071	0.068	**0.24**
0.8	2.6	726	12	13.7	8.9	24	1.73	2.29		24			726	1.70	12.2	43.0	1.00	0.292	1.1	0.071	0.069	**0.24**
0.9	3.0	414	9	15.6	9.7	13	2.16	2.58		33			414	1.70	7.0	38.8	1.00	0.302	1.1	0.068	0.065	**0.22**
1.0	3.3	385	7	17.4	10.5	11	1.77	2.58		33			385	1.70	6.5	38.2	1.00	0.310	1.1	0.067	0.065	**0.21**
1.1	3.6	330	5	19.2	11.4	9	1.75	2.67	Clay-Like	36			330	1.70	5.6	37.3	1.00	0.318	1.1	0.066	0.064	**N/A**
1.2	3.9	294	5	21.0	12.2	8	1.86	2.76	Clay-Like	39			294	1.70	5.0	36.8	1.00	0.324	1.1	0.066	0.064	**N/A**
1.3	4.3	284	5	22.8	13.0	7	1.79	2.79	Clay-Like	40			284	1.70	4.8	36.6	1.00	0.330	1.1	0.066	0.064	**N/A**
1.4	4.6	339	6	24.6	13.8	8	1.77	2.75	Clay-Like	39			339	1.69	5.7	37.7	1.00	0.334	1.1	0.067	0.064	**N/A**
1.5	4.9	346	5	26.4	14.7	8	1.62	2.75	Clay-Like	39			346	1.66	5.7	37.7	1.00	0.339	1.1	0.067	0.064	**N/A**
1.6	5.2	250	4	28.2	15.5	6	1.94	2.93	Clay-Like	46			250	1.65	4.1	35.8	1.00	0.342	1.1	0.065	0.063	**N/A**
1.7	5.6	219	4	30.0	16.3	5	2.28	3.03	Clay-Like	50			219	1.70	3.7	35.3	1.00	0.346	1.1	0.065	0.063	**N/A**
1.8	5.9	212	4	31.8	17.2	4	2.39	3.08	Clay-Like	52			212	1.70	3.6	35.1	1.00	0.349	1.1	0.065	0.062	**N/A**
1.9	6.2	201	4	33.6	18.0	4	2.40	3.12	Clay-Like	54			201	1.70	3.4	34.9	1.00	0.351	1.1	0.065	0.062	**N/A**
2.0	6.6	148	3	35.4	18.8	3	3.07	3.32	Clay-Like	63			148	1.70	2.5	33.6	1.00	0.354	1.1	0.064	0.061	**N/A**
2.1	6.9	149	3	37.2	19.6	3	2.82	3.31	Clay-Like	63			149	1.70	2.5	33.6	0.99	0.356	1.1	0.064	0.061	**N/A**
2.2	7.2	252	4	39.1	20.5	5	1.80	3	Clay-Like	49			252	1.53	3.8	35.5	0.99	0.358	1.1	0.065	0.063	**N/A**
2.3	7.5	1125	9	40.9	21.3	23	0.81	2.25		23			1125	1.51	16.8	48.3	0.99	0.360	1.1	0.076	0.073	**0.20**
2.4	7.9	1320	16	42.7	22.1	27	1.24	2.3		24			1320	1.49	19.5	52.8	0.99	0.361	1.1	0.080	0.077	**0.21**
2.5	8.2	690	14	44.5	22.9	13	2.11	2.68	Clay-Like	36			690	1.48	10.1	43.5	0.99	0.363	1.1	0.071	0.069	**N/A**
2.6	8.5	253	8	46.3	23.8	4	3.89	3.23	Clay-Like	59			253	1.47	3.7	35.2	0.99	0.364	1.1	0.065	0.062	**N/A**
2.7	8.9	142	7	48.1	24.6	2	7.12	3.62	Clay-Like	79			142	1.70	2.4	33.2	0.99	0.365	1.1	0.063	0.060	**N/A**
2.8	9.2	108	6	49.9	25.4	1	10.49	3.8	Clay-Like	90			108	1.70	1.8	32.2	0.99	0.367	1.1	0.063	0.060	**N/A**
2.9	9.5	119	7	51.7	26.2	1	10.35	3.74	Clay-Like	86			119	1.70	2.0	32.5	0.99	0.368	1.1	0.063	0.060	**N/A**
3.0	9.8	148	8	53.5	27.1	2	8.04	3.59	Clay-Like	78			148	1.70	2.5	33.3	0.99	0.369	1.1	0.064	0.060	**N/A**
3.1	10.2	158	7	55.3	27.9	2	7.29	3.54	Clay-Like	75			158	1.65	2.6	33.5	0.99	0.370	1.1	0.064	0.060	**N/A**
3.2	10.5	135	7	57.1	28.7	1	9.37	3.66	Clay-Like	82			135	1.70	2.3	33.0	0.99	0.370	1.1	0.063	0.060	**N/A**
3.3	10.8	127	8	58.9	29.6	1	11.60	3.73	Clay-Like	86			127	1.70	2.1	32.7	0.99	0.371	1.1	0.063	0.059	**N/A**
3.4	11.2	132	7	60.7	30.4	1	10.07	3.68	Clay-Like	83			132	1.68	2.2	32.9	0.99	0.372	1.1	0.063	0.059	**N/A**
3.5	11.5	123	7	62.6	31.2	1	11.10	3.73	Clay-Like	86			123	1.70	2.1	32.6	0.99	0.373	1.1	0.063	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	128	7	64.4	32.0	1	10.76	3.71	Clay-Like	85			128	1.66	2.1	32.7	0.99	0.373	1.1	0.063	0.059	**N/A**
3.7	12.1	126	7	66.2	32.9	1	11.92	3.74	Clay-Like	86			126	1.65	2.1	32.6	0.98	0.374	1.1	0.063	0.059	**N/A**
3.8	12.5	171	8	68.0	33.7	2	7.83	3.54	Clay-Like	75			171	1.50	2.5	33.4	0.98	0.374	1.1	0.064	0.059	**N/A**
3.9	12.8	229	8	69.8	34.5	3	5.16	3.35	Clay-Like	65			229	1.37	3.1	34.4	0.98	0.375	1.1	0.064	0.060	**N/A**
4.0	13.1	196	8	71.6	35.3	2	6.53	3.47	Clay-Like	71			196	1.42	2.8	33.8	0.98	0.375	1.1	0.064	0.060	**N/A**
4.1	13.5	199	8	73.4	36.2	2	6.48	3.46	Clay-Like	71			199	1.40	2.8	33.8	0.98	0.376	1.1	0.064	0.059	**N/A**
4.2	13.8	196	8	75.2	37.0	2	6.72	3.48	Clay-Like	72			196	1.40	2.7	33.7	0.98	0.376	1.1	0.064	0.059	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-58**

Test Boring Information:

Approx. ground elevation		1	ft	0.30 m
Approx. water table elevation		0	ft	0.00 m
Approx. depth to ground water table		1	ft	0.30 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	277	6	1.6	1.6	22	2.26	2.03	Unsaturated	18			277	1.70	4.7	27.5	1.00	0.189	1.1	0.060	0.058	**N/A**
0.2	0.7	235	6	3.1	3.1	13	2.40	2.29	Unsaturated	24			235	1.70	4.0	32.2	1.00	0.189	1.1	0.063	0.060	**N/A**
0.3	1.0	181	4	4.7	4.7	8	2.18	2.47	Unsaturated	29			181	1.70	3.0	32.9	1.00	0.189	1.1	0.063	0.061	**N/A**
0.4	1.3	104	2	6.5	5.6	4	2.46	2.76	Clay-Like	39			104	1.70	1.7	32.4	1.00	0.220	1.1	0.063	0.061	**N/A**
0.5	1.6	122	2	8.3	6.4	4	1.60	2.69	Clay-Like	37			122	1.70	2.1	32.7	1.00	0.245	1.1	0.063	0.061	**N/A**
0.6	2.0	299	3	10.1	7.2	11	1.03	2.33		25			299	1.70	5.0	34.1	1.00	0.264	1.1	0.064	0.062	**0.23**
0.7	2.3	838	6	11.9	8.1	29	0.68	1.93		15			838	1.70	14.1	35.6	1.00	0.279	1.1	0.065	0.063	**0.22**
0.8	2.6	885	10	13.7	8.9	29	1.12	2.09		19			885	1.70	14.9	42.2	1.00	0.292	1.1	0.070	0.068	**0.23**
0.9	3.0	673	9	15.6	9.7	21	1.44	2.29		24			673	1.70	11.3	41.9	1.00	0.302	1.1	0.070	0.068	**0.22**
1.0	3.3	504	7	17.4	10.5	15	1.47	2.44		28			504	1.70	8.5	39.9	1.00	0.310	1.1	0.069	0.066	**0.21**
1.1	3.6	332	5	19.2	11.4	9	1.71	2.66	Clay-Like	36			332	1.70	5.6	37.3	1.00	0.318	1.1	0.066	0.064	**N/A**
1.2	3.9	314	6	21.0	12.2	8	2.13	2.77	Clay-Like	40			314	1.70	5.3	37.2	1.00	0.324	1.1	0.066	0.064	**N/A**
1.3	4.3	283	5	22.8	13.0	7	1.80	2.8	Clay-Like	41			283	1.70	4.8	36.6	1.00	0.330	1.1	0.066	0.064	**N/A**
1.4	4.6	321	5	24.6	13.8	8	1.65	2.76	Clay-Like	39			321	1.69	5.4	37.3	1.00	0.334	1.1	0.066	0.064	**N/A**
1.5	4.9	299	5	26.4	14.7	7	1.86	2.85	Clay-Like	43			299	1.66	4.9	36.9	1.00	0.339	1.1	0.066	0.064	**N/A**
1.6	5.2	144	5	28.2	15.5	3	4.30	3.32	Clay-Like	63			144	1.70	2.4	33.5	1.00	0.342	1.1	0.064	0.061	**N/A**
1.7	5.6	149	5	30.0	16.3	3	3.79	3.29	Clay-Like	62			149	1.70	2.5	33.6	1.00	0.346	1.1	0.064	0.061	**N/A**
1.8	5.9	137	4	31.8	17.2	3	3.65	3.32	Clay-Like	63			137	1.70	2.3	33.3	1.00	0.349	1.1	0.064	0.061	**N/A**
1.9	6.2	125	4	33.6	18.0	2	4.31	3.41	Clay-Like	68			125	1.70	2.1	33.0	1.00	0.351	1.1	0.063	0.061	**N/A**
2.0	6.6	138	4	35.4	18.8	2	3.72	3.35	Clay-Like	65			138	1.70	2.3	33.3	1.00	0.354	1.1	0.064	0.061	**N/A**
2.1	6.9	135	4	37.2	19.6	2	3.93	3.38	Clay-Like	66			135	1.70	2.3	33.2	0.99	0.356	1.1	0.063	0.061	**N/A**
2.2	7.2	154	4	39.1	20.5	3	3.66	3.33	Clay-Like	64			154	1.70	2.6	33.7	0.99	0.358	1.1	0.064	0.061	**N/A**
2.3	7.5	148	5	40.9	21.3	2	4.30	3.39	Clay-Like	67			148	1.70	2.5	33.5	0.99	0.360	1.1	0.064	0.061	**N/A**
2.4	7.9	146	5	42.7	22.1	2	4.55	3.42	Clay-Like	68			146	1.70	2.5	33.4	0.99	0.361	1.1	0.064	0.061	**N/A**
2.5	8.2	151	5	44.5	22.9	2	4.21	3.39	Clay-Like	67			151	1.70	2.5	33.6	0.99	0.363	1.1	0.064	0.061	**N/A**
2.6	8.5	153	5	46.3	23.8	2	4.21	3.39	Clay-Like	67			153	1.70	2.6	33.6	0.99	0.364	1.1	0.064	0.061	**N/A**
2.7	8.9	164	5	48.1	24.6	2	3.96	3.35	Clay-Like	65			164	1.70	2.8	33.9	0.99	0.365	1.1	0.064	0.061	**N/A**
2.8	9.2	192	5	49.9	25.4	3	3.44	3.28	Clay-Like	61			192	1.60	3.0	34.3	0.99	0.367	1.1	0.064	0.061	**N/A**
2.9	9.5	189	5	51.7	26.2	3	3.77	3.32	Clay-Like	63			189	1.59	3.0	34.2	0.99	0.368	1.1	0.064	0.061	**N/A**
3.0	9.8	159	5	53.5	27.1	2	4.28	3.43	Clay-Like	69			159	1.67	2.6	33.7	0.99	0.369	1.1	0.064	0.060	**N/A**
3.1	10.2	155	4	55.3	27.9	2	3.55	3.4	Clay-Like	67			155	1.66	2.6	33.6	0.99	0.370	1.1	0.064	0.060	**N/A**
3.2	10.5	217	4	57.1	28.7	3	2.46	3.2	Clay-Like	58			217	1.47	3.2	34.5	0.99	0.370	1.1	0.064	0.061	**N/A**
3.3	10.8	215	4	58.9	29.6	3	2.46	3.22	Clay-Like	59			215	1.46	3.1	34.5	0.99	0.371	1.1	0.064	0.061	**N/A**
3.4	11.2	176	4	60.7	30.4	2	3.65	3.38	Clay-Like	66			176	1.55	2.7	33.8	0.99	0.372	1.1	0.064	0.060	**N/A**
3.5	11.5	168	4	62.6	31.2	2	3.73	3.43	Clay-Like	69			168	1.55	2.6	33.6	0.99	0.373	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	151	3	64.4	32.0	2	3.41	3.45	Clay-Like	70			151	1.58	2.4	33.3	0.99	0.373	1.1	0.064	0.060	**N/A**
3.7	12.1	151	3	66.2	32.9	1	3.48	3.47	Clay-Like	71			151	1.57	2.4	33.3	0.98	0.374	1.1	0.064	0.059	**N/A**
3.8	12.5	149	3	68.0	33.7	1	4.04	3.51	Clay-Like	73			149	1.56	2.3	33.1	0.98	0.374	1.1	0.063	0.059	**N/A**
3.9	12.8	151	3	69.8	34.5	1	3.52	3.49	Clay-Like	72			151	1.54	2.3	33.2	0.98	0.375	1.1	0.063	0.059	**N/A**
4.0	13.1	159	3	71.6	35.3	1	3.08	3.44	Clay-Like	70			159	1.50	2.4	33.3	0.98	0.375	1.1	0.064	0.059	**N/A**
4.1	13.5	180	3	73.4	36.2	2	2.52	3.35	Clay-Like	65			180	1.44	2.6	33.7	0.98	0.376	1.1	0.064	0.059	**N/A**
4.2	13.8	183	3	75.2	37.0	2	3.03	3.39	Clay-Like	67			183	1.43	2.6	33.6	0.98	0.376	1.1	0.064	0.059	**N/A**
4.3	14.1	201	4	77.0	37.8	2	3.01	3.36	Clay-Like	65			201	1.38	2.7	33.9	0.98	0.376	1.1	0.064	0.059	**N/A**
4.4	14.4	206	4	78.8	38.7	2	3.08	3.36	Clay-Like	65			206	1.36	2.8	33.9	0.98	0.377	1.1	0.064	0.059	**N/A**
4.5	14.8	179	3	80.6	39.5	2	3.51	3.46	Clay-Like	71			179	1.40	2.5	33.4	0.98	0.377	1.1	0.064	0.059	**N/A**
4.6	15.1	199	4	82.4	40.3	2	3.12	3.4	Clay-Like	67			199	1.36	2.7	33.7	0.98	0.377	1.1	0.064	0.059	**N/A**
4.7	15.4	203	4	84.2	41.1	2	3.31	3.41	Clay-Like	68			203	1.34	2.7	33.8	0.98	0.377	1.1	0.064	0.059	**N/A**
4.8	15.7	213	4	86.1	42.0	2	2.95	3.37	Clay-Like	66			213	1.32	2.8	33.9	0.98	0.378	1.1	0.064	0.059	**N/A**
4.9	16.1	213	4	87.9	42.8	2	3.53	3.41	Clay-Like	68			213	1.31	2.8	33.9	0.98	0.378	1.1	0.064	0.059	**N/A**
5.0	16.4	206	4	89.7	43.6	2	3.61	3.43	Clay-Like	69			206	1.31	2.7	33.7	0.98	0.378	1.1	0.064	0.059	**N/A**
5.1	16.7	211	4	91.5	44.4	2	3.37	3.42	Clay-Like	68			211	1.30	2.7	33.8	0.97	0.378	1.1	0.064	0.059	**N/A**
5.2	17.1	212	4	93.3	45.3	2	3.47	3.43	Clay-Like	69			212	1.29	2.7	33.8	0.97	0.378	1.0	0.064	0.059	**N/A**
5.3	17.4	208	4	95.1	46.1	2	3.64	3.46	Clay-Like	71			208	1.28	2.6	33.7	0.97	0.378	1.0	0.064	0.059	**N/A**
5.4	17.7	204	4	96.9	46.9	2	3.68	3.48	Clay-Like	72			204	1.28	2.6	33.6	0.97	0.379	1.0	0.064	0.058	**N/A**
5.5	18.0	206	4	98.7	47.7	2	3.50	3.47	Clay-Like	71			206	1.27	2.6	33.6	0.97	0.379	1.0	0.064	0.058	**N/A**
5.6	18.4	210	4	100.5	48.6	2	3.41	3.46	Clay-Like	71			210	1.26	2.6	33.6	0.97	0.379	1.0	0.064	0.058	**N/A**
5.7	18.7	221	3	102.3	49.4	2	2.90	3.41	Clay-Like	68			221	1.24	2.7	33.8	0.97	0.379	1.0	0.064	0.058	**N/A**
5.8	19.0	244	3	104.1	50.2	2	2.40	3.33	Clay-Like	64			244	1.21	2.9	34.2	0.97	0.379	1.0	0.064	0.059	**N/A**
5.9	19.4	234	5	105.9	51.1	2	3.67	3.45	Clay-Like	70			234	1.22	2.8	33.9	0.97	0.379	1.0	0.064	0.058	**N/A**
6.0	19.7	254	4	107.7	51.9	2	2.94	3.37	Clay-Like	66			254	1.19	3.0	34.2	0.97	0.379	1.0	0.064	0.059	**N/A**
6.1	20.0	255	4	109.6	52.7	2	2.57	3.34	Clay-Like	64			255	1.19	3.0	34.2	0.97	0.379	1.0	0.064	0.058	**N/A**
6.2	20.3	271	4	111.4	53.5	2	2.53	3.33	Clay-Like	64			271	1.18	3.2	34.5	0.97	0.379	1.0	0.064	0.059	**N/A**
6.3	20.7	272	5	113.2	54.4	2	2.95	3.36	Clay-Like	65			272	1.18	3.2	34.5	0.97	0.379	1.0	0.064	0.059	**N/A**
6.4	21.0	269	4	115.0	55.2	2	2.80	3.36	Clay-Like	65			269	1.17	3.1	34.4	0.96	0.379	1.0	0.064	0.058	**N/A**
6.5	21.3	258	4	116.8	56.0	2	2.85	3.39	Clay-Like	67			258	1.17	3.0	34.2	0.96	0.379	1.0	0.064	0.058	**N/A**
6.6	21.7	260	5	118.6	56.8	2	3.33	3.43	Clay-Like	69			260	1.16	3.0	34.2	0.96	0.379	1.0	0.064	0.058	**N/A**
6.7	22.0	267	5	120.4	57.7	2	3.40	3.42	Clay-Like	68			267	1.16	3.1	34.3	0.96	0.378	1.0	0.064	0.058	**N/A**
6.8	22.3	272	5	122.2	58.5	2	3.19	3.41	Clay-Like	68			272	1.15	3.1	34.3	0.96	0.378	1.0	0.064	0.058	**N/A**
6.9	22.6	266	4	124.0	59.3	2	3.03	3.41	Clay-Like	68			266	1.15	3.0	34.2	0.96	0.378	1.0	0.064	0.058	**N/A**
7.0	23.0	266	4	125.8	60.1	2	2.87	3.41	Clay-Like	68			266	1.15	3.0	34.2	0.96	0.378	1.0	0.064	0.058	**N/A**
7.1	23.3	250	4	127.6	61.0	2	3.06	3.46	Clay-Like	71			250	1.15	2.8	33.9	0.96	0.378	1.0	0.064	0.058	**N/A**
7.2	23.6	249	4	129.4	61.8	2	3.59	3.49	Clay-Like	72			249	1.14	2.8	33.9	0.96	0.378	1.0	0.064	0.058	**N/A**
7.3	24.0	274	5	131.3	62.6	2	3.28	3.44	Clay-Like	70			274	1.13	3.1	34.3	0.96	0.378	1.0	0.064	0.058	**N/A**
7.4	24.3	271	4	133.1	63.5	2	3.06	3.44	Clay-Like	70			271	1.13	3.0	34.2	0.96	0.378	1.0	0.064	0.058	**N/A**
7.5	24.6	271	4	134.9	64.3	2	2.82	3.42	Clay-Like	68			271	1.13	3.0	34.2	0.95	0.378	1.0	0.064	0.058	**N/A**
7.6	24.9	282	4	136.7	65.1	2	2.91	3.42	Clay-Like	68			282	1.12	3.1	34.4	0.95	0.377	1.0	0.064	0.058	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-59**

Test Boring Information:

Approx. ground elevation		1	ft	0.30 m
Approx. water table elevation		0	ft	0.00 m
Approx. depth to ground water table		1	ft	0.30 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	428	3	1.6	1.6	34	0.76	1.54	Unsaturated	9			428	1.70	7.2	10.5	1.00	0.189	1.1	0.052	0.050	**N/A**
0.2	0.7	302	2	3.1	3.1	17	0.64	1.85	Unsaturated	14			302	1.70	5.1	21.4	1.00	0.189	1.1	0.056	0.054	**N/A**
0.3	1.0	201	1	4.7	4.7	9	0.29	2.01	Unsaturated	17			201	1.70	3.4	25.3	1.00	0.189	1.1	0.058	0.056	**N/A**
0.4	1.3	128	1	6.5	5.6	5	0.63	2.44		28			128	1.70	2.2	31.5	1.00	0.220	1.1	0.062	0.060	**0.27**
0.5	1.6	116	1	8.3	6.4	4	1.06	2.67	Clay-Like	36			116	1.70	2.0	32.5	1.00	0.245	1.1	0.063	0.061	**N/A**
0.6	2.0	103	1	10.1	7.2	3	1.55	2.85	Clay-Like	43			103	1.70	1.7	32.5	1.00	0.264	1.1	0.063	0.061	**N/A**
0.7	2.3	120	2	11.9	8.1	4	1.42	2.83	Clay-Like	42			120	1.70	2.0	32.9	1.00	0.279	1.1	0.063	0.061	**N/A**
0.8	2.6	143	1	13.7	8.9	4	0.67	2.68	Clay-Like	36			143	1.70	2.4	33.1	1.00	0.292	1.1	0.063	0.061	**N/A**
0.9	3.0	228	2	15.6	9.7	7	0.81	2.56		32			228	1.70	3.8	34.5	1.00	0.302	1.1	0.064	0.062	**0.21**
1.0	3.3	320	4	17.4	10.5	9	1.30	2.57		33			320	1.70	5.4	36.7	1.00	0.310	1.1	0.066	0.064	**0.20**
1.1	3.6	173	4	19.2	11.4	5	2.55	2.99	Clay-Like	48			173	1.70	2.9	34.3	1.00	0.318	1.1	0.064	0.062	**N/A**
1.2	3.9	116	3	21.0	12.2	3	3.51	3.23	Clay-Like	59			116	1.70	2.0	32.9	1.00	0.324	1.1	0.063	0.061	**N/A**
1.3	4.3	118	3	22.8	13.0	3	3.31	3.24	Clay-Like	60			118	1.70	2.0	32.9	1.00	0.330	1.1	0.063	0.061	**N/A**
1.4	4.6	119	2	24.6	13.8	3	2.63	3.22	Clay-Like	59			119	1.70	2.0	33.0	1.00	0.334	1.1	0.063	0.061	**N/A**
1.5	4.9	145	3	26.4	14.7	3	2.18	3.13	Clay-Like	54			145	1.70	2.4	33.6	1.00	0.339	1.1	0.064	0.061	**N/A**
1.6	5.2	147	2	28.2	15.5	3	2.02	3.12	Clay-Like	54			147	1.70	2.5	33.6	1.00	0.342	1.1	0.064	0.061	**N/A**
1.7	5.6	139	2	30.0	16.3	3	2.11	3.16	Clay-Like	56			139	1.70	2.3	33.5	1.00	0.346	1.1	0.064	0.061	**N/A**
1.8	5.9	127	2	31.8	17.2	2	2.10	3.22	Clay-Like	59			127	1.70	2.1	33.2	1.00	0.349	1.1	0.063	0.061	**N/A**
1.9	6.2	115	2	33.6	18.0	2	2.36	3.29	Clay-Like	62			115	1.70	1.9	32.8	1.00	0.351	1.1	0.063	0.061	**N/A**
2.0	6.6	153	2	35.4	18.8	3	2.11	3.16	Clay-Like	56			153	1.70	2.6	33.8	1.00	0.354	1.1	0.064	0.062	**N/A**
2.1	6.9	142	2	37.2	19.6	2	2.28	3.23	Clay-Like	59			142	1.70	2.4	33.5	0.99	0.356	1.1	0.064	0.061	**N/A**
2.2	7.2	95	1	39.1	20.5	1	1.87	3.36	Clay-Like	65			95	1.70	1.6	32.3	0.99	0.358	1.1	0.063	0.060	**N/A**
2.3	7.5	91	1	40.9	21.3	1	2.11	3.41	Clay-Like	68			91	1.70	1.5	32.2	0.99	0.360	1.1	0.063	0.060	**N/A**
2.4	7.9	129	2	42.7	22.1	2	2.21	3.29	Clay-Like	62			129	1.70	2.2	33.2	0.99	0.361	1.1	0.063	0.061	**N/A**
2.5	8.2	125	2	44.5	22.9	2	2.98	3.38	Clay-Like	66			125	1.70	2.1	33.0	0.99	0.363	1.1	0.063	0.060	**N/A**
2.6	8.5	134	3	46.3	23.8	2	3.06	3.35	Clay-Like	65			134	1.70	2.3	33.2	0.99	0.364	1.1	0.063	0.060	**N/A**
2.7	8.9	183	4	48.1	24.6	3	2.99	3.24	Clay-Like	60			183	1.65	3.0	34.3	0.99	0.365	1.1	0.064	0.061	**N/A**
2.8	9.2	186	4	49.9	25.4	3	2.88	3.24	Clay-Like	60			186	1.62	3.0	34.3	0.99	0.367	1.1	0.064	0.061	**N/A**
2.9	9.5	172	3	51.7	26.2	2	2.80	3.27	Clay-Like	61			172	1.65	2.8	34.0	0.99	0.368	1.1	0.064	0.061	**N/A**
3.0	9.8	134	2	53.5	27.1	2	2.26	3.33	Clay-Like	64			134	1.70	2.3	33.2	0.99	0.369	1.1	0.063	0.060	**N/A**
3.1	10.2	102	2	55.3	27.9	1	3.30	3.52	Clay-Like	74			102	1.70	1.7	32.4	0.99	0.370	1.1	0.063	0.059	**N/A**
3.2	10.5	110	2	57.1	28.7	1	3.44	3.53	Clay-Like	74			110	1.70	1.9	32.5	0.99	0.370	1.1	0.063	0.059	**N/A**
3.3	10.8	113	2	58.9	29.6	1	3.20	3.5	Clay-Like	73			113	1.70	1.9	32.6	0.99	0.371	1.1	0.063	0.059	**N/A**
3.4	11.2	115	1	60.7	30.4	1	2.67	3.46	Clay-Like	71			115	1.70	1.9	32.7	0.99	0.372	1.1	0.063	0.059	**N/A**
3.5	11.5	138	2	62.6	31.2	1	2.42	3.38	Clay-Like	66			138	1.65	2.2	33.2	0.99	0.373	1.1	0.063	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	151	2	64.4	32.0	2	2.42	3.34	Clay-Like	64			151	1.59	2.4	33.4	0.99	0.373	1.1	0.064	0.060	**N/A**
3.7	12.1	155	3	66.2	32.9	2	3.23	3.41	Clay-Like	68			155	1.56	2.4	33.4	0.98	0.374	1.1	0.064	0.059	**N/A**
3.8	12.5	170	3	68.0	33.7	2	2.54	3.33	Clay-Like	64			170	1.50	2.5	33.6	0.98	0.374	1.1	0.064	0.060	**N/A**
3.9	12.8	188	2	69.8	34.5	2	2.03	3.25	Clay-Like	60			188	1.45	2.7	33.9	0.98	0.375	1.1	0.064	0.060	**N/A**
4.0	13.1	204	2	71.6	35.3	2	1.23	3.14	Clay-Like	55			204	1.41	2.8	34.1	0.98	0.375	1.1	0.064	0.060	**N/A**

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-60**

Test Boring Information:

Approx. ground elevation		1.3 ft	0.40 m
Approx. water table elevation		0 ft	0.00 m
Approx. depth to ground water table		1.3 ft	0.40 m
Moist unit weight of soil	γ_m	100 pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	207	2	1.6	1.6	16	0.98	1.84	Unsaturated	14			207	1.70	3.5	19.1	1.00	0.189	1.1	0.055	0.053	**N/A**
0.2	0.7	147	1	3.1	3.1	8	0.80	2.16	Unsaturated	21			147	1.70	2.5	28.0	1.00	0.189	1.1	0.060	0.058	**N/A**
0.3	1.0	105	1	4.7	4.7	5	1.05	2.46	Unsaturated	29			105	1.70	1.8	31.1	1.00	0.189	1.1	0.062	0.060	**N/A**
0.4	1.3	92	2	6.3	6.3	3	1.79	2.7	Clay-Like	37			92	1.70	1.5	32.0	1.00	0.190	1.1	0.063	0.060	**N/A**
0.5	1.6	378	4	8.1	7.1	14	1.09	2.18		21			378	1.70	6.4	33.4	1.00	0.216	1.1	0.064	0.061	**0.28**
0.6	2.0	376	5	9.9	7.9	13	1.39	2.32		25			376	1.70	6.3	35.7	1.00	0.236	1.1	0.065	0.063	**0.27**
0.7	2.3	143	3	11.7	8.7	4	2.55	2.89	Clay-Like	44			143	1.70	2.4	33.5	1.00	0.253	1.1	0.064	0.061	**N/A**
0.8	2.6	98	1	13.5	9.6	3	1.24	2.91	Clay-Like	45			98	1.70	1.7	32.5	1.00	0.267	1.1	0.063	0.061	**N/A**
0.9	3.0	62	0	15.3	10.4	1	0.20	2.92	Clay-Like	45			62	1.70	1.0	31.7	1.00	0.278	1.1	0.062	0.060	**N/A**
1.0	3.3	70	0	17.1	11.2	2	0.18	2.9	Clay-Like	45			70	1.70	1.2	31.8	1.00	0.288	1.1	0.063	0.060	**N/A**
1.1	3.6	82	1	19.0	12.0	2	1.22	3.08	Clay-Like	52			82	1.70	1.4	32.2	1.00	0.296	1.1	0.063	0.060	**N/A**
1.2	3.9	354	1	20.8	12.9	9	0.23	2.27		24			354	1.70	6.0	34.5	1.00	0.304	1.1	0.064	0.062	**0.20**
1.3	4.3	657	6	22.6	13.7	17	0.91	2.29		24			657	1.69	11.0	41.4	1.00	0.310	1.1	0.070	0.067	**0.22**
1.4	4.6	192	7	24.4	14.5	4	4.41	3.14	Clay-Like	55			192	1.70	3.2	34.7	1.00	0.316	1.1	0.065	0.062	**N/A**
1.5	4.9	61	5	26.2	15.4	1	13.39	3.81	Clay-Like	91			61	1.70	1.0	31.1	1.00	0.321	1.1	0.062	0.060	**N/A**
1.6	5.2	66	5	28.0	16.2	1	11.85	3.78	Clay-Like	89			66	1.70	1.1	31.3	1.00	0.325	1.1	0.062	0.060	**N/A**
1.7	5.6	47	2	29.8	17.0	0	9.05	3.85	Clay-Like	93			47	1.70	0.8	30.8	1.00	0.329	1.1	0.062	0.060	**N/A**
1.8	5.9	72	0	31.6	17.8	1	0.24	3.11	Clay-Like	53			72	1.70	1.2	31.9	1.00	0.333	1.1	0.063	0.060	**N/A**
1.9	6.2	108	1	33.4	18.7	2	1.15	3.09	Clay-Like	53			108	1.70	1.8	32.8	1.00	0.336	1.1	0.063	0.061	**N/A**
2.0	6.6	85	2	35.2	19.5	1	3.82	3.39	Clay-Like	67			85	1.70	1.4	32.1	1.00	0.339	1.1	0.063	0.060	**N/A**
2.1	6.9	93	1	37.0	20.3	1	2.58	3.3	Clay-Like	62			93	1.70	1.6	32.3	0.99	0.342	1.1	0.063	0.060	**N/A**
2.2	7.2	92	2	38.8	21.1	1	3.08	3.34	Clay-Like	64			92	1.70	1.5	32.3	0.99	0.344	1.1	0.063	0.060	**N/A**
2.3	7.5	95	2	40.6	22.0	1	3.32	3.35	Clay-Like	65			95	1.70	1.6	32.4	0.99	0.347	1.1	0.063	0.060	**N/A**
2.4	7.9	119	2	42.5	22.8	2	2.49	3.23	Clay-Like	59			119	1.70	2.0	33.0	0.99	0.349	1.1	0.063	0.060	**N/A**
2.5	8.2	229	4	44.3	23.6	4	2.02	2.97	Clay-Like	47			229	1.53	3.5	35.0	0.99	0.351	1.1	0.065	0.062	**N/A**
2.6	8.5	252	4	46.1	24.5	4	2.04	2.94	Clay-Like	46			252	1.46	3.6	35.2	0.99	0.352	1.1	0.065	0.062	**N/A**
2.7	8.9	183	3	47.9	25.3	3	2.12	3.08	Clay-Like	52			183	1.63	3.0	34.3	0.99	0.354	1.1	0.064	0.061	**N/A**
2.8	9.2	129	3	49.7	26.1	2	3.36	3.3	Clay-Like	62			129	1.70	2.2	33.2	0.99	0.355	1.1	0.063	0.060	**N/A**
2.9	9.5	145	4	51.5	26.9	2	3.79	3.3	Clay-Like	62			145	1.70	2.4	33.5	0.99	0.357	1.1	0.064	0.060	**N/A**
3.0	9.8	139	3	53.3	27.8	2	3.89	3.33	Clay-Like	64			139	1.70	2.3	33.4	0.99	0.358	1.1	0.064	0.060	**N/A**
3.1	10.2	149	3	55.1	28.6	2	3.55	3.29	Clay-Like	62			149	1.67	2.5	33.6	0.99	0.359	1.1	0.064	0.060	**N/A**
3.2	10.5	165	3	56.9	29.4	2	2.83	3.22	Clay-Like	59			165	1.60	2.6	33.8	0.99	0.360	1.1	0.064	0.060	**N/A**
3.3	10.8	162	3	58.7	30.2	2	2.87	3.24	Clay-Like	60			162	1.59	2.6	33.7	0.99	0.362	1.1	0.064	0.060	**N/A**
3.4	11.2	161	3	60.5	31.1	2	2.94	3.25	Clay-Like	60			161	1.57	2.5	33.7	0.99	0.362	1.1	0.064	0.060	**N/A**
3.5	11.5	180	3	62.3	31.9	2	2.85	3.22	Clay-Like	59			180	1.51	2.7	33.9	0.99	0.363	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	181	4	64.1	32.7	2	3.20	3.25	Clay-Like	60			181	1.49	2.7	33.9	0.99	0.364	1.1	0.064	0.060	**N/A**
3.7	12.1	193	4	66.0	33.5	2	2.80	3.2	Clay-Like	58			193	1.45	2.8	34.0	0.98	0.365	1.1	0.064	0.060	**N/A**
3.8	12.5	193	4	67.8	34.4	2	3.53	3.26	Clay-Like	60			193	1.44	2.8	34.0	0.98	0.366	1.1	0.064	0.060	**N/A**
3.9	12.8	200	5	69.6	35.2	2	3.75	3.28	Clay-Like	61			200	1.42	2.8	34.0	0.98	0.366	1.1	0.064	0.060	**N/A**
4.0	13.1	197	4	71.4	36.0	2	3.12	3.25	Clay-Like	60			197	1.41	2.8	34.0	0.98	0.367	1.1	0.064	0.060	**N/A**
4.1	13.5	192	4	73.2	36.9	2	3.15	3.27	Clay-Like	61			192	1.41	2.7	33.9	0.98	0.368	1.1	0.064	0.059	**N/A**
4.2	13.8	203	4	75.0	37.7	2	3.37	3.28	Clay-Like	61			203	1.38	2.8	34.0	0.98	0.368	1.1	0.064	0.059	**N/A**
4.3	14.1	194	4	76.8	38.5	2	3.36	3.31	Clay-Like	63			194	1.39	2.7	33.8	0.98	0.369	1.1	0.064	0.059	**N/A**
4.4	14.4	194	4	78.6	39.3	2	3.50	3.32	Clay-Like	63			194	1.38	2.6	33.8	0.98	0.369	1.1	0.064	0.059	**N/A**
4.5	14.8	219	5	80.4	40.2	2	3.45	3.28	Clay-Like	61			219	1.32	2.9	34.1	0.98	0.370	1.1	0.064	0.059	**N/A**
4.6	15.1	233	5	82.2	41.0	2	3.30	3.26	Clay-Like	60			233	1.30	3.0	34.3	0.98	0.370	1.1	0.064	0.059	**N/A**
4.7	15.4	247	5	84.0	41.8	2	2.88	3.21	Clay-Like	58			247	1.27	3.1	34.5	0.98	0.370	1.1	0.064	0.059	**N/A**
4.8	15.7	239	5	85.8	42.6	2	3.55	3.28	Clay-Like	61			239	1.27	3.0	34.3	0.98	0.371	1.1	0.064	0.059	**N/A**
4.9	16.1	240	5	87.6	43.5	2	3.20	3.26	Clay-Like	60			240	1.27	3.0	34.3	0.98	0.371	1.1	0.064	0.059	**N/A**
5.0	16.4	269	5	89.5	44.3	3	2.78	3.19	Clay-Like	57			269	1.24	3.3	34.8	0.98	0.371	1.1	0.065	0.059	**N/A**
5.1	16.7	264	5	91.3	45.1	3	3.16	3.24	Clay-Like	60			264	1.24	3.2	34.6	0.97	0.372	1.0	0.064	0.059	**N/A**
5.2	17.1	243	5	93.1	45.9	2	3.57	3.3	Clay-Like	62			243	1.24	3.0	34.3	0.97	0.372	1.0	0.064	0.059	**N/A**
5.3	17.4	241	5	94.9	46.8	2	3.53	3.31	Clay-Like	63			241	1.24	3.0	34.2	0.97	0.372	1.0	0.064	0.059	**N/A**
5.4	17.7	235	5	96.7	47.6	2	3.33	3.31	Clay-Like	63			235	1.24	2.9	34.1	0.97	0.372	1.0	0.064	0.059	**N/A**
5.5	18.0	234	5	98.5	48.4	2	3.33	3.32	Clay-Like	63			234	1.24	2.9	34.1	0.97	0.372	1.0	0.064	0.059	**N/A**
5.6	18.4	246	5	100.3	49.3	2	3.10	3.3	Clay-Like	62			246	1.22	3.0	34.2	0.97	0.373	1.0	0.064	0.059	**N/A**
5.7	18.7	250	5	102.1	50.1	2	3.31	3.31	Clay-Like	63			250	1.21	3.0	34.2	0.97	0.373	1.0	0.064	0.059	**N/A**
5.8	19.0	258	5	103.9	50.9	2	3.36	3.31	Clay-Like	63			258	1.20	3.1	34.3	0.97	0.373	1.0	0.064	0.059	**N/A**
5.9	19.4	271	5	105.7	51.7	2	3.14	3.28	Clay-Like	61			271	1.19	3.2	34.5	0.97	0.373	1.0	0.064	0.059	**N/A**
6.0	19.7	278	5	107.5	52.6	2	2.87	3.26	Clay-Like	60			278	1.19	3.3	34.7	0.97	0.373	1.0	0.065	0.059	**N/A**
6.1	20.0	250	6	109.3	53.4	2	4.23	3.39	Clay-Like	67			250	1.19	2.9	34.1	0.97	0.373	1.0	0.064	0.058	**N/A**
6.2	20.3	251	7	111.1	54.2	2	4.64	3.41	Clay-Like	68			251	1.18	2.9	34.1	0.97	0.373	1.0	0.064	0.058	**N/A**
6.3	20.7	271	6	113.0	55.0	2	3.56	3.33	Clay-Like	64			271	1.17	3.2	34.5	0.97	0.373	1.0	0.064	0.058	**N/A**
6.4	21.0	275	6	114.8	55.9	2	3.58	3.33	Clay-Like	64			275	1.17	3.2	34.5	0.96	0.373	1.0	0.064	0.058	**N/A**
6.5	21.3	275	6	116.6	56.7	2	3.68	3.35	Clay-Like	65			275	1.16	3.2	34.5	0.96	0.373	1.0	0.064	0.058	**N/A**
6.6	21.7	266	6	118.4	57.5	2	3.76	3.37	Clay-Like	66			266	1.16	3.1	34.3	0.96	0.373	1.0	0.064	0.058	**N/A**
6.7	22.0	259	5	120.2	58.3	2	3.94	3.39	Clay-Like	67			259	1.16	3.0	34.1	0.96	0.373	1.0	0.064	0.058	**N/A**
6.8	22.3	288	6	122.0	59.2	2	3.58	3.33	Clay-Like	64			288	1.15	3.3	34.6	0.96	0.373	1.0	0.064	0.058	**N/A**
6.9	22.6	312	7	123.8	60.0	2	3.72	3.32	Clay-Like	63			312	1.15	3.5	35.0	0.96	0.373	1.0	0.065	0.059	**N/A**
7.0	23.0	286	6	125.6	60.8	2	4.00	3.38	Clay-Like	66			286	1.14	3.2	34.5	0.96	0.373	1.0	0.064	0.058	**N/A**
7.1	23.3	272	5	127.4	61.7	2	3.76	3.39	Clay-Like	67			272	1.14	3.1	34.3	0.96	0.373	1.0	0.064	0.058	**N/A**
7.2	23.6	279	6	129.2	62.5	2	3.84	3.39	Clay-Like	67			279	1.14	3.1	34.4	0.96	0.373	1.0	0.064	0.058	**N/A**
7.3	24.0	295	6	131.0	63.3	2	3.38	3.35	Clay-Like	65			295	1.13	3.3	34.6	0.96	0.373	1.0	0.064	0.058	**N/A**
7.4	24.3	312	6	132.8	64.1	2	3.32	3.32	Clay-Like	63			312	1.13	3.5	34.9	0.96	0.373	1.0	0.065	0.058	**N/A**
7.5	24.6	312	6	134.7	65.0	2	3.51	3.34	Clay-Like	64			312	1.12	3.5	34.9	0.95	0.373	1.0	0.065	0.058	**N/A**
7.6	24.9	310	6	136.5	65.8	2	3.20	3.33	Clay-Like	64			310	1.12	3.4	34.8	0.95	0.373	1.0	0.065	0.058	**N/A**
7.7	25.262	326	6	138.3	66.6	2	3.22	3.31	Clay-Like	63			326	1.12	3.6	35.1	0.95	0.373	1.0	0.065	0.058	**N/A**
7.8	25.591	347	7	140.1	67.4	3	3.15	3.29	Clay-Like	62			347	1.11	3.8	35.4	0.95	0.373	1.0	0.065	0.058	**N/A**
7.9	25.919	349	7	141.9	68.3	2	3.24	3.3	Clay-Like	62			349	1.11	3.8	35.4	0.95	0.373	1.0	0.065	0.058	**N/A**
8	26.247	324	6	143.7	69.1	2	3.51	3.35	Clay-Like	65			324	1.11	3.5	35.0	0.95	0.372	1.0	0.065	0.058	**N/A**
8.1	26.575	315	6	145.5	69.9	2	3.74	3.38	Clay-Like	66			315	1.10	3.4	34.8	0.95	0.372	1.0	0.065	0.058	**N/A**
8.2	26.903	331	7	147.3	70.8	2	3.75	3.37	Clay-Like	66			331	1.10	3.6	35.0	0.95	0.372	1.0	0.065	0.058	**N/A**
8.3	27.231	346	7	149.1	71.6	2	3.51	3.34	Clay-Like	64			346	1.10	3.7	35.3	0.95	0.372	1.0	0.065	0.058	**N/A**
8.4	27.559	342	7	150.9	72.4	2	3.56	3.35	Clay-Like	65			342	1.09	3.7	35.2	0.95	0.372	1.0	0.065	0.058	**N/A**
8.5	27.887	346	7	152.7	73.2	2	3.57	3.35	Clay-Like	65			346	1.09	3.7	35.2	0.95	0.372	1.0	0.065	0.058	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
8.6	28.215	358	7	154.5	74.1	2	3.39	3.33	Clay-Like	64			358	1.09	3.8	35.4	0.94	0.372	1.0	0.065	0.058	**N/A**
8.7	28.543	368	7	156.3	74.9	2	3.17	3.31	Clay-Like	63			368	1.08	3.9	35.5	0.94	0.371	1.0	0.065	0.058	**N/A**
8.8	28.871	374	7	158.2	75.7	2	3.10	3.3	Clay-Like	62			374	1.08	4.0	35.6	0.94	0.371	1.0	0.065	0.058	**N/A**
8.9	29.199	379	7	160.0	76.5	2	3.11	3.3	Clay-Like	62			379	1.08	4.0	35.7	0.94	0.371	1.0	0.065	0.058	**N/A**
9	29.528	379	6	161.8	77.4	2	2.91	3.29	Clay-Like	62			379	1.07	4.0	35.7	0.94	0.371	1.0	0.065	0.058	**N/A**
9.1	29.856	459	8	163.6	78.2	3	2.73	3.2	Clay-Like	58			459	1.07	4.9	36.8	0.94	0.371	1.0	0.066	0.059	**N/A**
9.2	30.184	1271	13	165.4	79.0	12	1.13	2.62	Clay-Like	34			1271	1.07	13.4	47.7	0.94	0.370	1.0	0.075	0.067	**N/A**
9.3	30.512	1249	15	167.2	79.8	12	1.39	2.68	Clay-Like	36			1249	1.06	13.2	47.6	0.94	0.370	1.0	0.075	0.067	**N/A**
9.4	30.84	790	14	169.0	80.7	7	2.24	2.97	Clay-Like	47			790	1.06	8.3	41.5	0.94	0.370	1.0	0.070	0.062	**N/A**
9.5	31.168	1542	19	170.8	81.5	15	1.38	2.6	Clay-Like	34			1542	1.06	16.2	51.3	0.94	0.370	1.0	0.079	0.070	**N/A**
9.6	31.496	1938	44	172.6	82.3	19	2.47	2.66	Clay-Like	36			1938	1.06	20.3	57.0	0.93	0.370	1.0	0.085	0.075	**N/A**
9.7	31.824	901	33	174.4	83.2	8	4.48	3.11	Clay-Like	53			901	1.05	9.4	43.0	0.93	0.369	1.0	0.071	0.063	**N/A**
9.8	32.152	925	22	176.2	84.0	8	2.94	2.99	Clay-Like	48			925	1.05	9.6	43.3	0.93	0.369	1.0	0.071	0.063	**N/A**
9.9	32.48	649	16	178.0	84.8	5	3.31	3.16	Clay-Like	56			649	1.05	6.7	39.4	0.93	0.369	1.0	0.068	0.060	**N/A**
10	32.808	427	7	179.8	85.6	3	2.67	3.26	Clay-Like	60			427	1.04	4.4	36.2	0.93	0.369	1.0	0.066	0.058	**N/A**
10.1	33.136	404	5	181.7	86.5	2	2.20	3.24	Clay-Like	60			404	1.04	4.2	35.9	0.93	0.368	1.0	0.065	0.058	**N/A**
10.2	33.465	406	5	183.5	87.3	2	2.41	3.26	Clay-Like	60			406	1.04	4.2	35.9	0.93	0.368	1.0	0.065	0.058	**N/A**
10.3	33.793	413	6	185.3	88.1	2	2.69	3.28	Clay-Like	61			413	1.04	4.2	36.0	0.93	0.368	1.0	0.065	0.058	**N/A**
10.4	34.121	416	6	187.1	88.9	2	2.47	3.27	Clay-Like	61			416	1.03	4.3	36.0	0.93	0.368	1.0	0.065	0.058	**N/A**
10.5	34.449	435	5	188.9	89.8	3	2.03	3.22	Clay-Like	59			435	1.03	4.4	36.3	0.93	0.367	1.0	0.066	0.058	**N/A**
10.6	34.777	409	5	190.7	90.6	2	2.19	3.26	Clay-Like	60			409	1.03	4.2	35.9	0.92	0.367	1.0	0.065	0.058	**N/A**
10.7	35.105	434	5	192.5	91.4	3	1.86	3.2	Clay-Like	58			434	1.03	4.4	36.2	0.92	0.367	1.0	0.066	0.058	**N/A**
10.8	35.433	445	6	194.3	92.2	3	2.25	3.23	Clay-Like	59			445	1.02	4.5	36.4	0.92	0.366	1.0	0.066	0.058	**N/A**
10.9	35.761	440	7	196.1	93.1	3	2.82	3.29	Clay-Like	62			440	1.02	4.5	36.2	0.92	0.366	1.0	0.066	0.058	**N/A**
11	36.089	457	6	197.9	93.9	3	2.37	3.24	Clay-Like	60			457	1.02	4.6	36.5	0.92	0.366	1.0	0.066	0.058	**N/A**
11.1	36.417	633	6	199.7	94.7	4	1.37	3.01	Clay-Like	49			633	1.02	6.4	38.9	0.92	0.366	1.0	0.068	0.060	**N/A**
11.2	36.745	1689	12	201.5	95.6	15	0.80	2.51		31			1689	1.01	17.0	51.8	0.92	0.365	1.0	0.079	0.070	**0.19**
11.3	37.073	3053	23	203.3	96.4	29	0.80	2.28		24			3053	1.01	30.6	67.0	0.92	0.365	1.0	0.096	0.084	**0.23**
11.4	37.402	4539	65	205.2	97.2	44	1.50	2.29		24			4539	1.01	45.4	86.6	0.92	0.365	1.0	0.122	0.107	**0.29**
11.5	37.73	6129	67	207.0	98.0	59	1.13	2.11		20			6129	1.01	61.2	101.7	0.92	0.364	1.0	0.145	0.128	**0.35**
11.6	38.058	6626	49	208.8	98.9	64	0.76	1.99		17			6626	1.01	66.0	102.1	0.91	0.364	1.0	0.146	0.128	**0.35**
11.7	38.386	6804	146	210.6	99.7	66	2.21	2.27		24			6804	1.00	67.6	115.2	0.91	0.364	1.0	0.170	0.149	**0.41**
11.8	38.714	7983	309	212.4	100.5	77	3.98	2.41		28			7983	1.00	79.1	133.4	0.91	0.363	1.0	0.212	0.186	**0.51**
11.9	39.042	6533	358	214.2	101.3	62	5.67	2.59		33			6533	1.00	64.6	116.2	0.91	0.363	1.0	0.172	0.150	**0.41**
12	39.37	4237	255	216.0	102.2	40	6.33	2.76	Clay-Like	39			4237	1.00	41.8	86.4	0.91	0.363	1.0	0.122	0.106	**N/A**
12.1	39.698	2234	190	217.8	103.0	20	9.44	3.08	Clay-Like	52			2234	0.99	22.0	60.0	0.91	0.362	1.0	0.088	0.077	**N/A**
12.2	40.026	1537	123	219.6	103.8	13	9.36	3.19	Clay-Like	57			1537	0.99	15.1	50.7	0.91	0.362	1.0	0.078	0.068	**N/A**
12.3	40.354	1610	129	221.4	104.6	13	9.27	3.16	Clay-Like	56			1610	0.99	15.8	51.6	0.91	0.362	1.0	0.079	0.069	**N/A**
12.4	40.682	3614	197	223.2	105.5	33	5.81	2.78	Clay-Like	40			3614	0.99	35.4	77.8	0.91	0.361	1.0	0.110	0.096	**N/A**
12.5	41.011	5124	254	225.0	106.3	47	5.18	2.64	Clay-Like	35			5124	0.99	50.1	97.0	0.90	0.361	1.0	0.138	0.120	**N/A**
12.6	41.339	6601	227	226.8	107.1	61	3.57	2.45		29			6601	0.98	64.3	114.4	0.90	0.361	1.0	0.168	0.146	**0.41**
12.7	41.667	7688	160	228.7	108.0	71	2.14	2.25		23			7688	0.98	74.8	124.1	0.90	0.360	1.0	0.189	0.164	**0.45**
12.8	41.995	7311	211	230.5	108.8	67	2.98	2.37		26			7311	0.98	71.0	121.9	0.90	0.360	1.0	0.184	0.159	**0.44**
12.9	42.323	5347	325	232.3	109.6	49	6.35	2.71	Clay-Like	37			5347	0.98	51.8	99.7	0.90	0.360	1.0	0.142	0.123	**N/A**
13	42.651	10201	416	234.1	110.4	94	4.18	2.38		27			10201	0.98	98.6	158.7	0.90	0.359	1.0	0.318	0.274	**0.76**
13.1	42.979	23266	514	235.9	111.3	217	2.23	1.95		16			23266	0.97	224.5	293.4	0.90	0.359	1.0	2.000	1.701	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-61**

Test Boring Information:

Approx. ground elevation		1	ft	0.30 m
Approx. water table elevation		0	ft	0.00 m
Approx. depth to ground water table		1	ft	0.30 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	488	5	1.6	1.6	39	0.96	1.58	Unsaturated	9			488	1.70	8.2	12.9	1.00	0.189	1.1	0.053	0.051	**N/A**
0.2	0.7	919	3	3.1	3.1	51	0.36	1.3	Unsaturated	6			919	1.70	15.5	15.5	1.00	0.189	1.1	0.054	0.052	**N/A**
0.3	1.0	1276	3	4.7	4.7	58	0.26	1.27	Unsaturated	5			1276	1.70	21.5	21.5	1.00	0.189	1.1	0.056	0.054	**N/A**
0.4	1.3	1135	4	6.5	5.6	47	0.35	1.48		8			1135	1.70	19.1	21.1	1.00	0.220	1.1	0.056	0.054	**0.25**
0.5	1.6	646	5	8.3	6.4	25	0.81	1.97		16			646	1.70	10.9	33.2	1.00	0.245	1.1	0.063	0.061	**0.25**
0.6	2.0	259	5	10.1	7.2	9	1.93	2.58		33			259	1.70	4.4	35.3	1.00	0.264	1.1	0.065	0.063	**0.24**
0.7	2.3	192	2	11.9	8.1	6	1.07	2.62	Clay-Like	34			192	1.70	3.2	34.0	1.00	0.279	1.1	0.064	0.062	**N/A**
0.8	2.6	194	1	13.7	8.9	6	0.79	2.6	Clay-Like	34			194	1.70	3.3	34.0	1.00	0.292	1.1	0.064	0.062	**N/A**
0.9	3.0	222	1	15.6	9.7	7	0.70	2.57		33			222	1.70	3.7	34.4	1.00	0.302	1.1	0.064	0.062	**0.21**
1.0	3.3	204	1	17.4	10.5	6	0.72	2.66	Clay-Like	36			204	1.70	3.4	34.4	1.00	0.310	1.1	0.064	0.062	**N/A**
1.1	3.6	169	1	19.2	11.4	4	0.70	2.78	Clay-Like	40			169	1.70	2.8	33.9	1.00	0.318	1.1	0.064	0.062	**N/A**
1.2	3.9	168	1	21.0	12.2	4	0.65	2.8	Clay-Like	41			168	1.70	2.8	34.0	1.00	0.324	1.1	0.064	0.062	**N/A**
1.3	4.3	197	1	22.8	13.0	5	0.60	2.76	Clay-Like	39			197	1.70	3.3	34.5	1.00	0.330	1.1	0.064	0.062	**N/A**
1.4	4.6	170	1	24.6	13.8	4	0.79	2.89	Clay-Like	44			170	1.70	2.9	34.1	1.00	0.334	1.1	0.064	0.062	**N/A**
1.5	4.9	179	1	26.4	14.7	4	0.75	2.9	Clay-Like	45			179	1.70	3.0	34.3	1.00	0.339	1.1	0.064	0.062	**N/A**
1.6	5.2	227	2	28.2	15.5	5	1.26	2.9	Clay-Like	45			227	1.70	3.8	35.4	1.00	0.342	1.1	0.065	0.063	**N/A**
1.7	5.6	270	3	30.0	16.3	6	1.36	2.86	Clay-Like	43			270	1.62	4.3	36.1	1.00	0.346	1.1	0.066	0.063	**N/A**
1.8	5.9	235	3	31.8	17.2	5	1.27	2.91	Clay-Like	45			235	1.66	3.9	35.5	1.00	0.349	1.1	0.065	0.063	**N/A**
1.9	6.2	259	2	33.6	18.0	5	1.02	2.84	Clay-Like	42			259	1.58	4.0	35.7	1.00	0.351	1.1	0.065	0.063	**N/A**
2.0	6.6	244	2	35.4	18.8	5	0.96	2.87	Clay-Like	43			244	1.59	3.8	35.4	1.00	0.354	1.1	0.065	0.063	**N/A**
2.1	6.9	179	2	37.2	19.6	3	1.15	3.05	Clay-Like	51			179	1.70	3.0	34.4	0.99	0.356	1.1	0.064	0.062	**N/A**
2.2	7.2	151	1	39.1	20.5	2	1.28	3.14	Clay-Like	55			151	1.70	2.5	33.7	0.99	0.358	1.1	0.064	0.061	**N/A**
2.3	7.5	170	2	40.9	21.3	3	1.86	3.17	Clay-Like	56			170	1.70	2.9	34.2	0.99	0.360	1.1	0.064	0.062	**N/A**
2.4	7.9	168	4	42.7	22.1	3	3.21	3.3	Clay-Like	62			168	1.70	2.8	34.0	0.99	0.361	1.1	0.064	0.061	**N/A**
2.5	8.2	155	5	44.5	22.9	2	4.33	3.41	Clay-Like	68			155	1.70	2.6	33.7	0.99	0.363	1.1	0.064	0.061	**N/A**
2.6	8.5	145	5	46.3	23.8	2	5.05	3.49	Clay-Like	72			145	1.70	2.4	33.4	0.99	0.364	1.1	0.064	0.061	**N/A**
2.7	8.9	138	5	48.1	24.6	2	5.72	3.55	Clay-Like	75			138	1.70	2.3	33.2	0.99	0.365	1.1	0.063	0.060	**N/A**
2.8	9.2	270	8	49.9	25.4	4	3.66	3.19	Clay-Like	57			270	1.44	3.8	35.5	0.99	0.367	1.1	0.065	0.062	**N/A**
2.9	9.5	277	9	51.7	26.2	4	3.78	3.2	Clay-Like	58			277	1.43	3.9	35.6	0.99	0.368	1.1	0.065	0.062	**N/A**
3.0	9.8	169	5	53.5	27.1	2	3.90	3.43	Clay-Like	69			169	1.64	2.7	33.8	0.99	0.369	1.1	0.064	0.060	**N/A**
3.1	10.2	170	4	55.3	27.9	2	3.18	3.39	Clay-Like	67			170	1.61	2.7	33.8	0.99	0.370	1.1	0.064	0.060	**N/A**
3.2	10.5	189	5	57.1	28.7	2	4.14	3.39	Clay-Like	67			189	1.54	2.9	34.0	0.99	0.370	1.1	0.064	0.060	**N/A**
3.3	10.8	223	6	58.9	29.6	3	3.50	3.29	Clay-Like	62			223	1.45	3.2	34.5	0.99	0.371	1.1	0.064	0.061	**N/A**
3.4	11.2	257	5	60.7	30.4	4	2.59	3.18	Clay-Like	57			257	1.37	3.5	35.0	0.99	0.372	1.1	0.065	0.061	**N/A**
3.5	11.5	206	5	62.6	31.2	3	3.19	3.33	Clay-Like	64			206	1.46	3.0	34.2	0.99	0.373	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	183	5	64.4	32.0	2	3.81	3.42	Clay-Like	68			183	1.50	2.7	33.8	0.99	0.373	1.1	0.064	0.060	**N/A**
3.7	12.1	168	4	66.2	32.9	2	3.67	3.46	Clay-Like	71			168	1.52	2.5	33.5	0.98	0.374	1.1	0.064	0.060	**N/A**
3.8	12.5	145	3	68.0	33.7	1	4.10	3.57	Clay-Like	77			145	1.57	2.3	33.0	0.98	0.374	1.1	0.063	0.059	**N/A**
3.9	12.8	146	4	69.8	34.5	1	4.78	3.6	Clay-Like	78			146	1.55	2.2	33.0	0.98	0.375	1.1	0.063	0.059	**N/A**
4.0	13.1	168	4	71.6	35.3	2	3.98	3.5	Clay-Like	73			168	1.48	2.5	33.4	0.98	0.375	1.1	0.064	0.059	**N/A**
4.1	13.5	162	4	73.4	36.2	1	4.31	3.55	Clay-Like	75			162	1.48	2.4	33.2	0.98	0.376	1.1	0.063	0.059	**N/A**
4.2	13.8	160	5	75.2	37.0	1	5.33	3.61	Clay-Like	79			160	1.48	2.3	33.1	0.98	0.376	1.1	0.063	0.059	**N/A**
4.3	14.1	164	4	77.0	37.8	1	5.05	3.59	Clay-Like	78			164	1.45	2.4	33.2	0.98	0.376	1.1	0.063	0.059	**N/A**
4.4	14.4	189	5	78.8	38.7	2	4.08	3.49	Clay-Like	72			189	1.39	2.6	33.6	0.98	0.377	1.1	0.064	0.059	**N/A**
4.5	14.8	199	5	80.6	39.5	2	4.12	3.48	Clay-Like	72			199	1.36	2.7	33.7	0.98	0.377	1.1	0.064	0.059	**N/A**
4.6	15.1	180	5	82.4	40.3	2	4.72	3.57	Clay-Like	77			180	1.39	2.5	33.3	0.98	0.377	1.1	0.064	0.059	**N/A**
4.7	15.4	161	4	84.2	41.1	1	5.21	3.65	Clay-Like	81			161	1.41	2.3	33.0	0.98	0.377	1.1	0.063	0.058	**N/A**
4.8	15.7	178	4	86.1	42.0	1	4.17	3.56	Clay-Like	76			178	1.37	2.4	33.3	0.98	0.378	1.1	0.064	0.059	**N/A**
4.9	16.1	177	4	87.9	42.8	1	4.83	3.6	Clay-Like	78			177	1.36	2.4	33.2	0.98	0.378	1.1	0.063	0.058	**N/A**
5.0	16.4	169	4	89.7	43.6	1	5.44	3.66	Clay-Like	82			169	1.37	2.3	33.0	0.98	0.378	1.1	0.063	0.058	**N/A**
5.1	16.7	191	4	91.5	44.4	1	4.05	3.54	Clay-Like	75			191	1.32	2.5	33.4	0.97	0.378	1.1	0.064	0.058	**N/A**
5.2	17.1	219	5	93.3	45.3	2	3.57	3.45	Clay-Like	70			219	1.28	2.8	33.8	0.97	0.378	1.0	0.064	0.059	**N/A**
5.3	17.4	225	4	95.1	46.1	2	3.40	3.44	Clay-Like	70			225	1.26	2.8	33.9	0.97	0.378	1.0	0.064	0.059	**N/A**
5.4	17.7	210	5	96.9	46.9	2	3.98	3.51	Clay-Like	73			210	1.27	2.7	33.6	0.97	0.379	1.0	0.064	0.058	**N/A**
5.5	18.0	198	4	98.7	47.7	1	4.43	3.57	Clay-Like	77			198	1.28	2.5	33.4	0.97	0.379	1.0	0.064	0.058	**N/A**
5.6	18.4	202	4	100.5	48.6	1	3.97	3.54	Clay-Like	75			202	1.27	2.5	33.4	0.97	0.379	1.0	0.064	0.058	**N/A**
5.7	18.7	193	4	102.3	49.4	1	4.56	3.6	Clay-Like	78			193	1.27	2.4	33.2	0.97	0.379	1.0	0.063	0.058	**N/A**
5.8	19.0	226	4	104.1	50.2	2	3.47	3.47	Clay-Like	71			226	1.23	2.7	33.8	0.97	0.379	1.0	0.064	0.058	**N/A**
5.9	19.4	228	4	105.9	51.1	2	3.62	3.48	Clay-Like	72			228	1.22	2.8	33.8	0.97	0.379	1.0	0.064	0.058	**N/A**
6.0	19.7	223	5	107.7	51.9	2	3.91	3.51	Clay-Like	73			223	1.22	2.7	33.7	0.97	0.379	1.0	0.064	0.058	**N/A**
6.1	20.0	229	4	109.6	52.7	2	3.68	3.49	Clay-Like	72			229	1.21	2.7	33.8	0.97	0.379	1.0	0.064	0.058	**N/A**
6.2	20.3	253	5	111.4	53.5	2	3.24	3.43	Clay-Like	69			253	1.18	3.0	34.1	0.97	0.379	1.0	0.064	0.058	**N/A**
6.3	20.7	273	5	113.2	54.4	2	2.99	3.38	Clay-Like	66			273	1.18	3.2	34.5	0.97	0.379	1.0	0.064	0.059	**N/A**
6.4	21.0	266	5	115.0	55.2	2	3.36	3.43	Clay-Like	69			266	1.17	3.1	34.3	0.96	0.379	1.0	0.064	0.058	**N/A**
6.5	21.3	246	5	116.8	56.0	2	3.79	3.49	Clay-Like	72			246	1.17	2.9	33.9	0.96	0.379	1.0	0.064	0.058	**N/A**
6.6	21.7	228	4	118.6	56.8	1	3.92	3.54	Clay-Like	75			228	1.18	2.7	33.6	0.96	0.379	1.0	0.064	0.058	**N/A**
6.7	22.0	258	4	120.4	57.7	2	3.21	3.45	Clay-Like	70			258	1.16	3.0	34.1	0.96	0.378	1.0	0.064	0.058	**N/A**
6.8	22.3	278	5	122.2	58.5	2	3.32	3.43	Clay-Like	69			278	1.15	3.2	34.4	0.96	0.378	1.0	0.064	0.058	**N/A**
6.9	22.6	246	5	124.0	59.3	2	4.09	3.54	Clay-Like	75			246	1.16	2.8	33.8	0.96	0.378	1.0	0.064	0.058	**N/A**
7.0	23.0	245	5	125.8	60.1	2	3.86	3.53	Clay-Like	74			245	1.15	2.8	33.8	0.96	0.378	1.0	0.064	0.058	**N/A**
7.1	23.3	247	5	127.6	61.0	2	3.78	3.52	Clay-Like	74			247	1.15	2.8	33.8	0.96	0.378	1.0	0.064	0.058	**N/A**
7.2	23.6	262	4	129.4	61.8	2	3.24	3.47	Clay-Like	71			262	1.14	3.0	34.1	0.96	0.378	1.0	0.064	0.058	**N/A**
7.3	24.0	266	4	131.3	62.6	2	3.27	3.48	Clay-Like	72			266	1.13	3.0	34.1	0.96	0.378	1.0	0.064	0.058	**N/A**
7.4	24.3	265	5	133.1	63.5	2	3.55	3.5	Clay-Like	73			265	1.13	3.0	34.1	0.96	0.378	1.0	0.064	0.058	**N/A**
7.5	24.6	278	5	134.9	64.3	2	3.35	3.47	Clay-Like	71			278	1.13	3.1	34.3	0.95	0.378	1.0	0.064	0.058	**N/A**
7.6	24.9	282	5	136.7	65.1	2	3.41	3.47	Clay-Like	71			282	1.12	3.1	34.3	0.95	0.377	1.0	0.064	0.058	**N/A**
7.7	25.262	279	5	138.5	65.9	2	3.68	3.49	Clay-Like	72			279	1.12	3.1	34.2	0.95	0.377	1.0	0.064	0.058	**N/A**
7.8	25.591	291	5	140.3	66.8	2	3.50	3.47	Clay-Like	71			291	1.12	3.2	34.4	0.95	0.377	1.0	0.064	0.058	**N/A**
7.9	25.919	290	5	142.1	67.6	2	3.31	3.46	Clay-Like	71			290	1.11	3.2	34.4	0.95	0.377	1.0	0.064	0.058	**N/A**
8	26.247	287	5	143.9	68.4	2	3.48	3.48	Clay-Like	72			287	1.11	3.2	34.3	0.95	0.377	1.0	0.064	0.058	**N/A**
8.1	26.575	298	5	145.7	69.2	2	3.46	3.46	Clay-Like	71			298	1.10	3.3	34.5	0.95	0.377	1.0	0.064	0.058	**N/A**
8.2	26.903	308	5	147.5	70.1	2	2.92	3.42	Clay-Like	68			308	1.10	3.4	34.7	0.95	0.376	1.0	0.065	0.058	**N/A**
8.3	27.231	300	5	149.3	70.9	2	3.24	3.46	Clay-Like	71			300	1.10	3.3	34.5	0.95	0.376	1.0	0.064	0.058	**N/A**
8.4	27.559	302	5	151.1	71.7	2	3.43	3.47	Clay-Like	71			302	1.09	3.3	34.5	0.95	0.376	1.0	0.064	0.058	**N/A**
8.5	27.887	307	5	152.9	72.5	2	3.16	3.45	Clay-Like	70			307	1.09	3.3	34.6	0.95	0.376	1.0	0.064	0.058	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
8.6	28.215	316	5	154.8	73.4	2	2.86	3.42	Clay-Like	68			316	1.09	3.4	34.7	0.94	0.376	1.0	0.065	0.058	**N/A**
8.7	28.543	324	5	156.6	74.2	2	3.26	3.44	Clay-Like	70			324	1.08	3.5	34.8	0.94	0.375	1.0	0.065	0.058	**N/A**
8.8	28.871	334	6	158.4	75.0	2	3.16	3.43	Clay-Like	69			334	1.08	3.6	34.9	0.94	0.375	1.0	0.065	0.058	**N/A**
8.9	29.199	318	5	160.2	75.9	2	3.27	3.46	Clay-Like	71			318	1.08	3.4	34.7	0.94	0.375	1.0	0.065	0.058	**N/A**
9	29.528	330	5	162.0	76.7	2	3.19	3.43	Clay-Like	69			330	1.08	3.5	34.9	0.94	0.375	1.0	0.065	0.058	**N/A**
9.1	29.856	356	5	163.8	77.5	2	2.84	3.38	Clay-Like	66			356	1.07	3.8	35.3	0.94	0.374	1.0	0.065	0.058	**N/A**
9.2	30.184	504	5	165.6	78.3	4	1.61	3.11	Clay-Like	53			504	1.07	5.3	37.5	0.94	0.374	1.0	0.067	0.059	**N/A**
9.3	30.512	739	6	167.4	79.2	6	1.09	2.88	Clay-Like	44			739	1.07	7.8	40.8	0.94	0.374	1.0	0.069	0.062	**N/A**
9.4	30.84	886	8	169.2	80.0	8	1.10	2.81	Clay-Like	41			886	1.06	9.3	42.7	0.94	0.374	1.0	0.071	0.063	**N/A**
9.5	31.168	1292	9	171.0	80.8	12	0.79	2.59		33			1292	1.06	13.6	47.7	0.94	0.373	1.0	0.075	0.067	**0.18**
9.6	31.496	1474	14	172.8	81.6	14	1.08	2.61	Clay-Like	34			1474	1.06	15.4	50.3	0.93	0.373	1.0	0.078	0.069	**N/A**
9.7	31.824	1440	11	174.6	82.5	14	0.89	2.58		33			1440	1.05	15.0	49.7	0.93	0.373	1.0	0.077	0.069	**0.18**
9.8	32.152	1767	14	176.4	83.3	17	0.89	2.5		30			1767	1.05	18.4	53.6	0.93	0.373	1.0	0.081	0.072	**0.19**
9.9	32.48	668	19	178.3	84.1	5	3.97	3.25	Clay-Like	60			668	1.05	6.9	39.6	0.93	0.372	1.0	0.068	0.061	**N/A**
10	32.808	384	8	180.1	85.0	2	4.08	3.48	Clay-Like	72			384	1.05	4.0	35.4	0.93	0.372	1.0	0.065	0.058	**N/A**
10.1	33.136	375	4	181.9	85.8	2	2.28	3.35	Clay-Like	65			375	1.04	3.9	35.4	0.93	0.372	1.0	0.065	0.058	**N/A**
10.2	33.465	383	5	183.7	86.6	2	2.35	3.35	Clay-Like	65			383	1.04	4.0	35.5	0.93	0.371	1.0	0.065	0.058	**N/A**
10.3	33.793	395	5	185.5	87.4	2	2.51	3.35	Clay-Like	65			395	1.04	4.1	35.7	0.93	0.371	1.0	0.065	0.058	**N/A**
10.4	34.121	1033	9	187.3	88.3	9	1.06	2.77	Clay-Like	40			1033	1.04	10.6	44.4	0.93	0.371	1.0	0.072	0.064	**N/A**
10.5	34.449	5328	15	189.1	89.1	54	0.28	1.86		14			5328	1.03	54.5	80.3	0.93	0.370	1.0	0.113	0.100	**0.27**
10.6	34.777	7096	21	190.9	89.9	72	0.30	1.76		12			7096	1.03	72.4	93.8	0.92	0.370	1.0	0.133	0.118	**0.32**
10.7	35.105	5628	30	192.7	90.7	57	0.55	1.97		16			5628	1.03	57.3	90.3	0.92	0.370	1.0	0.127	0.113	**0.30**
10.8	35.433	4214	52	194.5	91.6	42	1.29	2.28		24			4214	1.03	42.8	83.0	0.92	0.370	1.0	0.117	0.103	**0.28**
10.9	35.761	4275	72	196.3	92.4	42	1.77	2.36		26			4275	1.02	43.3	85.1	0.92	0.369	1.0	0.120	0.106	**0.29**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-62**

Test Boring Information:

Approx. ground elevation		1 ft	0.30	m
Approx. water table elevation		0 ft	0.00	m
Approx. depth to ground water table		1 ft	0.30	m
Moist unit weight of soil	γ_m	100 pcf	15.72	kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	226	3	1.6	1.6	18	1.15	1.88	Unsaturated	14			226	1.70	3.8	21.1	1.00	0.189	1.1	0.056	0.054	**N/A**
0.2	0.7	22	1	3.1	3.1	1	5.58	3.33	Unsaturated	64			22	1.70	0.4	30.7	1.00	0.189	1.1	0.062	0.060	**N/A**
0.3	1.0	23	1	4.7	4.7	1	5.27	3.38	Unsaturated	66			23	1.70	0.4	30.7	1.00	0.189	1.1	0.062	0.059	**N/A**
0.4	1.3	100	2	6.5	5.6	4	1.64	2.63	Clay-Like	35			100	1.70	1.7	32.0	1.00	0.220	1.1	0.063	0.060	**N/A**
0.5	1.6	296	3	8.3	6.4	11	0.90	2.2		22			296	1.70	5.0	32.0	1.00	0.245	1.1	0.063	0.060	**0.25**
0.6	2.0	426	3	10.1	7.2	15	0.74	2.1		19			426	1.70	7.2	32.6	1.00	0.264	1.1	0.063	0.061	**0.23**
0.7	2.3	259	3	11.9	8.1	9	1.13	2.46		29			259	1.70	4.4	34.5	1.00	0.279	1.1	0.064	0.062	**0.22**
0.8	2.6	130	2	13.7	8.9	4	1.97	2.89	Clay-Like	44			130	1.70	2.2	33.2	1.00	0.292	1.1	0.063	0.061	**N/A**
0.9	3.0	93	2	15.6	9.7	2	2.86	3.13	Clay-Like	54			93	1.70	1.6	32.4	1.00	0.302	1.1	0.063	0.061	**N/A**
1.0	3.3	89	2	17.4	10.5	2	2.41	3.14	Clay-Like	55			89	1.70	1.5	32.3	1.00	0.310	1.1	0.063	0.061	**N/A**
1.1	3.6	167	2	19.2	11.4	4	1.23	2.8	Clay-Like	41			167	1.70	2.8	33.9	1.00	0.318	1.1	0.064	0.062	**N/A**
1.2	3.9	354	1	21.0	12.2	9	0.43	2.36		26			354	1.70	6.0	35.7	1.00	0.324	1.1	0.065	0.063	**0.19**
1.3	4.3	463	2	22.8	13.0	12	0.50	2.31		25			463	1.70	7.8	37.5	1.00	0.330	1.1	0.067	0.064	**0.19**
1.4	4.6	275	2	24.6	13.8	7	0.88	2.66	Clay-Like	36			275	1.69	4.6	36.0	1.00	0.334	1.1	0.065	0.063	**N/A**
1.5	4.9	192	2	26.4	14.7	4	0.93	2.85	Clay-Like	43			192	1.70	3.2	34.6	1.00	0.339	1.1	0.064	0.062	**N/A**
1.6	5.2	183	2	28.2	15.5	4	1.24	2.93	Clay-Like	46			183	1.70	3.1	34.4	1.00	0.342	1.1	0.064	0.062	**N/A**
1.7	5.6	189	2	30.0	16.3	4	1.39	2.95	Clay-Like	47			189	1.70	3.2	34.6	1.00	0.346	1.1	0.064	0.062	**N/A**
1.8	5.9	177	2	31.8	17.2	3	1.12	2.95	Clay-Like	47			177	1.70	3.0	34.3	1.00	0.349	1.1	0.064	0.062	**N/A**
1.9	6.2	206	2	33.6	18.0	4	0.89	2.85	Clay-Like	43			206	1.70	3.5	34.9	1.00	0.351	1.1	0.065	0.062	**N/A**
2.0	6.6	206	2	35.4	18.8	4	1.24	2.94	Clay-Like	46			206	1.70	3.5	35.0	1.00	0.354	1.1	0.065	0.062	**N/A**
2.1	6.9	172	2	37.2	19.6	3	1.78	3.09	Clay-Like	53			172	1.70	2.9	34.2	0.99	0.356	1.1	0.064	0.062	**N/A**
2.2	7.2	244	3	39.1	20.5	5	1.36	2.91	Clay-Like	45			244	1.55	3.7	35.3	0.99	0.358	1.1	0.065	0.063	**N/A**
2.3	7.5	136	2	40.9	21.3	2	2.42	3.28	Clay-Like	61			136	1.70	2.3	33.3	0.99	0.360	1.1	0.064	0.061	**N/A**
2.4	7.9	119	4	42.7	22.1	2	5.13	3.49	Clay-Like	72			119	1.70	2.0	32.8	0.99	0.361	1.1	0.063	0.060	**N/A**
2.5	8.2	253	5	44.5	22.9	4	2.62	3.07	Clay-Like	52			253	1.48	3.7	35.3	0.99	0.363	1.1	0.065	0.062	**N/A**
2.6	8.5	142	4	46.3	23.8	2	4.29	3.42	Clay-Like	68			142	1.70	2.4	33.4	0.99	0.364	1.1	0.064	0.061	**N/A**
2.7	8.9	178	3	48.1	24.6	3	2.66	3.23	Clay-Like	59			178	1.66	2.9	34.2	0.99	0.365	1.1	0.064	0.061	**N/A**
2.8	9.2	168	2	49.9	25.4	2	1.79	3.2	Clay-Like	58			168	1.68	2.8	34.0	0.99	0.367	1.1	0.064	0.061	**N/A**
2.9	9.5	74	2	51.7	26.2	1	6.78	3.79	Clay-Like	89			74	1.70	1.3	31.5	0.99	0.368	1.1	0.062	0.059	**N/A**
3.0	9.8	50	2	53.5	27.1	1	0.10	4.06	Clay-Like	107			50	1.70	0.8	30.7	0.99	0.369	1.1	0.062	0.058	**N/A**
3.1	10.2	39	3	55.3	27.9	1	0.10	4.06	Clay-Like	107			39	1.70	0.7	30.4	0.99	0.370	1.1	0.062	0.058	**N/A**
3.2	10.5	89	4	57.1	28.7	1	12.03	3.81	Clay-Like	91			89	1.70	1.5	31.8	0.99	0.370	1.1	0.062	0.059	**N/A**
3.3	10.8	142	4	58.9	29.6	2	5.29	3.49	Clay-Like	72			142	1.67	2.3	33.2	0.99	0.371	1.1	0.063	0.060	**N/A**
3.4	11.2	114	4	60.7	30.4	1	7.22	3.66	Clay-Like	82			114	1.70	1.9	32.5	0.99	0.372	1.1	0.063	0.059	**N/A**
3.5	11.5	69	4	62.6	31.2	1	66.40	4.06	Clay-Like	107			69	1.70	1.2	31.1	0.99	0.373	1.1	0.062	0.058	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	39	4	64.4	32.0	1	0.10	4.06	Clay-Like	107			39	1.70	0.6	30.4	0.99	0.373	1.1	0.062	0.058	**N/A**
3.7	12.1	37	3	66.2	32.9	1	0.10	4.06	Clay-Like	107			37	1.70	0.6	30.4	0.98	0.374	1.1	0.062	0.057	**N/A**
3.8	12.5	41	3	68.0	33.7	1	0.10	4.06	Clay-Like	107			41	1.70	0.7	30.5	0.98	0.374	1.1	0.062	0.057	**N/A**
3.9	12.8	52	3	69.8	34.5	1	0.10	4.06	Clay-Like	107			52	1.70	0.9	30.7	0.98	0.375	1.1	0.062	0.058	**N/A**
4.0	13.1	50	4	71.6	35.3	1	0.10	4.06	Clay-Like	107			50	1.70	0.8	30.7	0.98	0.375	1.1	0.062	0.057	**N/A**
4.1	13.5	64	4	73.4	36.2	1	0.10	4.06	Clay-Like	107			64	1.70	1.1	31.0	0.98	0.376	1.1	0.062	0.058	**N/A**
4.2	13.8	89	4	75.2	37.0	1	27.85	3.9	Clay-Like	96			89	1.69	1.5	31.7	0.98	0.376	1.1	0.062	0.058	**N/A**
4.3	14.1	93	4	77.0	37.8	1	28.09	3.91	Clay-Like	97			93	1.66	1.5	31.7	0.98	0.376	1.1	0.062	0.058	**N/A**
4.4	14.4	92	5	78.8	38.7	1	38.56	3.96	Clay-Like	100			92	1.64	1.5	31.6	0.98	0.377	1.1	0.062	0.058	**N/A**
4.5	14.8	93	5	80.6	39.5	1	42.07	3.98	Clay-Like	102			93	1.62	1.5	31.6	0.98	0.377	1.1	0.062	0.058	**N/A**
4.6	15.1	89	4	82.4	40.3	1	63.14	3.97	Clay-Like	101			89	1.62	1.4	31.5	0.98	0.377	1.1	0.062	0.058	**N/A**
4.7	15.4	107	4	84.2	41.1	1	18.24	3.81	Clay-Like	91			107	1.54	1.6	32.0	0.98	0.377	1.1	0.063	0.058	**N/A**
4.8	15.7	117	5	86.1	42.0	1	15.39	3.79	Clay-Like	89			117	1.50	1.7	32.1	0.98	0.378	1.1	0.063	0.058	**N/A**
4.9	16.1	116	3	87.9	42.8	1	12.09	3.73	Clay-Like	86			116	1.49	1.7	32.1	0.98	0.378	1.1	0.063	0.058	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-63**

Test Boring Information:

Approx. ground elevation		1.8	ft	0.55 m
Approx. water table elevation		0	ft	0.00 m
Approx. depth to ground water table		1.8	ft	0.55 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	899	3	1.6	1.6	71	0.32	1.05	Unsaturated	3			899	1.70	15.1	15.1	1.00	0.189	1.1	0.054	0.052	**N/A**
0.2	0.7	1249	2	3.1	3.1	70	0.20	1.06	Unsaturated	3			1249	1.70	21.0	21.0	1.00	0.189	1.1	0.056	0.054	**N/A**
0.3	1.0	1338	1	4.7	4.7	61	0.05	1.08	Unsaturated	3			1338	1.70	22.5	22.5	1.00	0.189	1.1	0.057	0.055	**N/A**
0.4	1.3	1301	2	6.3	6.3	51	0.18	1.3	Unsaturated	6			1301	1.70	21.9	22.0	1.00	0.189	1.1	0.057	0.055	**N/A**
0.5	1.6	1600	4	7.9	7.9	56	0.24	1.36	Unsaturated	6			1600	1.70	26.9	27.2	1.00	0.189	1.1	0.060	0.057	**N/A**
0.6	2.0	1822	5	9.6	9.1	60	0.26	1.4		7			1822	1.70	30.7	31.3	1.00	0.199	1.1	0.062	0.060	**0.30**
0.7	2.3	1757	4	11.4	9.9	55	0.22	1.45		7			1757	1.70	29.6	31.0	1.00	0.217	1.1	0.062	0.060	**0.28**
0.8	2.6	1557	2	13.2	10.7	47	0.12	1.47		8			1557	1.70	26.2	28.1	1.00	0.232	1.1	0.060	0.058	**0.25**
0.9	3.0	1198	0	15.0	11.5	35	0.04	1.62		10			1198	1.70	20.2	27.3	1.00	0.245	1.1	0.060	0.057	**0.23**
1.0	3.3	705	2	16.8	12.4	19	0.25	1.99		17			705	1.70	11.9	35.1	1.00	0.256	1.1	0.065	0.062	**0.24**
1.1	3.6	342	2	18.6	13.2	9	0.65	2.48		30			342	1.70	5.8	36.6	1.00	0.266	1.1	0.066	0.064	**0.24**
1.2	3.9	123	1	20.4	14.0	3	0.75	2.98	Clay-Like	48			123	1.70	2.1	33.1	1.00	0.274	1.1	0.063	0.061	**N/A**
1.3	4.3	72	1	22.2	14.8	1	1.33	3.32	Clay-Like	63			72	1.70	1.2	31.9	1.00	0.282	1.1	0.063	0.060	**N/A**
1.4	4.6	77	1	24.0	15.7	1	1.98	3.38	Clay-Like	66			77	1.70	1.3	31.9	1.00	0.289	1.1	0.063	0.060	**N/A**
1.5	4.9	74	1	25.8	16.5	1	1.97	3.41	Clay-Like	68			74	1.70	1.3	31.8	1.00	0.295	1.1	0.063	0.060	**N/A**
1.6	5.2	62	0	27.6	17.3	1	0.83	3.38	Clay-Like	66			62	1.70	1.0	31.6	1.00	0.300	1.1	0.062	0.060	**N/A**
1.7	5.6	49	1	29.4	18.1	0	2.99	3.69	Clay-Like	83			49	1.70	0.8	31.0	1.00	0.305	1.1	0.062	0.060	**N/A**
1.8	5.9	46	1	31.2	19.0	0	5.89	3.84	Clay-Like	93			46	1.70	0.8	30.8	1.00	0.309	1.1	0.062	0.060	**N/A**
1.9	6.2	71	1	33.1	19.8	1	2.04	3.47	Clay-Like	71			71	1.70	1.2	31.7	1.00	0.313	1.1	0.062	0.060	**N/A**
2.0	6.6	100	1	34.9	20.6	1	0.88	3.19	Clay-Like	57			100	1.70	1.7	32.6	1.00	0.317	1.1	0.063	0.060	**N/A**
2.1	6.9	63	1	36.7	21.5	1	2.16	3.58	Clay-Like	77			63	1.70	1.1	31.4	0.99	0.321	1.1	0.062	0.060	**N/A**
2.2	7.2	74	1	38.5	22.3	1	1.87	3.47	Clay-Like	71			74	1.70	1.3	31.8	0.99	0.324	1.1	0.062	0.060	**N/A**
2.3	7.5	83	1	40.3	23.1	1	1.36	3.37	Clay-Like	66			83	1.70	1.4	32.0	0.99	0.327	1.1	0.063	0.060	**N/A**
2.4	7.9	79	0	42.1	23.9	1	1.30	3.38	Clay-Like	66			79	1.70	1.3	32.0	0.99	0.329	1.1	0.063	0.060	**N/A**
2.5	8.2	83	1	43.9	24.8	1	1.49	3.38	Clay-Like	66			83	1.70	1.4	32.0	0.99	0.332	1.1	0.063	0.060	**N/A**
2.6	8.5	92	0	45.7	25.6	1	0.62	3.25	Clay-Like	60			92	1.70	1.5	32.3	0.99	0.334	1.1	0.063	0.060	**N/A**
2.7	8.9	88	0	47.5	26.4	1	0.95	3.29	Clay-Like	62			88	1.70	1.5	32.2	0.99	0.336	1.1	0.063	0.059	**N/A**
2.8	9.2	125	1	49.3	27.2	1	1.78	3.24	Clay-Like	60			125	1.70	2.1	33.1	0.99	0.338	1.1	0.063	0.060	**N/A**
2.9	9.5	239	5	51.1	28.1	4	2.80	3.08	Clay-Like	52			239	1.43	3.4	34.9	0.99	0.340	1.1	0.065	0.061	**N/A**
3.0	9.8	369	7	52.9	28.9	6	2.18	2.88	Clay-Like	44			369	1.39	5.1	37.1	0.99	0.342	1.1	0.066	0.063	**N/A**
3.1	10.2	228	4	54.7	29.7	3	2.54	3.1	Clay-Like	53			228	1.43	3.2	34.7	0.99	0.343	1.1	0.065	0.061	**N/A**
3.2	10.5	183	2	56.6	30.5	2	1.96	3.14	Clay-Like	55			183	1.52	2.8	34.0	0.99	0.345	1.1	0.064	0.060	**N/A**
3.3	10.8	159	2	58.4	31.4	2	1.72	3.18	Clay-Like	57			159	1.58	2.5	33.6	0.99	0.346	1.1	0.064	0.060	**N/A**
3.4	11.2	166	2	60.2	32.2	2	1.72	3.17	Clay-Like	56			166	1.54	2.5	33.7	0.99	0.348	1.1	0.064	0.060	**N/A**
3.5	11.5	165	2	62.0	33.0	2	1.86	3.19	Clay-Like	57			165	1.53	2.5	33.7	0.99	0.349	1.1	0.064	0.060	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	170	2	63.8	33.9	2	1.63	3.17	Clay-Like	56			170	1.50	2.5	33.7	0.99	0.350	1.1	0.064	0.060	**N/A**
3.7	12.1	172	2	65.6	34.7	2	2.08	3.22	Clay-Like	59			172	1.48	2.5	33.7	0.98	0.351	1.1	0.064	0.060	**N/A**
3.8	12.5	189	3	67.4	35.5	2	2.29	3.21	Clay-Like	58			189	1.43	2.7	33.9	0.98	0.352	1.1	0.064	0.060	**N/A**
3.9	12.8	199	2	69.2	36.3	2	1.92	3.17	Clay-Like	56			199	1.40	2.8	34.0	0.98	0.353	1.1	0.064	0.060	**N/A**
4.0	13.1	212	3	71.0	37.2	2	2.04	3.16	Clay-Like	56			212	1.37	2.9	34.2	0.98	0.354	1.1	0.064	0.060	**N/A**
4.1	13.5	228	4	72.8	38.0	3	2.28	3.16	Clay-Like	56			228	1.33	3.0	34.4	0.98	0.355	1.1	0.064	0.060	**N/A**
4.2	13.8	213	3	74.6	38.8	2	2.43	3.21	Clay-Like	58			213	1.35	2.8	34.1	0.98	0.356	1.1	0.064	0.059	**N/A**
4.3	14.1	220	3	76.4	39.6	2	2.07	3.17	Clay-Like	56			220	1.33	2.9	34.2	0.98	0.356	1.1	0.064	0.059	**N/A**
4.4	14.4	226	3	78.2	40.5	2	2.14	3.18	Clay-Like	57			226	1.31	2.9	34.2	0.98	0.357	1.1	0.064	0.059	**N/A**
4.5	14.8	220	3	80.1	41.3	2	2.12	3.19	Clay-Like	57			220	1.31	2.9	34.1	0.98	0.358	1.1	0.064	0.059	**N/A**
4.6	15.1	225	3	81.9	42.1	2	2.35	3.21	Clay-Like	58			225	1.30	2.9	34.2	0.98	0.358	1.1	0.064	0.059	**N/A**
4.7	15.4	260	4	83.7	42.9	3	2.45	3.18	Clay-Like	57			260	1.25	3.2	34.6	0.98	0.359	1.1	0.064	0.059	**N/A**
4.8	15.7	265	4	85.5	43.8	3	2.40	3.17	Clay-Like	56			265	1.25	3.3	34.7	0.98	0.360	1.1	0.065	0.059	**N/A**
4.9	16.1	235	3	87.3	44.6	2	2.01	3.19	Clay-Like	57			235	1.26	2.9	34.3	0.98	0.360	1.1	0.064	0.059	**N/A**
5.0	16.4	217	3	89.1	45.4	2	2.33	3.26	Clay-Like	60			217	1.28	2.7	33.9	0.98	0.361	1.0	0.064	0.059	**N/A**
5.1	16.7	224	3	90.9	46.3	2	2.59	3.28	Clay-Like	61			224	1.26	2.8	34.0	0.97	0.361	1.0	0.064	0.059	**N/A**
5.2	17.1	218	3	92.7	47.1	2	2.44	3.28	Clay-Like	61			218	1.26	2.7	33.9	0.97	0.361	1.0	0.064	0.059	**N/A**
5.3	17.4	227	3	94.5	47.9	2	2.16	3.25	Clay-Like	60			227	1.25	2.8	34.0	0.97	0.362	1.0	0.064	0.059	**N/A**
5.4	17.7	234	3	96.3	48.7	2	2.09	3.24	Clay-Like	60			234	1.23	2.9	34.1	0.97	0.362	1.0	0.064	0.059	**N/A**
5.5	18.0	244	3	98.1	49.6	2	2.04	3.23	Clay-Like	59			244	1.22	2.9	34.2	0.97	0.363	1.0	0.064	0.059	**N/A**
5.6	18.4	243	3	99.9	50.4	2	2.14	3.24	Clay-Like	60			243	1.21	2.9	34.2	0.97	0.363	1.0	0.064	0.059	**N/A**
5.7	18.7	241	3	101.8	51.2	2	2.27	3.27	Clay-Like	61			241	1.21	2.9	34.1	0.97	0.363	1.0	0.064	0.059	**N/A**
5.8	19.0	263	4	103.6	52.0	2	2.34	3.24	Clay-Like	60			263	1.19	3.1	34.5	0.97	0.364	1.0	0.064	0.059	**N/A**
5.9	19.4	249	4	105.4	52.9	2	2.46	3.28	Clay-Like	61			249	1.19	2.9	34.2	0.97	0.364	1.0	0.064	0.058	**N/A**
6.0	19.7	267	4	107.2	53.7	2	2.40	3.26	Clay-Like	60			267	1.18	3.1	34.5	0.97	0.364	1.0	0.064	0.059	**N/A**
6.1	20.0	282	4	109.0	54.5	2	2.48	3.25	Clay-Like	60			282	1.18	3.3	34.7	0.97	0.364	1.0	0.065	0.059	**N/A**
6.2	20.3	286	5	110.8	55.4	2	2.79	3.28	Clay-Like	61			286	1.17	3.3	34.7	0.97	0.364	1.0	0.065	0.059	**N/A**
6.3	20.7	267	4	112.6	56.2	2	2.73	3.31	Clay-Like	63			267	1.17	3.1	34.4	0.97	0.365	1.0	0.064	0.058	**N/A**
6.4	21.0	269	4	114.4	57.0	2	2.36	3.28	Clay-Like	61			269	1.16	3.1	34.4	0.96	0.365	1.0	0.064	0.058	**N/A**
6.5	21.3	265	4	116.2	57.8	2	2.51	3.3	Clay-Like	62			265	1.16	3.0	34.3	0.96	0.365	1.0	0.064	0.058	**N/A**
6.6	21.7	271	4	118.0	58.7	2	2.64	3.31	Clay-Like	63			271	1.15	3.1	34.4	0.96	0.365	1.0	0.064	0.058	**N/A**
6.7	22.0	290	4	119.8	59.5	2	2.25	3.26	Clay-Like	60			290	1.15	3.3	34.7	0.96	0.365	1.0	0.065	0.058	**N/A**
6.8	22.3	277	4	121.6	60.3	2	2.28	3.28	Clay-Like	61			277	1.15	3.1	34.5	0.96	0.365	1.0	0.064	0.058	**N/A**
6.9	22.6	279	4	123.4	61.1	2	2.28	3.29	Clay-Like	62			279	1.14	3.2	34.5	0.96	0.365	1.0	0.064	0.058	**N/A**
7.0	23.0	313	3	125.3	62.0	2	1.84	3.2	Clay-Like	58			313	1.14	3.5	35.0	0.96	0.365	1.0	0.065	0.058	**N/A**
7.1	23.3	303	4	127.1	62.8	2	2.40	3.28	Clay-Like	61			303	1.13	3.4	34.8	0.96	0.366	1.0	0.065	0.058	**N/A**
7.2	23.6	305	4	128.9	63.6	2	2.13	3.25	Clay-Like	60			305	1.13	3.4	34.9	0.96	0.366	1.0	0.065	0.058	**N/A**
7.3	24.0	278	3	130.7	64.4	2	2.21	3.3	Clay-Like	62			278	1.13	3.1	34.4	0.96	0.366	1.0	0.064	0.058	**N/A**
7.4	24.3	274	3	132.5	65.3	2	2.23	3.32	Clay-Like	63			274	1.12	3.0	34.3	0.96	0.366	1.0	0.064	0.058	**N/A**
7.5	24.6	288	3	134.3	66.1	2	1.99	3.28	Clay-Like	61			288	1.12	3.2	34.5	0.95	0.366	1.0	0.064	0.058	**N/A**
7.6	24.9	301	3	136.1	66.9	2	1.80	3.25	Clay-Like	60			301	1.11	3.3	34.7	0.95	0.366	1.0	0.065	0.058	**N/A**
7.7	25.262	290	4	137.9	67.8	2	2.39	3.33	Clay-Like	64			290	1.11	3.2	34.5	0.95	0.366	1.0	0.064	0.058	**N/A**
7.8	25.591	300	4	139.7	68.6	2	2.51	3.33	Clay-Like	64			300	1.11	3.3	34.6	0.95	0.366	1.0	0.064	0.058	**N/A**
7.9	25.919	306	4	141.5	69.4	2	2.56	3.33	Clay-Like	64			306	1.10	3.3	34.7	0.95	0.366	1.0	0.065	0.058	**N/A**
8	26.247	314	5	143.3	70.2	2	2.81	3.34	Clay-Like	64			314	1.10	3.4	34.8	0.95	0.366	1.0	0.065	0.058	**N/A**
8.1	26.575	316	5	145.1	71.1	2	2.91	3.35	Clay-Like	65			316	1.10	3.4	34.8	0.95	0.365	1.0	0.065	0.058	**N/A**
8.2	26.903	326	5	146.9	71.9	2	2.52	3.32	Clay-Like	63			326	1.09	3.5	35.0	0.95	0.365	1.0	0.065	0.058	**N/A**
8.3	27.231	318	4	148.8	72.7	2	2.49	3.33	Clay-Like	64			318	1.09	3.4	34.8	0.95	0.365	1.0	0.065	0.058	**N/A**
8.4	27.559	316	4	150.6	73.5	2	2.37	3.32	Clay-Like	63			316	1.09	3.4	34.8	0.95	0.365	1.0	0.065	0.058	**N/A**
8.5	27.887	316	4	152.4	74.4	2	2.22	3.32	Clay-Like	63			316	1.08	3.4	34.8	0.95	0.365	1.0	0.065	0.058	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
8.6	28.215	317	4	154.2	75.2	2	2.41	3.34	Clay-Like	64			317	1.08	3.4	34.8	0.94	0.365	1.0	0.065	0.058	**N/A**
8.7	28.543	338	4	156.0	76.0	2	2.06	3.28	Clay-Like	61			338	1.08	3.6	35.1	0.94	0.365	1.0	0.065	0.058	**N/A**
8.8	28.871	456	4	157.8	76.8	3	1.25	3.07	Clay-Like	52			456	1.07	4.9	36.9	0.94	0.365	1.0	0.066	0.059	**N/A**
8.9	29.199	474	4	159.6	77.7	4	1.25	3.06	Clay-Like	51			474	1.07	5.0	37.1	0.94	0.365	1.0	0.066	0.059	**N/A**
9	29.528	339	3	161.4	78.5	2	1.88	3.29	Clay-Like	62			339	1.07	3.6	35.1	0.94	0.365	1.0	0.065	0.058	**N/A**
9.1	29.856	322	4	163.2	79.3	2	2.65	3.37	Clay-Like	66			322	1.07	3.4	34.8	0.94	0.364	1.0	0.065	0.057	**N/A**
9.2	30.184	343	5	165.0	80.2	2	2.74	3.36	Clay-Like	65			343	1.06	3.6	35.0	0.94	0.364	1.0	0.065	0.058	**N/A**
9.3	30.512	358	5	166.8	81.0	2	2.51	3.32	Clay-Like	63			358	1.06	3.8	35.3	0.94	0.364	1.0	0.065	0.058	**N/A**
9.4	30.84	351	4	168.6	81.8	2	2.41	3.32	Clay-Like	63			351	1.06	3.7	35.2	0.94	0.364	1.0	0.065	0.058	**N/A**
9.5	31.168	409	3	170.4	82.6	3	1.44	3.16	Clay-Like	56			409	1.05	4.3	36.1	0.94	0.364	1.0	0.066	0.058	**N/A**
9.6	31.496	629	3	172.3	83.5	5	0.59	2.83	Clay-Like	42			629	1.05	6.6	39.0	0.93	0.364	1.0	0.068	0.060	**N/A**
9.7	31.824	713	3	174.1	84.3	6	0.53	2.77	Clay-Like	40			713	1.05	7.4	40.1	0.93	0.364	1.0	0.069	0.061	**N/A**
9.8	32.152	955	7	175.9	85.1	8	0.95	2.73	Clay-Like	38			955	1.05	9.9	43.3	0.93	0.363	1.0	0.071	0.063	**N/A**
9.9	32.48	2962	22	177.7	85.9	30	0.80	2.25		23			2962	1.04	30.6	66.4	0.93	0.363	1.0	0.095	0.084	**0.23**
10	32.808	5307	60	179.5	86.8	55	1.16	2.12		20			5307	1.04	54.7	93.8	0.93	0.363	1.0	0.133	0.118	**0.33**
10.1	33.136	5439	64	181.3	87.6	56	1.21	2.13		20			5439	1.04	55.9	95.7	0.93	0.363	1.0	0.136	0.121	**0.33**
10.2	33.465	4596	80	183.1	88.4	47	1.82	2.3		24			4596	1.04	47.1	89.0	0.93	0.363	1.0	0.125	0.111	**0.31**
10.3	33.793	3688	84	184.9	89.2	37	2.41	2.46		29			3688	1.03	37.7	79.0	0.93	0.362	1.0	0.111	0.099	**0.27**
10.4	34.121	2909	115	186.7	90.1	28	4.21	2.69	Clay-Like	37			2909	1.03	29.7	69.8	0.93	0.362	1.0	0.099	0.088	**N/A**
10.5	34.449	2707	147	188.5	90.9	26	5.86	2.81	Clay-Like	41			2707	1.03	27.6	67.3	0.93	0.362	1.0	0.096	0.085	**N/A**
10.6	34.777	2292	158	190.3	91.7	22	7.51	2.95	Clay-Like	47			2292	1.03	23.3	61.7	0.92	0.362	1.0	0.090	0.079	**N/A**
10.7	35.105	3011	224	192.1	92.6	29	7.93	2.89	Clay-Like	44			3011	1.02	30.5	71.5	0.92	0.362	1.0	0.101	0.089	**N/A**
10.8	35.433	3195	251	193.9	93.4	31	8.36	2.89	Clay-Like	44			3195	1.02	32.3	73.9	0.92	0.361	1.0	0.104	0.092	**N/A**
10.9	35.761	3163	222	195.8	94.2	30	7.47	2.85	Clay-Like	43			3163	1.02	31.9	73.3	0.92	0.361	1.0	0.104	0.091	**N/A**
11	36.089	5052	277	197.6	95.0	49	5.70	2.63	Clay-Like	35			5052	1.02	50.8	98.0	0.92	0.361	1.0	0.139	0.123	**N/A**
11.1	36.417	8002	390	199.4	95.9	79	5.00	2.46		29			8002	1.01	80.3	135.8	0.92	0.361	1.0	0.219	0.193	**0.54**
11.2	36.745	10604	496	201.2	96.7	105	4.76	2.38		27			10604	1.01	106.2	168.7	0.92	0.360	1.0	0.395	0.349	**0.97**
11.3	37.073	14931	537	203.0	97.5	148	3.65	2.2		22			14931	1.01	149.2	218.9	0.92	0.360	1.0	2.000	1.770	**2.00**
11.4	37.402	21661	615	204.8	98.3	215	2.87	2.02		17			21661	1.01	216.0	290.7	0.92	0.360	1.0	2.000	1.766	**2.00**
11.5	37.73	25625	702	206.6	99.2	254	2.76	1.97		16			25625	1.00	254.9	333.2	0.92	0.360	1.0	2.000	1.761	**2.00**
11.6	38.058	24333	674	208.4	100.0	240	2.80	1.99		17			24333	1.00	241.6	319.2	0.91	0.359	1.0	2.000	1.757	**2.00**
11.7	38.386	24175	473	210.2	100.8	237	1.97	1.87		14			24175	1.00	239.5	300.6	0.91	0.359	1.0	2.000	1.753	**2.00**
11.8	38.714	20273	817	212.0	101.7	198	4.07	2.17		21			20273	1.00	200.4	283.4	0.91	0.359	1.0	2.000	1.748	**2.00**
11.9	39.042	22341	863	213.8	102.5	217	3.90	2.14		20			22341	1.00	220.4	307.0	0.91	0.358	1.0	2.000	1.744	**2.00**
12	39.37	23016	791	215.6	103.3	223	3.47	2.09		19			23016	0.99	226.5	310.7	0.91	0.358	1.0	2.000	1.740	**2.00**
12.1	39.698	24616	671	217.4	104.1	238	2.75	1.99		17			24616	0.99	241.8	319.5	0.91	0.358	1.0	2.000	1.736	**2.00**
12.2	40.026	24216	805	219.3	105.0	233	3.35	2.07		19			24216	0.99	237.3	322.6	0.91	0.358	1.0	2.000	1.731	**2.00**
12.3	40.354	18803	642	221.1	105.8	180	3.45	2.14		20			18803	0.99	183.9	260.2	0.91	0.357	1.0	2.000	1.727	**2.00**
12.4	40.682	18169	694	222.9	106.6	173	3.87	2.19		21			18169	0.99	177.3	254.8	0.91	0.357	1.0	2.000	1.723	**2.00**
12.5	41.011	16665	632	224.7	107.4	158	3.85	2.21		22			16665	0.98	162.3	236.5	0.90	0.357	1.0	2.000	1.719	**2.00**
12.6	41.339	16453	744	226.5	108.3	155	4.58	2.28		24			16453	0.98	159.9	236.5	0.90	0.356	1.0	2.000	1.715	**2.00**
12.7	41.667	20441	772	228.3	109.1	192	3.82	2.17		21			20441	0.98	198.3	280.7	0.90	0.356	1.0	2.000	1.711	**2.00**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-64**

Test Boring Information:

Approx. ground elevation		1.5 ft	0.46	m
Approx. water table elevation		0.5 ft	0.15	m
Approx. depth to ground water table		1 ft	0.30	m
Moist unit weight of soil	γ_m	100 pcf	15.72	kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	495	1	1.6	1.6	39	0.23	1.18	Unsaturated	4			495	1.70	8.3	8.3	1.00	0.189	1.1	0.051	0.049	**N/A**
0.2	0.7	835	1	3.1	3.1	47	0.16	1.17	Unsaturated	4			835	1.70	14.1	14.1	1.00	0.189	1.1	0.053	0.051	**N/A**
0.3	1.0	920	2	4.7	4.7	42	0.22	1.35	Unsaturated	6			920	1.70	15.5	15.7	1.00	0.189	1.1	0.054	0.052	**N/A**
0.4	1.3	825	1	6.5	5.6	34	0.15	1.46		7			825	1.70	13.9	15.3	1.00	0.220	1.1	0.054	0.052	**0.23**
0.5	1.6	966	1	8.3	6.4	38	0.08	1.43		7			966	1.70	16.3	17.2	1.00	0.245	1.1	0.054	0.052	**0.21**
0.6	2.0	1113	1	10.1	7.2	41	0.11	1.47		8			1113	1.70	18.7	20.5	1.00	0.264	1.1	0.056	0.054	**0.20**
0.7	2.3	1248	1	11.9	8.1	43	0.11	1.49		8			1248	1.70	21.0	23.3	1.00	0.279	1.1	0.057	0.055	**0.20**
0.8	2.6	1210	1	13.7	8.9	40	0.10	1.56		9			1210	1.70	20.4	24.9	1.00	0.292	1.1	0.058	0.056	**0.19**
0.9	3.0	1018	1	15.6	9.7	32	0.11	1.69		11			1018	1.70	17.1	27.4	1.00	0.302	1.1	0.060	0.058	**0.19**
1.0	3.3	815	1	17.4	10.5	24	0.07	1.81		13			815	1.70	13.7	29.7	1.00	0.310	1.1	0.061	0.059	**0.19**
1.1	3.6	640	0	19.2	11.4	18	0.05	1.97		16			640	1.70	10.8	33.1	1.00	0.318	1.1	0.063	0.061	**0.19**
1.2	3.9	500	1	21.0	12.2	14	0.22	2.19		21			500	1.70	8.4	36.3	1.00	0.324	1.1	0.066	0.063	**0.20**
1.3	4.3	277	3	22.8	13.0	7	1.36	2.77	Clay-Like	40			277	1.70	4.7	36.4	1.00	0.330	1.1	0.066	0.063	**N/A**
1.4	4.6	139	3	24.6	13.8	3	2.50	3.21	Clay-Like	58			139	1.70	2.3	33.4	1.00	0.334	1.1	0.064	0.061	**N/A**
1.5	4.9	114	2	26.4	14.7	2	1.86	3.26	Clay-Like	60			114	1.70	1.9	32.8	1.00	0.339	1.1	0.063	0.061	**N/A**
1.6	5.2	98	2	28.2	15.5	2	2.19	3.35	Clay-Like	65			98	1.70	1.7	32.4	1.00	0.342	1.1	0.063	0.061	**N/A**
1.7	5.6	99	2	30.0	16.3	2	2.78	3.4	Clay-Like	67			99	1.70	1.7	32.4	1.00	0.346	1.1	0.063	0.061	**N/A**
1.8	5.9	107	2	31.8	17.2	2	2.79	3.38	Clay-Like	66			107	1.70	1.8	32.6	1.00	0.349	1.1	0.063	0.061	**N/A**
1.9	6.2	110	2	33.6	18.0	2	2.38	3.35	Clay-Like	65			110	1.70	1.9	32.7	1.00	0.351	1.1	0.063	0.061	**N/A**
2.0	6.6	68	2	35.4	18.8	1	6.20	3.76	Clay-Like	88			68	1.70	1.1	31.4	1.00	0.354	1.1	0.062	0.060	**N/A**
2.1	6.9	72	2	37.2	19.6	1	4.89	3.69	Clay-Like	83			72	1.70	1.2	31.5	0.99	0.356	1.1	0.062	0.060	**N/A**
2.2	7.2	77	2	39.1	20.5	1	5.29	3.68	Clay-Like	83			77	1.70	1.3	31.6	0.99	0.358	1.1	0.062	0.060	**N/A**
2.3	7.5	77	2	40.9	21.3	1	6.08	3.72	Clay-Like	85			77	1.70	1.3	31.6	0.99	0.360	1.1	0.062	0.060	**N/A**
2.4	7.9	80	2	42.7	22.1	1	6.44	3.72	Clay-Like	85			80	1.70	1.3	31.7	0.99	0.361	1.1	0.062	0.060	**N/A**
2.5	8.2	69	2	44.5	22.9	1	10.25	3.88	Clay-Like	95			69	1.70	1.2	31.3	0.99	0.363	1.1	0.062	0.059	**N/A**
2.6	8.5	65	2	46.3	23.8	0	10.17	3.91	Clay-Like	97			65	1.70	1.1	31.1	0.99	0.364	1.1	0.062	0.059	**N/A**
2.7	8.9	79	2	48.1	24.6	1	5.59	3.7	Clay-Like	84			79	1.70	1.3	31.7	0.99	0.365	1.1	0.062	0.059	**N/A**
2.8	9.2	113	3	49.9	25.4	1	5.02	3.53	Clay-Like	74			113	1.70	1.9	32.6	0.99	0.367	1.1	0.063	0.060	**N/A**
2.9	9.5	195	5	51.7	26.2	3	3.40	3.24	Clay-Like	60			195	1.57	3.0	34.4	0.99	0.368	1.1	0.064	0.061	**N/A**
3.0	9.8	134	4	53.5	27.1	2	4.89	3.48	Clay-Like	72			134	1.70	2.3	33.1	0.99	0.369	1.1	0.063	0.060	**N/A**
3.1	10.2	139	4	55.3	27.9	2	4.44	3.43	Clay-Like	69			139	1.70	2.3	33.3	0.99	0.370	1.1	0.064	0.060	**N/A**
3.2	10.5	150	4	57.1	28.7	2	4.00	3.4	Clay-Like	67			150	1.66	2.5	33.5	0.99	0.370	1.1	0.064	0.060	**N/A**
3.3	10.8	108	3	58.9	29.6	1	6.60	3.64	Clay-Like	81			108	1.70	1.8	32.4	0.99	0.371	1.1	0.063	0.059	**N/A**
3.4	11.2	109	3	60.7	30.4	1	6.72	3.64	Clay-Like	81			109	1.70	1.8	32.4	0.99	0.372	1.1	0.063	0.059	**N/A**
3.5	11.5	117	3	62.6	31.2	1	5.76	3.59	Clay-Like	78			117	1.70	2.0	32.6	0.99	0.373	1.1	0.063	0.059	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	126	3	64.4	32.0	1	5.31	3.55	Clay-Like	75			126	1.67	2.1	32.8	0.99	0.373	1.1	0.063	0.059	**N/A**
3.7	12.1	128	4	66.2	32.9	1	5.85	3.57	Clay-Like	77			128	1.64	2.1	32.8	0.98	0.374	1.1	0.063	0.059	**N/A**
3.8	12.5	115	3	68.0	33.7	1	6.56	3.65	Clay-Like	81			115	1.67	1.9	32.5	0.98	0.374	1.1	0.063	0.059	**N/A**
3.9	12.8	147	3	69.8	34.5	1	4.35	3.47	Clay-Like	71			147	1.55	2.3	33.1	0.98	0.375	1.1	0.063	0.059	**N/A**
4.0	13.1	194	5	71.6	35.3	2	3.66	3.34	Clay-Like	64			194	1.42	2.7	33.9	0.98	0.375	1.1	0.064	0.060	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-65**

Test Boring Information:

Approx. ground elevation		2 ft	0.61	m
Approx. water table elevation		1 ft	0.30	m
Approx. depth to ground water table		1 ft	0.30	m
Moist unit weight of soil	γ_m	100 pcf	15.72	kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8	
Peak horizontal ground surface acceleration	a_{max}	0.29	g
Magnitude Scaling Factor	M_F	0.88	

Atomospheric pressure	P_a	101.3	kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	368	2	1.6	1.6	29	0.52	1.48	Unsaturated	8			368	1.70	6.2	7.9	1.00	0.189	1.1	0.051	0.049	**N/A**
0.2	0.7	650	2	3.1	3.1	36	0.27	1.37	Unsaturated	6			650	1.70	10.9	11.3	1.00	0.189	1.1	0.052	0.050	**N/A**
0.3	1.0	875	2	4.7	4.7	40	0.23	1.38	Unsaturated	6			875	1.70	14.7	15.1	1.00	0.189	1.1	0.054	0.052	**N/A**
0.4	1.3	1101	2	6.5	5.6	46	0.18	1.37		6			1101	1.70	18.5	18.9	1.00	0.220	1.1	0.055	0.053	**0.24**
0.5	1.6	1059	2	8.3	6.4	41	0.19	1.48		8			1059	1.70	17.8	19.8	1.00	0.245	1.1	0.056	0.054	**0.22**
0.6	2.0	730	12	10.1	7.2	27	1.65	2.18		21			730	1.70	12.3	41.1	1.00	0.264	1.1	0.069	0.067	**0.25**
0.7	2.3	2366	29	11.9	8.1	82	1.24	1.78		13			2366	1.70	39.8	58.0	1.00	0.279	1.1	0.086	0.083	**0.30**
0.8	2.6	8082	26	13.7	8.9	269	0.32	1.03		3			8082	1.70	136.0	136.0	1.00	0.292	1.1	0.220	0.212	**0.73**
0.9	3.0	8055	39	15.6	9.7	256	0.48	1.19		4			8055	1.70	135.6	135.6	1.00	0.302	1.1	0.218	0.210	**0.70**
1.0	3.3	3020	36	17.4	10.5	92	1.21	1.81		13			3020	1.70	50.8	72.7	1.00	0.310	1.1	0.103	0.099	**0.32**
1.1	3.6	855	24	19.2	11.4	25	2.85	2.5		30			855	1.70	14.4	48.3	1.00	0.318	1.1	0.076	0.073	**0.23**
1.2	3.9	211	9	21.0	12.2	5	4.79	3.14	Clay-Like	55			211	1.70	3.6	35.1	1.00	0.324	1.1	0.065	0.062	**N/A**
1.3	4.3	169	5	22.8	13.0	4	3.34	3.16	Clay-Like	56			169	1.70	2.8	34.1	1.00	0.330	1.1	0.064	0.062	**N/A**
1.4	4.6	169	5	24.6	13.8	4	3.52	3.2	Clay-Like	58			169	1.70	2.8	34.1	1.00	0.334	1.1	0.064	0.062	**N/A**
1.5	4.9	178	5	26.4	14.7	4	3.16	3.18	Clay-Like	57			178	1.70	3.0	34.3	1.00	0.339	1.1	0.064	0.062	**N/A**
1.6	5.2	183	5	28.2	15.5	4	2.90	3.17	Clay-Like	56			183	1.70	3.1	34.5	1.00	0.342	1.1	0.064	0.062	**N/A**
1.7	5.6	164	4	30.0	16.3	3	3.21	3.25	Clay-Like	60			164	1.70	2.8	34.0	1.00	0.346	1.1	0.064	0.062	**N/A**
1.8	5.9	172	4	31.8	17.2	3	3.15	3.24	Clay-Like	60			172	1.70	2.9	34.2	1.00	0.349	1.1	0.064	0.062	**N/A**
1.9	6.2	190	5	33.6	18.0	4	3.25	3.22	Clay-Like	59			190	1.70	3.2	34.6	1.00	0.351	1.1	0.064	0.062	**N/A**
2.0	6.6	194	5	35.4	18.8	4	3.21	3.21	Clay-Like	58			194	1.70	3.3	34.7	1.00	0.354	1.1	0.065	0.062	**N/A**
2.1	6.9	208	5	37.2	19.6	4	3.08	3.19	Clay-Like	57			208	1.69	3.5	35.0	0.99	0.356	1.1	0.065	0.062	**N/A**
2.2	7.2	227	6	39.1	20.5	4	3.22	3.17	Clay-Like	56			227	1.60	3.6	35.2	0.99	0.358	1.1	0.065	0.062	**N/A**
2.3	7.5	239	6	40.9	21.3	4	3.09	3.15	Clay-Like	55			239	1.55	3.7	35.3	0.99	0.360	1.1	0.065	0.062	**N/A**
2.4	7.9	327	8	42.7	22.1	6	2.83	3.01	Clay-Like	49			327	1.49	4.8	36.8	0.99	0.361	1.1	0.066	0.063	**N/A**
2.5	8.2	333	8	44.5	22.9	6	2.69	3.01	Clay-Like	49			333	1.48	4.9	36.9	0.99	0.363	1.1	0.066	0.063	**N/A**
2.6	8.5	249	5	46.3	23.8	4	2.22	3.09	Clay-Like	53			249	1.48	3.6	35.2	0.99	0.364	1.1	0.065	0.062	**N/A**
2.7	8.9	226	3	48.1	24.6	4	1.94	3.11	Clay-Like	53			226	1.52	3.4	34.9	0.99	0.365	1.1	0.065	0.062	**N/A**
2.8	9.2	204	3	49.9	25.4	3	1.99	3.17	Clay-Like	56			204	1.56	3.2	34.6	0.99	0.367	1.1	0.064	0.061	**N/A**
2.9	9.5	210	3	51.7	26.2	3	1.93	3.16	Clay-Like	56			210	1.53	3.2	34.6	0.99	0.368	1.1	0.064	0.061	**N/A**
3.0	9.8	253	5	53.5	27.1	4	2.54	3.13	Clay-Like	54			253	1.42	3.6	35.1	0.99	0.369	1.1	0.065	0.061	**N/A**
3.1	10.2	372	9	55.3	27.9	6	2.97	3.04	Clay-Like	50			372	1.40	5.2	37.3	0.99	0.370	1.1	0.066	0.063	**N/A**
3.2	10.5	348	9	57.1	28.7	5	3.16	3.09	Clay-Like	53			348	1.39	4.8	36.8	0.99	0.370	1.1	0.066	0.062	**N/A**
3.3	10.8	282	6	58.9	29.6	4	2.80	3.13	Clay-Like	54			282	1.38	3.9	35.5	0.99	0.371	1.1	0.065	0.061	**N/A**
3.4	11.2	263	5	60.7	30.4	4	2.55	3.14	Clay-Like	55			263	1.37	3.6	35.1	0.99	0.372	1.1	0.065	0.061	**N/A**
3.5	11.5	262	5	62.6	31.2	4	2.54	3.15	Clay-Like	55			262	1.36	3.5	35.1	0.99	0.373	1.1	0.065	0.061	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	270	5	64.4	32.0	4	2.33	3.13	Clay-Like	54			270	1.35	3.6	35.2	0.99	0.373	1.1	0.065	0.061	**N/A**
3.7	12.1	283	5	66.2	32.9	4	2.34	3.11	Clay-Like	53			283	1.34	3.8	35.4	0.98	0.374	1.1	0.065	0.061	**N/A**
3.8	12.5	302	6	68.0	33.7	4	2.50	3.11	Clay-Like	53			302	1.34	4.0	35.7	0.98	0.374	1.1	0.065	0.061	**N/A**
3.9	12.8	305	6	69.8	34.5	4	2.37	3.11	Clay-Like	53			305	1.33	4.0	35.7	0.98	0.375	1.1	0.065	0.061	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-66**

Test Boring Information:

Approx. ground elevation		2 ft	0.61	m
Approx. water table elevation		1 ft	0.30	m
Approx. depth to ground water table		1 ft	0.30	m
Moist unit weight of soil	γ_m	100 pcf	15.72	kN/m^3
Saturated unit weight of soil	γ_{sat}	115 pcf	18.08	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	467	5	1.6	1.6	37	1.09	1.63	Unsaturated	10			467	1.70	7.9	14.6	1.00	0.189	1.1	0.053	0.051	**N/A**
0.2	0.7	281	2	3.1	3.1	16	0.62	1.87	Unsaturated	14			281	1.70	4.7	21.8	1.00	0.189	1.1	0.057	0.054	**N/A**
0.3	1.0	269	1	4.7	4.7	12	0.25	1.88	Unsaturated	14			269	1.70	4.5	22.0	1.00	0.189	1.1	0.057	0.055	**N/A**
0.4	1.3	399	1	6.5	5.6	17	0.17	1.77		12			399	1.70	6.7	19.7	1.00	0.220	1.1	0.056	0.053	**0.24**
0.5	1.6	603	1	8.3	6.4	23	0.11	1.66		10			603	1.70	10.1	18.3	1.00	0.245	1.1	0.055	0.053	**0.22**
0.6	2.0	1115	36	10.1	7.2	41	3.27	2.26		23			1115	1.70	18.8	51.1	1.00	0.264	1.1	0.079	0.076	**0.29**
0.7	2.3	5520	64	11.9	8.1	193	1.16	1.52		8			5520	1.70	92.9	98.2	1.00	0.279	1.1	0.140	0.134	**0.48**
0.8	2.6	3469	31	13.7	8.9	115	0.88	1.59		9			3469	1.70	58.4	66.2	1.00	0.292	1.1	0.095	0.092	**0.31**
0.9	3.0	1999	9	15.6	9.7	63	0.47	1.64		10			1999	1.70	33.6	42.7	1.00	0.302	1.1	0.071	0.068	**0.23**
1.0	3.3	2657	9	17.4	10.5	81	0.36	1.52		8			2657	1.70	44.7	48.6	1.00	0.310	1.1	0.076	0.073	**0.24**
1.1	3.6	3333	13	19.2	11.4	98	0.39	1.49		8			3333	1.70	56.1	59.1	1.00	0.318	1.1	0.087	0.084	**0.26**
1.2	3.9	3567	15	21.0	12.2	101	0.42	1.51		8			3567	1.70	60.0	63.9	1.00	0.324	1.1	0.092	0.089	**0.27**
1.3	4.3	3431	15	22.8	13.0	94	0.45	1.57		9			3431	1.70	57.7	64.4	1.00	0.330	1.1	0.093	0.089	**0.27**
1.4	4.6	3232	15	24.6	13.8	86	0.48	1.64		10			3232	1.69	54.1	64.7	1.00	0.334	1.1	0.093	0.090	**0.27**
1.5	4.9	2913	14	26.4	14.7	75	0.50	1.71		11			2913	1.66	48.0	62.7	1.00	0.339	1.1	0.091	0.088	**0.26**
1.6	5.2	2611	12	28.2	15.5	65	0.46	1.75		12			2611	1.64	42.4	59.1	1.00	0.342	1.1	0.087	0.084	**0.24**
1.7	5.6	2280	13	30.0	16.3	55	0.58	1.86		14			2280	1.62	36.5	59.0	1.00	0.346	1.1	0.087	0.084	**0.24**
1.8	5.9	2440	15	31.8	17.2	58	0.61	1.86		14			2440	1.60	38.6	61.4	1.00	0.349	1.1	0.089	0.086	**0.25**
1.9	6.2	2681	15	33.6	18.0	62	0.56	1.81		13			2681	1.58	41.9	62.3	1.00	0.351	1.1	0.090	0.087	**0.25**
2.0	6.6	2478	12	35.4	18.8	56	0.51	1.83		13			2478	1.56	38.2	59.3	1.00	0.354	1.1	0.087	0.084	**0.24**
2.1	6.9	2465	11	37.2	19.6	54	0.47	1.83		13			2465	1.54	37.6	58.5	0.99	0.356	1.1	0.086	0.083	**0.23**
2.2	7.2	2388	9	39.1	20.5	52	0.39	1.82		13			2388	1.52	36.0	56.1	0.99	0.358	1.1	0.084	0.081	**0.23**
2.3	7.5	2403	11	40.9	21.3	51	0.47	1.86		14			2403	1.51	35.9	58.3	0.99	0.360	1.1	0.086	0.083	**0.23**
2.4	7.9	2475	12	42.7	22.1	51	0.49	1.87		14			2475	1.49	36.6	59.6	0.99	0.361	1.1	0.087	0.084	**0.23**
2.5	8.2	2472	12	44.5	22.9	50	0.50	1.88		14			2472	1.48	36.2	59.7	0.99	0.363	1.1	0.088	0.084	**0.23**
2.6	8.5	2574	14	46.3	23.8	52	0.54	1.89		15			2574	1.46	37.3	61.6	0.99	0.364	1.1	0.090	0.086	**0.24**
2.7	8.9	2477	15	48.1	24.6	49	0.62	1.95		16			2477	1.45	35.6	62.6	0.99	0.365	1.1	0.091	0.087	**0.24**
2.8	9.2	1682	21	49.9	25.4	32	1.30	2.27		24			1682	1.44	24.0	58.1	0.99	0.367	1.1	0.086	0.083	**0.23**
2.9	9.5	673	23	51.7	26.2	12	3.70	2.89	Clay-Like	44			673	1.43	9.5	43.1	0.99	0.368	1.1	0.071	0.068	**N/A**
3.0	9.8	433	14	53.5	27.1	7	3.66	3.06	Clay-Like	51			433	1.42	6.1	38.5	0.99	0.369	1.1	0.067	0.064	**N/A**
3.1	10.2	408	5	55.3	27.9	7	1.52	2.87	Clay-Like	43			408	1.40	5.7	37.9	0.99	0.370	1.1	0.067	0.063	**N/A**
3.2	10.5	354	6	57.1	28.7	6	2.06	2.99	Clay-Like	48			354	1.39	4.9	36.9	0.99	0.370	1.1	0.066	0.063	**N/A**
3.3	10.8	284	5	58.9	29.6	4	2.34	3.1	Clay-Like	53			284	1.38	3.9	35.6	0.99	0.371	1.1	0.065	0.061	**N/A**
3.4	11.2	307	6	60.7	30.4	4	2.25	3.07	Clay-Like	52			307	1.37	4.2	36.0	0.99	0.372	1.1	0.065	0.062	**N/A**
3.5	11.5	337	6	62.6	31.2	5	2.24	3.05	Clay-Like	51			337	1.36	4.5	36.5	0.99	0.373	1.1	0.066	0.062	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	301	7	64.4	32.0	4	2.75	3.15	Clay-Like	55			301	1.35	4.0	35.7	0.99	0.373	1.1	0.065	0.061	**N/A**
3.7	12.1	288	6	66.2	32.9	4	2.85	3.18	Clay-Like	57			288	1.34	3.8	35.5	0.98	0.374	1.1	0.065	0.061	**N/A**
3.8	12.5	289	6	68.0	33.7	4	2.56	3.16	Clay-Like	56			289	1.34	3.8	35.5	0.98	0.374	1.1	0.065	0.061	**N/A**
3.9	12.8	284	5	69.8	34.5	4	2.54	3.17	Clay-Like	56			284	1.33	3.7	35.3	0.98	0.375	1.1	0.065	0.061	**N/A**
4.0	12.8	320	5	71.6	35.3	4	2.04	3.08	Clay-Like	52			320	1.32	4.2	36.0	0.98	0.375	1.1	0.065	0.061	**N/A**
4.1	12.8	299	5	73.4	36.2	4	2.21	3.13	Clay-Like	54			299	1.31	3.9	35.6	0.98	0.376	1.1	0.065	0.061	**N/A**
4.2	12.8	274	6	75.2	37.0	3	2.93	3.23	Clay-Like	59			274	1.30	3.5	35.0	0.98	0.376	1.1	0.065	0.060	**N/A**
4.3	12.8	296	6	77.0	37.8	4	2.62	3.18	Clay-Like	57			296	1.30	3.8	35.4	0.98	0.376	1.1	0.065	0.060	**N/A**
4.4	12.8	307	6	78.8	38.7	4	2.43	3.16	Clay-Like	56			307	1.29	3.9	35.6	0.98	0.377	1.1	0.065	0.061	**N/A**
4.5	12.8	280	5	80.6	39.5	3	2.69	3.23	Clay-Like	59			280	1.28	3.5	35.1	0.98	0.377	1.1	0.065	0.060	**N/A**
4.6	12.8	283	4	82.4	40.3	3	2.05	3.17	Clay-Like	56			283	1.27	3.6	35.1	0.98	0.377	1.1	0.065	0.060	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-67**

Test Boring Information:

Approx. ground elevation		4	ft	1.22 m
Approx. water table elevation		2	ft	0.61 m
Approx. depth to ground water table		2	ft	0.61 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	1062	5	1.6	1.6	84	0.43	1.1	Unsaturated	4			1062	1.70	17.9	17.9	1.00	0.189	1.1	0.055	0.053	**N/A**
0.2	0.7	1625	4	3.1	3.1	91	0.22	1	Unsaturated	3			1625	1.70	27.3	27.3	1.00	0.189	1.1	0.060	0.057	**N/A**
0.3	1.0	1931	4	4.7	4.7	88	0.22	1.08	Unsaturated	3			1931	1.70	32.5	32.5	1.00	0.189	1.1	0.063	0.061	**N/A**
0.4	1.3	2417	5	6.3	6.3	96	0.19	1.07	Unsaturated	3			2417	1.70	40.7	40.7	1.00	0.189	1.1	0.069	0.067	**N/A**
0.5	1.6	2447	4	7.9	7.9	86	0.16	1.13	Unsaturated	4			2447	1.70	41.2	41.2	1.00	0.189	1.1	0.070	0.067	**N/A**
0.6	2.0	2143	3	9.4	9.4	69	0.13	1.23	Unsaturated	5			2143	1.70	36.1	36.1	1.00	0.189	1.1	0.066	0.063	**N/A**
0.7	2.3	2053	3	11.2	10.3	63	0.15	1.33		6			2053	1.70	34.6	34.7	1.00	0.205	1.1	0.065	0.062	**0.30**
0.8	2.6	3161	6	13.0	11.2	94	0.20	1.26		5			3161	1.70	53.2	53.2	1.00	0.220	1.1	0.081	0.078	**0.35**
0.9	3.0	5242	18	14.8	12.0	150	0.34	1.23		5			5242	1.70	88.2	88.2	1.00	0.233	1.1	0.124	0.120	**0.51**
1.0	3.3	6496	25	16.6	12.8	180	0.39	1.23		5			6496	1.70	109.3	109.4	1.00	0.245	1.1	0.159	0.153	**0.62**
1.1	3.6	6806	28	18.4	13.6	183	0.41	1.27		5			6806	1.70	114.3	114.3	1.00	0.255	1.1	0.168	0.162	**0.63**
1.2	3.9	6669	32	20.3	14.5	174	0.48	1.34		6			6669	1.67	110.3	110.6	1.00	0.264	1.1	0.161	0.155	**0.59**
1.3	4.3	6895	33	22.1	15.3	175	0.49	1.36		6			6895	1.65	112.3	112.9	1.00	0.272	1.1	0.165	0.159	**0.59**
1.4	4.6	7014	35	23.9	16.1	173	0.51	1.39		7			7014	1.62	112.7	113.7	1.00	0.279	1.1	0.167	0.161	**0.58**
1.5	4.9	6833	36	25.7	16.9	164	0.53	1.44		7			6833	1.60	108.3	110.5	1.00	0.285	1.1	0.161	0.155	**0.54**
1.6	5.2	5794	32	27.5	17.8	136	0.56	1.52		8			5794	1.58	90.7	95.9	1.00	0.291	1.1	0.136	0.131	**0.45**
1.7	5.6	4481	26	29.3	18.6	103	0.58	1.63		10			4481	1.56	69.3	80.4	1.00	0.296	1.1	0.113	0.109	**0.37**
1.8	5.9	3527	22	31.1	19.4	79	0.63	1.75		12			3527	1.54	53.9	72.1	1.00	0.301	1.1	0.102	0.099	**0.33**
1.9	6.2	3459	21	32.9	20.3	76	0.63	1.76		12			3459	1.53	52.3	71.0	1.00	0.305	1.1	0.101	0.097	**0.32**
2.0	6.6	3448	19	34.7	21.1	74	0.54	1.74		12			3448	1.51	51.6	68.8	1.00	0.309	1.1	0.098	0.095	**0.31**
2.1	6.9	2841	26	36.5	21.9	60	0.92	1.95		16			2841	1.50	42.1	70.6	0.99	0.313	1.1	0.100	0.097	**0.31**
2.2	7.2	1937	32	38.3	22.7	40	1.68	2.25		23			1937	1.48	28.4	63.5	0.99	0.316	1.1	0.092	0.088	**0.28**
2.3	7.5	1715	25	40.1	23.6	34	1.51	2.27		24			1715	1.47	24.9	59.4	0.99	0.319	1.1	0.087	0.084	**0.26**
2.4	7.9	2304	17	41.9	24.4	46	0.75	2		17			2304	1.45	33.2	61.9	0.99	0.322	1.1	0.090	0.087	**0.27**
2.5	8.2	2998	12	43.8	25.2	58	0.41	1.78		13			2998	1.44	42.8	61.5	0.99	0.325	1.1	0.089	0.086	**0.27**
2.6	8.5	3230	15	45.6	26.0	62	0.48	1.79		13			3230	1.43	45.7	65.5	0.99	0.327	1.1	0.094	0.091	**0.28**
2.7	8.9	3588	18	47.4	26.9	68	0.51	1.77		12			3588	1.42	50.4	69.4	0.99	0.329	1.1	0.099	0.095	**0.29**
2.8	9.2	3840	20	49.2	27.7	72	0.54	1.77		12			3840	1.41	53.5	73.0	0.99	0.332	1.1	0.103	0.100	**0.30**
2.9	9.5	3784	21	51.0	28.5	69	0.56	1.79		13			3784	1.40	52.3	73.0	0.99	0.334	1.1	0.103	0.100	**0.30**
3.0	9.8	3422	18	52.8	29.3	62	0.53	1.82		13			3422	1.39	46.9	68.8	0.99	0.336	1.1	0.098	0.095	**0.28**
3.1	10.2	3192	18	54.6	30.2	57	0.56	1.87		14			3192	1.38	43.5	67.8	0.99	0.337	1.1	0.097	0.093	**0.28**
3.2	10.5	3279	18	56.4	31.0	58	0.56	1.87		14			3279	1.37	44.3	68.9	0.99	0.339	1.1	0.098	0.094	**0.28**
3.3	10.8	3444	19	58.2	31.8	60	0.57	1.86		14			3444	1.36	46.2	70.5	0.99	0.340	1.1	0.100	0.096	**0.28**
3.4	11.2	3925	21	60.0	32.7	67	0.55	1.81		13			3925	1.35	52.3	74.4	0.99	0.342	1.1	0.105	0.101	**0.30**
3.5	11.5	4287	23	61.8	33.5	73	0.55	1.79		13			4287	1.34	56.8	78.2	0.99	0.343	1.1	0.110	0.106	**0.31**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	4276	22	63.6	34.3	71	0.52	1.78		13			4276	1.33	56.3	76.9	0.99	0.345	1.1	0.108	0.104	**0.30**
3.7	12.1	4176	20	65.5	35.1	69	0.48	1.78		13			4176	1.32	54.6	75.0	0.98	0.346	1.1	0.106	0.101	**0.29**
3.8	12.5	3772	26	67.3	36.0	61	0.71	1.91		15			3772	1.31	49.0	76.8	0.98	0.347	1.1	0.108	0.104	**0.30**
3.9	12.8	2471	40	69.1	36.8	39	1.65	2.29		24			2471	1.31	31.9	68.9	0.98	0.348	1.1	0.098	0.093	**0.27**
4.0	12.8	935	30	70.9	37.6	14	3.50	2.84	Clay-Like	42			935	1.30	12.0	46.4	0.98	0.349	1.1	0.074	0.069	**N/A**
4.1	12.8	530	10	72.7	38.4	7	2.22	2.93	Clay-Like	46			530	1.29	6.8	39.4	0.98	0.350	1.1	0.068	0.063	**N/A**
4.2	12.8	481	6	74.5	39.3	6	1.46	2.87	Clay-Like	43			481	1.28	6.1	38.5	0.98	0.351	1.1	0.067	0.063	**N/A**
4.3	12.8	413	6	76.3	40.1	5	1.74	2.97	Clay-Like	47			413	1.28	5.2	37.4	0.98	0.352	1.1	0.067	0.062	**N/A**
4.4	12.8	402	6	78.1	40.9	5	1.89	3	Clay-Like	49			402	1.27	5.0	37.1	0.98	0.353	1.1	0.066	0.061	**N/A**
4.5	12.8	429	7	79.9	41.7	5	2.00	2.99	Clay-Like	48			429	1.26	5.4	37.6	0.98	0.353	1.1	0.067	0.062	**N/A**
4.6	12.8	442	8	81.7	42.6	5	2.13	3.01	Clay-Like	49			442	1.26	5.5	37.7	0.98	0.354	1.1	0.067	0.062	**N/A**
4.7	12.8	377	7	83.5	43.4	4	2.22	3.08	Clay-Like	52			377	1.25	4.7	36.6	0.98	0.355	1.1	0.066	0.061	**N/A**
4.8	12.8	385	6	85.3	44.2	4	1.98	3.06	Clay-Like	51			385	1.24	4.7	36.7	0.98	0.355	1.1	0.066	0.061	**N/A**
4.9	12.8	409	6	87.1	45.1	5	1.93	3.03	Clay-Like	50			409	1.24	5.0	37.1	0.98	0.356	1.1	0.066	0.061	**N/A**
5.0	12.8	397	7	89.0	45.9	5	2.24	3.08	Clay-Like	52			397	1.23	4.8	36.9	0.98	0.356	1.0	0.066	0.061	**N/A**
5.1	12.8	372	7	90.8	46.7	4	2.35	3.12	Clay-Like	54			372	1.23	4.5	36.4	0.97	0.357	1.0	0.066	0.060	**N/A**
5.2	12.8	381	7	92.6	47.5	4	2.43	3.13	Clay-Like	54			381	1.22	4.6	36.5	0.97	0.357	1.0	0.066	0.060	**N/A**
5.3	12.8	389	8	94.4	48.4	4	2.57	3.14	Clay-Like	55			389	1.21	4.7	36.6	0.97	0.358	1.0	0.066	0.060	**N/A**
5.4	12.8	389	7	96.2	49.2	4	2.49	3.14	Clay-Like	55			389	1.21	4.7	36.6	0.97	0.358	1.0	0.066	0.060	**N/A**
5.5	12.8	371	5	98.0	50.0	4	1.86	3.1	Clay-Like	53			371	1.20	4.4	36.3	0.97	0.359	1.0	0.066	0.060	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-68**

Test Boring Information:

Approx. ground elevation		1	ft	0.30 m
Approx. water table elevation		0	ft	0.00 m
Approx. depth to ground water table		1	ft	0.30 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3																					
0.2	0.7																					
0.3	1.0																					
0.4	1.3																					
0.5	1.6	Hand augered through 0.5 m																				
0.6	2.0	516	1	10.1	7.2	19	0.23	1.88		14			516	1.70	8.7	26.9	1.00	0.264	1.1	0.059	0.057	**0.22**
0.7	2.3	1504	4	11.9	8.1	52	0.26	1.52		8			1504	1.70	25.3	28.6	1.00	0.279	1.1	0.060	0.058	**0.21**
0.8	2.6	1430	4	13.7	8.9	47	0.28	1.61		10			1430	1.70	24.1	30.9	1.00	0.292	1.1	0.062	0.060	**0.20**
0.9	3.0	1406	4	15.6	9.7	44	0.29	1.67		11			1406	1.70	23.7	33.5	1.00	0.302	1.1	0.064	0.061	**0.20**
1.0	3.3	1528	6	17.4	10.5	46	0.37	1.73		12			1528	1.70	25.7	39.1	1.00	0.310	1.1	0.068	0.065	**0.21**
1.1	3.6	1761	7	19.2	11.4	51	0.43	1.74		12			1761	1.70	29.6	44.1	1.00	0.318	1.1	0.072	0.069	**0.22**
1.2	3.9	1752	6	21.0	12.2	49	0.37	1.75		12			1752	1.70	29.5	44.5	1.00	0.324	1.1	0.072	0.070	**0.22**
1.3	4.3	1690	5	22.8	13.0	46	0.33	1.77		12			1690	1.70	28.5	44.5	1.00	0.330	1.1	0.072	0.070	**0.21**
1.4	4.6	1652	6	24.6	13.8	43	0.39	1.84		14			1652	1.69	27.6	47.4	1.00	0.334	1.1	0.075	0.072	**0.22**
1.5	4.9	1599	6	26.4	14.7	41	0.38	1.88		14			1599	1.66	26.3	48.0	1.00	0.339	1.1	0.076	0.073	**0.22**
1.6	5.2	1368	5	28.2	15.5	34	0.38	1.97		16			1368	1.64	22.2	47.1	1.00	0.342	1.1	0.075	0.072	**0.21**
1.7	5.6	1186	5	30.0	16.3	28	0.46	2.08		19			1186	1.62	19.0	47.0	1.00	0.346	1.1	0.075	0.072	**0.21**
1.8	5.9	1087	5	31.8	17.2	25	0.52	2.17		21			1087	1.60	17.2	47.2	1.00	0.349	1.1	0.075	0.072	**0.21**
1.9	6.2	1001	5	33.6	18.0	23	0.54	2.23		23			1001	1.58	15.6	46.4	1.00	0.351	1.1	0.074	0.071	**0.20**
2.0	6.6	991	5	35.4	18.8	22	0.56	2.26		23			991	1.56	15.3	46.5	1.00	0.354	1.1	0.074	0.072	**0.20**
2.1	6.9	1048	6	37.2	19.6	23	0.64	2.28		24			1048	1.54	16.0	47.8	0.99	0.356	1.1	0.075	0.073	**0.20**
2.2	7.2	1174	7	39.1	20.5	25	0.57	2.23		23			1174	1.52	17.7	49.1	0.99	0.358	1.1	0.077	0.074	**0.21**
2.3	7.5	1166	8	40.9	21.3	24	0.72	2.3		24			1166	1.51	17.4	50.0	0.99	0.360	1.1	0.077	0.075	**0.21**
2.4	7.9	1573	9	42.7	22.1	32	0.59	2.16		21			1573	1.49	23.3	54.7	0.99	0.361	1.1	0.082	0.079	**0.22**
2.5	8.2	1984	8	44.5	22.9	40	0.40	2.01		17			1984	1.48	29.0	57.2	0.99	0.363	1.1	0.085	0.082	**0.23**
2.6	8.5	2162	7	46.3	23.8	43	0.33	1.96		16			2162	1.46	31.3	57.9	0.99	0.364	1.1	0.086	0.082	**0.23**
2.7	8.9	2268	8	48.1	24.6	44	0.35	1.96		16			2268	1.45	32.6	59.4	0.99	0.365	1.1	0.087	0.084	**0.23**
2.8	9.2	2410	9	49.9	25.4	47	0.40	1.98		17			2410	1.44	34.3	62.5	0.99	0.367	1.1	0.091	0.087	**0.24**
2.9	9.5	2679	12	51.7	26.2	51	0.45	1.97		16			2679	1.43	37.9	66.3	0.99	0.368	1.1	0.095	0.092	**0.25**
3.0	9.8	2782	13	53.5	27.1	52	0.48	1.98		17			2782	1.42	39.0	68.2	0.99	0.369	1.1	0.097	0.094	**0.25**
3.1	10.2	2017	22	55.3	27.9	37	1.13	2.3		24			2017	1.40	28.0	64.0	0.99	0.370	1.1	0.092	0.089	**0.24**
3.2	10.5	888	26	57.1	28.7	15	3.16	2.87	Clay-Like	43			888	1.39	12.3	46.8	0.99	0.370	1.1	0.074	0.071	**N/A**
3.3	10.8	442	17	58.9	29.6	7	4.40	3.2	Clay-Like	58			442	1.38	6.1	38.5	0.99	0.371	1.1	0.067	0.064	**N/A**
3.4	11.2	334	7	60.7	30.4	5	2.52	3.16	Clay-Like	56			334	1.37	4.5	36.4	0.99	0.372	1.1	0.066	0.062	**N/A**
3.5	11.5	329	6	62.6	31.2	5	2.37	3.16	Clay-Like	56			329	1.36	4.4	36.3	0.99	0.373	1.1	0.066	0.062	**N/A**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	325	6	64.4	32.0	5	2.42	3.18	Clay-Like	57			325	1.35	4.4	36.2	0.99	0.373	1.1	0.066	0.062	**N/A**
3.7	12.1	319	5	66.2	32.9	4	1.93	3.14	Clay-Like	55			319	1.34	4.2	36.0	0.98	0.374	1.1	0.066	0.061	**N/A**
3.8	12.5	312	5	68.0	33.7	4	1.96	3.16	Clay-Like	56			312	1.34	4.1	35.9	0.98	0.374	1.1	0.065	0.061	**N/A**
3.9	12.8	309	5	69.8	34.5	4	2.00	3.17	Clay-Like	56			309	1.33	4.1	35.8	0.98	0.375	1.1	0.065	0.061	**N/A**
4.0	13.1	309	4	71.6	35.3	4	1.85	3.16	Clay-Like	56			309	1.32	4.0	35.8	0.98	0.375	1.1	0.065	0.061	**N/A**
4.1	13.5	315	4	73.4	36.2	4	1.67	3.14	Clay-Like	55			315	1.31	4.1	35.8	0.98	0.376	1.1	0.065	0.061	**N/A**
4.2	13.8	318	5	75.2	37.0	4	1.89	3.16	Clay-Like	56			318	1.30	4.1	35.8	0.98	0.376	1.1	0.065	0.061	**N/A**
4.3	14.1	333	5	77.0	37.8	4	1.95	3.16	Clay-Like	56			333	1.30	4.3	36.1	0.98	0.376	1.1	0.066	0.061	**N/A**
4.4	14.4	322	4	78.8	38.7	4	1.65	3.15	Clay-Like	55			322	1.29	4.1	35.8	0.98	0.377	1.1	0.065	0.061	**N/A**
4.5	14.8	304	4	80.6	39.5	4	1.89	3.2	Clay-Like	58			304	1.28	3.9	35.5	0.98	0.377	1.1	0.065	0.060	**N/A**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-69**

Test Boring Information:

Approx. ground elevation		11	ft	3.35 m
Approx. water table elevation		1	ft	0.30 m
Approx. depth to ground water table		10	ft	3.05 m
Moist unit weight of soil	γ_m	100	pcf	15.72 kN/m^3
Saturated unit weight of soil	γ_{sat}	115	pcf	18.08 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g
Magnitude Scaling Factor	M_F	0.88

Atomospheric pressure	P_a	101.3 kPa

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)

Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
0.1	0.3	2723	11	1.6	1.6	216	0.40	0.88	Unsaturated	2			2723	1.70	45.8	45.8	1.00	0.189	1.1	0.074	0.071	**N/A**
0.2	0.7	2926	9	3.1	3.1	164	0.31	0.91	Unsaturated	2			2926	1.70	49.3	49.3	1.00	0.189	1.1	0.077	0.074	**N/A**
0.3	1.0	3270	12	4.7	4.7	149	0.36	1.04	Unsaturated	3			3270	1.70	55.0	55.0	1.00	0.189	1.1	0.083	0.080	**N/A**
0.4	1.3	5318	35	6.3	6.3	210	0.66	1.21	Unsaturated	5			5318	1.70	89.5	89.5	1.00	0.189	1.1	0.126	0.122	**N/A**
0.5	1.6	6612	100	7.9	7.9	234	1.52	1.53	Unsaturated	8			6612	1.70	111.3	117.7	1.00	0.189	1.1	0.175	0.168	**N/A**
0.6	2.0	6547	78	9.4	9.4	212	1.20	1.48	Unsaturated	8			6547	1.70	110.2	113.9	1.00	0.189	1.1	0.167	0.161	**N/A**
0.7	2.3	4538	27	11.0	11.0	136	0.60	1.37	Unsaturated	6			4538	1.70	76.4	76.9	1.00	0.189	1.1	0.108	0.105	**N/A**
0.8	2.6	4139	30	12.6	12.6	116	0.73	1.49	Unsaturated	8			4139	1.70	69.7	73.0	1.00	0.189	1.1	0.103	0.100	**N/A**
0.9	3.0	8859	47	14.1	14.1	234	0.54	1.21	Unsaturated	5			8859	1.68	147.3	147.3	1.00	0.189	1.1	0.260	0.250	**N/A**
1.0	3.3	9651	37	15.7	15.7	241	0.38	1.11	Unsaturated	4			9651	1.63	156.1	156.1	1.00	0.189	1.1	0.302	0.291	**N/A**
1.1	3.6	9606	58	17.3	17.3	229	0.61	1.29	Unsaturated	5			9606	1.59	151.5	151.6	1.00	0.189	1.1	0.279	0.269	**N/A**
1.2	3.9	10394	115	18.9	18.9	237	1.10	1.5	Unsaturated	8			10394	1.56	160.2	166.0	1.00	0.188	1.1	0.371	0.358	**N/A**
1.3	4.3	9062	131	20.4	20.4	199	1.45	1.65	Unsaturated	10			9062	1.52	136.8	154.7	1.00	0.188	1.1	0.294	0.284	**N/A**
1.4	4.6	10400	126	22.0	22.0	220	1.22	1.57	Unsaturated	9			10400	1.49	153.9	165.0	1.00	0.188	1.1	0.362	0.349	**N/A**
1.5	4.9	14606	73	23.6	23.6	298	0.50	1.19	Unsaturated	4			14606	1.47	212.3	212.3	1.00	0.188	1.1	2.000	1.927	**N/A**
1.6	5.2	15396	122	25.2	25.2	305	0.80	1.36	Unsaturated	6			15396	1.44	220.0	220.8	1.00	0.188	1.1	2.000	1.927	**N/A**
1.7	5.6	19145	93	26.7	26.7	367	0.48	1.14	Unsaturated	4			19145	1.42	269.2	269.2	1.00	0.188	1.1	2.000	1.927	**N/A**
1.8	5.9	12595	62	28.3	28.3	235	0.50	1.29	Unsaturated	5			12595	1.40	174.4	174.6	1.00	0.188	1.1	0.458	0.442	**N/A**
1.9	6.2	5613	32	29.9	29.9	101	0.58	1.62	Unsaturated	10			5613	1.38	76.6	87.5	1.00	0.188	1.1	0.123	0.119	**N/A**
2.0	6.6	5128	59	31.4	31.4	90	1.17	1.86	Unsaturated	14			5128	1.36	69.1	97.5	1.00	0.188	1.1	0.139	0.133	**N/A**
2.1	6.9	7203	106	33.0	33.0	124	1.47	1.85	Unsaturated	14			7203	1.34	95.8	128.3	0.99	0.188	1.1	0.199	0.191	**N/A**
2.2	7.2	8838	141	34.6	34.6	149	1.60	1.83	Unsaturated	13			8838	1.33	116.1	150.3	0.99	0.187	1.1	0.273	0.263	**N/A**
2.3	7.5	11961	125	36.2	36.2	197	1.05	1.61	Unsaturated	10			11961	1.31	155.3	170.3	0.99	0.187	1.1	0.411	0.396	**N/A**
2.4	7.9	15624	104	37.7	37.7	252	0.67	1.4	Unsaturated	7			15624	1.30	200.6	202.2	0.99	0.187	1.1	1.265	1.219	**N/A**
2.5	8.2	14672	84	39.3	39.3	232	0.58	1.39	Unsaturated	7			14672	1.28	186.3	187.7	0.99	0.187	1.1	0.689	0.664	**N/A**
2.6	8.5	9891	119	40.9	40.9	153	1.21	1.75	Unsaturated	12			9891	1.27	124.3	151.6	0.99	0.187	1.1	0.279	0.269	**N/A**
2.7	8.9	11744	111	42.4	42.4	178	0.95	1.63	Unsaturated	10			11744	1.26	146.2	162.7	0.99	0.187	1.1	0.345	0.332	**N/A**
2.8	9.2	15014	168	44.0	44.0	224	1.12	1.63	Unsaturated	10			15014	1.24	185.1	204.4	0.99	0.187	1.1	1.404	1.353	**N/A**
2.9	9.5	14963	137	45.6	45.6	220	0.92	1.58	Unsaturated	9			14963	1.23	182.7	196.2	0.99	0.187	1.1	0.961	0.926	**N/A**
3.0	9.8	10980	78	47.2	47.2	158	0.71	1.6	Unsaturated	10			10980	1.22	132.9	145.6	0.99	0.187	1.1	0.253	0.244	**N/A**
3.1	10.2	10844	53	48.9	48.4	154	0.49	1.51		8			10844	1.21	130.4	136.1	0.99	0.188	1.1	0.220	0.212	**1.13**
3.2	10.5	8682	49	50.7	49.2	122	0.56	1.63		10			8682	1.21	103.9	117.5	0.99	0.192	1.1	0.174	0.166	**0.87**
3.3	10.8	7925	35	52.5	50.0	111	0.44	1.61		10			7925	1.20	94.5	105.7	0.99	0.195	1.1	0.152	0.144	**0.74**
3.4	11.2	10077	20	54.3	50.8	140	0.20	1.36		6			10077	1.20	119.6	120.1	0.99	0.199	1.1	0.180	0.171	**0.86**
3.5	11.5	8825	13	56.1	51.7	121	0.15	1.38		6			8825	1.19	104.3	105.0	0.99	0.202	1.1	0.151	0.142	**0.70**

Factor of Safety Against Liquefaction Based on Idriss & Boulanger (2008)																						
Depth, Z (m)	Depth, Z (ft)	q_t (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_C Near Interface	Thin Layer Factor	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	CRR	$(FS)_L$
3.6	11.8	6498	12	57.9	52.5	88	0.19	1.54		9			6498	1.19	76.5	82.2	0.99	0.205	1.1	0.116	0.107	**0.52**
3.7	12.1	5941	14	59.7	53.3	80	0.24	1.63		10			5941	1.18	69.6	80.7	0.98	0.208	1.1	0.114	0.105	**0.51**
3.8	12.5	5337	19	61.5	54.1	71	0.36	1.75		12			5337	1.18	62.3	81.5	0.98	0.211	1.1	0.115	0.106	**0.50**
3.9	12.8	4677	16	63.3	55.0	62	0.35	1.8		13			4677	1.17	54.4	76.1	0.98	0.214	1.1	0.107	0.099	**0.46**
4.0	13.1	4330	13	65.1	55.8	57	0.30	1.81		13			4330	1.17	50.1	71.9	0.98	0.216	1.1	0.102	0.094	**0.43**
4.1	13.5	3840	19	66.9	56.6	50	0.50	1.96		16			3840	1.16	44.3	73.8	0.98	0.219	1.1	0.104	0.096	**0.44**
4.2	13.8	3491	13	68.7	57.4	45	0.39	1.95		16			3491	1.16	40.1	68.1	0.98	0.221	1.0	0.097	0.089	**0.40**
4.3	14.1	2661	13	70.5	58.3	34	0.50	2.11		20			2661	1.16	30.5	62.5	0.98	0.224	1.0	0.091	0.083	**0.37**
4.4	14.4	2619	3	72.4	59.1	33	0.14	1.95		16			2619	1.15	29.9	55.6	0.98	0.226	1.0	0.083	0.076	**0.33**
4.5	14.8	2754	8	74.2	59.9	34	0.31	2.03		18			2754	1.15	31.3	60.8	0.98	0.228	1.0	0.089	0.081	**0.35**
4.6	15.1	2533	34	76.0	60.8	31	1.38	2.37		26			2533	1.14	28.7	65.9	0.98	0.231	1.0	0.095	0.086	**0.37**
4.7	15.4	3406	35	77.8	61.6	42	1.06	2.2		22			3406	1.14	38.4	75.4	0.98	0.233	1.0	0.106	0.097	**0.42**
4.8	15.7	3252	17	79.6	62.4	40	0.54	2.07		19			3252	1.14	36.6	68.9	0.98	0.235	1.0	0.098	0.090	**0.38**
4.9	16.1	2741	3	81.4	63.2	33	0.10	1.93		15			2741	1.13	30.7	55.7	0.98	0.237	1.0	0.083	0.075	**0.32**
5.0	16.4	2609	5	83.2	64.1	31	0.19	2.01		17			2609	1.13	29.1	57.3	0.98	0.239	1.0	0.085	0.077	**0.32**
5.1	16.7	2632	4	85.0	64.9	31	0.17	2		17			2632	1.12	29.3	57.1	0.97	0.241	1.0	0.085	0.077	**0.32**
5.2	17.1	2625	5	86.8	65.7	31	0.20	2.02		17			2625	1.12	29.1	57.7	0.97	0.243	1.0	0.085	0.077	**0.32**
5.3	17.4	2681	9	88.6	66.5	32	0.33	2.09		19			2681	1.12	29.6	60.9	0.97	0.244	1.0	0.089	0.080	**0.33**
5.4	17.7	3234	11	90.4	67.4	38	0.34	2.02		17			3234	1.11	35.6	65.8	0.97	0.246	1.0	0.095	0.085	**0.35**
5.5	18.0	3525	10	92.2	68.2	41	0.30	1.97		16			3525	1.11	38.7	67.4	0.97	0.248	1.0	0.096	0.087	**0.35**
5.6	18.4	3574	10	94.0	69.0	42	0.29	1.96		16			3574	1.11	39.1	67.4	0.97	0.249	1.0	0.096	0.087	**0.35**
5.7	18.7	4114	14	95.9	69.8	48	0.35	1.94		16			4114	1.10	44.9	73.5	0.97	0.251	1.0	0.104	0.094	**0.37**
5.8	19.0	4793	16	97.7	70.7	55	0.34	1.88		14			4793	1.10	52.1	78.7	0.97	0.252	1.0	0.111	0.100	**0.40**
5.9	19.4	5631	17	99.5	71.5	65	0.30	1.79		13			5631	1.10	61.1	83.1	0.97	0.254	1.0	0.117	0.106	**0.42**
6.0	19.7	6049	18	101.3	72.3	69	0.30	1.77		12			6049	1.09	65.4	86.6	0.97	0.255	1.0	0.122	0.110	**0.43**
6.1	20.0	5770	19	103.1	73.2	66	0.33	1.81		13			5770	1.09	62.2	85.9	0.97	0.257	1.0	0.121	0.109	**0.42**
6.2	20.3	5674	19	104.9	74.0	64	0.34	1.82		13			5674	1.09	61.0	85.2	0.97	0.258	1.0	0.120	0.108	**0.42**
6.3	20.7	6192	24	106.7	74.8	70	0.39	1.82		13			6192	1.08	66.4	91.4	0.97	0.259	1.0	0.129	0.116	**0.45**
6.4	21.0	6620	20	108.5	75.6	74	0.31	1.75		12			6620	1.08	70.7	91.1	0.96	0.261	1.0	0.129	0.116	**0.44**
6.5	21.3	5723	16	110.3	76.5	64	0.29	1.8		13			5723	1.08	61.0	83.7	0.96	0.262	1.0	0.118	0.106	**0.40**
6.6	21.7	5182	15	112.1	77.3	57	0.30	1.86		14			5182	1.07	55.1	80.9	0.96	0.263	1.0	0.114	0.102	**0.39**
6.7	22.0	5540	16	113.9	78.1	61	0.29	1.83		13			5540	1.07	58.7	83.2	0.96	0.264	1.0	0.117	0.105	**0.40**
6.8	22.3	5825	18	115.7	78.9	64	0.32	1.83		13			5825	1.07	61.5	86.5	0.96	0.266	1.0	0.122	0.109	**0.41**
6.9	22.6	4524	35	117.5	79.8	49	0.80	2.12		20			4524	1.06	47.7	84.8	0.96	0.267	1.0	0.119	0.107	**0.40**
7.0	23.0	1756	35	119.4	80.6	18	2.15	2.72	Clay-Like	38			1756	1.06	18.5	54.8	0.96	0.268	1.0	0.082	0.073	**N/A**
7.1	23.3	817	10	121.2	81.4	8	1.42	2.92	Clay-Like	45			817	1.06	8.6	41.8	0.96	0.269	1.0	0.070	0.062	**N/A**
7.2	23.6	682	2	123.0	82.2	6	0.41	2.78	Clay-Like	40			682	1.06	7.1	39.7	0.96	0.270	1.0	0.068	0.061	**N/A**
7.3	24.0	609	3	124.8	83.1	5	0.59	2.88	Clay-Like	44			609	1.05	6.3	38.8	0.96	0.271	1.0	0.068	0.060	**N/A**
7.4	24.3	511	2	126.6	83.9	4	0.50	2.93	Clay-Like	46			511	1.05	5.3	37.5	0.96	0.272	1.0	0.067	0.059	**N/A**
7.5	24.6	473	2	128.4	84.7	4	0.56	2.99	Clay-Like	48			473	1.05	4.9	36.9	0.95	0.273	1.0	0.066	0.059	**N/A**
7.6	24.9	444	2	130.2	85.6	3	0.61	3.04	Clay-Like	50			444	1.04	4.6	36.5	0.95	0.274	1.0	0.066	0.058	**N/A**
7.7	25.262	453	2	132.0	86.4	3	0.60	3.03	Clay-Like	50			453	1.04	4.7	36.6	0.95	0.275	1.0	0.066	0.058	**N/A**
7.8	25.591	429	2	133.8	87.2	3	0.65	3.07	Clay-Like	52			429	1.04	4.4	36.3	0.95	0.275	1.0	0.066	0.058	**N/A**
7.9	25.919	420	2	135.6	88.0	3	0.67	3.1	Clay-Like	53			420	1.04	4.3	36.1	0.95	0.276	1.0	0.066	0.058	**N/A**
8	26.247	422	2	137.4	88.9	3	0.67	3.1	Clay-Like	53			422	1.03	4.3	36.2	0.95	0.277	1.0	0.066	0.058	**N/A**
8.1	26.575	429	2	139.2	89.7	3	0.66	3.1	Clay-Like	53			429	1.03	4.4	36.2	0.95	0.278	1.0	0.066	0.058	**N/A**
8.2	26.903	426	2	141.1	90.5	3	0.67	3.11	Clay-Like	53			426	1.03	4.3	36.2	0.95	0.279	1.0	0.066	0.058	**N/A**

ATTACHMENT E5

Symbols used in the Spreadsheet Tables of Attachment E-5	
Z	Depth below ground surface
q_t	Cone tip resistance
f_s	Sleeve friction
OCR	Over-consoldiation ratio
σ_{vc}	Total vertical stress
σ'_{vc}	Effective vertical stress
$\alpha(z)$	Parameter used to estimate r_d
$\beta(z)$	Parameter used to estimate r_d
r_d	Shear stress reduction coefficient
Q	Normalized cone resistance
τ_{peak}	Peak cyclic shear stress
τ_s	Static shear stress
α	Ration of static shear stress to effective vertical stress
CSR_M	cyclic stress ratio at earthquake magnitude M
CRR_M	Cyclic resistance ratio at earthquake magnitude of M
FS	Factor of safety against cyclic softening

POTENTIAL FOR CYCLIC SOFTENING OF CLAYS AND PLASTIC SILTS

References:

Referenc Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**2002_CPT-15**

CPT Information:

Ground elevation		11.7 ft
Water table elevation		4 ft
Depth to ground water table		7.7 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	100 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g

Factor of safety from slope stability analysis	F	1.5

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	q_t (tsf)	f_s (tsf)	S_u Gregg (tsf)	S_u $0.3\sigma'_{vc}$ (psf)	OCR	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	τ_{peak} (psf)	MSF	$\tau_s = S_u/F$ (psf)	$\alpha = \tau_s/\sigma'_{vc}$	K_α	CSR_M	CRR_M	FS
0.49	14.7	0.34	1.17	115	10	49	49	0.010	-0.001	1.00	14	0.98	77	1.56				
1.48	20	0.46	1.59	115	3	148	148	-0.003	0.001	1.00	43	0.98	77	0.52				
2.46	30.5	0.94	2.43	115	2	246	246	-0.016	0.002	1.00	71	0.98	77	0.31				
3.44	14.7	0.45	1.16	115	1	344	344	-0.029	0.004	1.00	100	0.98	77	0.22	0.651	0.189	0.170	0.90
4.43	9.8	0.49	0.76	133	1	443	443	-0.044	0.005	1.00	128	0.98	89	0.20	0.651	0.188	0.153	0.81
5.41	8.4	0.46	0.65	162	1	541	541	-0.059	0.007	1.00	156	0.98	108	0.20	0.651	0.188	0.153	0.81
6.4	35.9	0.77	2.84	192	1	640	640	-0.074	0.009	1.00	185	0.98	128	0.20	0.651	0.188	0.153	0.81
7.3	73	1.64				730	730	-0.089	0.010	0.99	210	0.98	N/A	N/A	N/A	N/A	N/A	N/A
8.2	27.5	0.75	2.16	237	1	820	788.8	-0.105	0.012	0.99	236	0.98	158	0.20	0.651	0.195	0.153	0.79
9.19	2.3	0.01	0.14	248	1	919	826.02	-0.122	0.014	0.99	264	0.98	165	0.20	0.651	0.208	0.153	0.74
10.17	1.1	0.01	0.05	259	1	1017	862.87	-0.140	0.016	0.99	292	0.98	173	0.20	0.651	0.220	0.153	0.70
11.15	2.1	0.04	0.12	270	1	1115	899.72	-0.158	0.018	0.99	319	0.98	180	0.20	0.651	0.231	0.153	0.66
12.14	137.2	2.16				1214	936.94	-0.178	0.020	0.98	347	0.98	N/A	N/A	N/A	N/A	N/A	N/A
13.21	73.4	0.62				1321	977.18	-0.199	0.023	0.98	376	0.98	N/A	N/A	N/A	N/A	N/A	N/A
14.27	15.9	0.2	1.21	305	1	1427	1017	-0.221	0.025	0.98	406	0.98	203	0.20	0.651	0.259	0.153	0.59
15.26	3.2	0.03	0.19	316	1	1526	1054.3	-0.242	0.027	0.98	433	0.98	211	0.20	0.651	0.267	0.153	0.57
16.24	4.3	0.03	0.28	327	1	1624	1091.1	-0.263	0.030	0.98	460	0.98	218	0.20	0.651	0.274	0.153	0.56
17.22	3.7	0.03	0.22	338	1	1722	1128	-0.284	0.032	0.97	486	0.98	226	0.20	0.651	0.280	0.153	0.55
18.21	2.6	0.03	0.13	350	1	1821	1165.2	-0.307	0.035	0.97	513	0.98	233	0.20	0.651	0.286	0.153	0.53
19.19	2.6	0.03	0.13	361	1	1919	1202	-0.329	0.037	0.97	539	0.98	240	0.20	0.651	0.292	0.153	0.52
20.18	3.2	0.05	0.17	372	1	2018	1239.2	-0.353	0.040	0.97	566	0.98	248	0.20	0.651	0.297	0.153	0.52
21.16	2.8	0.05	0.14	383	1	2116	1276.1	-0.376	0.042	0.96	591	0.98	255	0.20	0.651	0.301	0.153	0.51
22.15	3.9	0.05	0.23	394	1	2215	1313.3	-0.400	0.045	0.96	617	0.98	263	0.20	0.651	0.306	0.153	0.50
23.13	3.2	0.03	0.16	405	1	2313	1350.2	-0.424	0.048	0.96	643	0.98	270	0.20	0.651	0.310	0.153	0.49
24.11	2.9	0.03	0.14	416	1	2411	1387	-0.449	0.051	0.96	668	0.98	277	0.20	0.651	0.313	0.153	0.49
25.1	3.2	0.07	0.16	427	1	2510	1424.2	-0.474	0.053	0.95	694	0.98	285	0.20	0.651	0.317	0.153	0.48
26.08	3.7	0.06	0.2	438	1	2608	1461.1	-0.500	0.056	0.95	719	0.98	292	0.20	0.651	0.320	0.153	0.48
27.07	3	0.03	0.14	449	1	2707	1498.3	-0.526	0.059	0.95	744	0.98	300	0.20	0.651	0.323	0.153	0.47
28.05	2.4	0.04	0.08	461	1	2805	1535.2	-0.552	0.062	0.95	769	0.98	307	0.20	0.651	0.325	0.153	0.47
29.04	3.2	0.03	0.14	472	1	2904	1572.4	-0.578	0.065	0.94	793	0.98	314	0.20	0.651	0.328	0.153	0.47
30.02	2.9	0.04	0.12	483	1	3002	1609.2	-0.605	0.068	0.94	818	0.98	322	0.20	0.651	0.330	0.153	0.46
31	3.1	0.04	0.13	494	1	3100	1646.1	-0.632	0.071	0.94	842	0.98	329	0.20	0.651	0.332	0.153	0.46
31.99	3.6	0.04	0.17	505	1	3199	1683.3	-0.659	0.074	0.93	866	0.98	337	0.20	0.651	0.334	0.153	0.46

Factor of Safety Against Liquefaction																		
Based on Idriss & Boulanger (2008)																		
Depth, Z (ft)	q_t (tsf)	f_s (tsf)	S_u Gregg (tsf)	S_u $0.3\sigma'_{vc}$ (psf)	OCR	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	τ_{peak} (psf)	MSF	$\tau_s = S_u/F$ (psf)	$\alpha = \tau_s/\sigma'_{vc}$	K_α	CSR_M	CRR_M	FS
32.97	3.5	0.05	0.16	516	1	3297	1720.2	-0.687	0.077	0.93	890	0.98	344	0.20	0.651	0.336	0.153	0.46
33.96	3.1	0.03	0.12	527	1	3396	1757.4	-0.714	0.080	0.93	913	0.98	351	0.20	0.651	0.338	0.153	0.45
34.94	3.6	0.04	0.16	538	1	3494	1794.2	-0.742	0.083	0.92	937	0.98	359	0.20	0.651	0.339	0.153	0.45
35.92	3.4	0.03	0.14	549	1	3592	1831.1	-0.770	0.086	0.92	960	0.98	366	0.20	0.651	0.341	0.153	0.45
36.91	4	0.04	0.19	560	1	3691	1868.3	-0.798	0.089	0.92	983	0.98	374	0.20	0.651	0.342	0.153	0.45
37.89	3.5	0.03	0.14	572	1	3789	1905.1	-0.827	0.092	0.91	1005	0.98	381	0.20	0.651	0.343	0.153	0.45
38.88	4.3	0.04	0.21	583	1	3888	1942.4	-0.855	0.095	0.91	1028	0.98	388	0.20	0.651	0.344	0.153	0.44
39.86	3.8	0.05	0.16	594	1	3986	1979.2	-0.884	0.098	0.91	1050	0.98	396	0.20	0.651	0.345	0.153	0.44
40.85	4.7	0.03	0.23	605	1	4085	2016.4	-0.913	0.102	0.91	1072	0.98	403	0.20	0.651	0.346	0.153	0.44
41.83	7.6	0.03	0.46	616	1	4183	2053.3	-0.941	0.105	0.90	1094	0.98	411	0.20	0.651	0.346	0.153	0.44
42.81	4.5	0.01	0.21	627	1	4281	2090.1	-0.970	0.108	0.90	1116	0.98	418	0.20	0.651	0.347	0.153	0.44
43.8	4.6	0.02	0.21	638	1	4380	2127.4	-0.999	0.111	0.90	1137	0.98	425	0.20	0.651	0.347	0.153	0.44
44.78	5	0.03	0.24	649	1	4478	2164.2	-1.027	0.114	0.89	1158	0.98	433	0.20	0.651	0.348	0.153	0.44
45.77	6.9	0.03	0.39	660	1	4577	2201.4	-1.056	0.117	0.89	1180	0.98	440	0.20	0.651	0.348	0.153	0.44
46.75	5.2	0.02	0.25	671	1	4675	2238.3	-1.085	0.120	0.89	1200	0.98	448	0.20	0.651	0.349	0.153	0.44
47.74	28.7	0.06				4774	2275.5	-1.114	0.124	0.88	1221	0.98	N/A	N/A	N/A	N/A	N/A	N/A
48.72	80.4	0.64				4872	2312.4	-1.142	0.127	0.88	1241	0.98	N/A	N/A	N/A	N/A	N/A	N/A
49.7	38	1.27	2.86	705	1	4970	2349.2	-1.171	0.130	0.88	1261	0.98	470	0.20	0.651	0.349	0.153	0.44
50.69	23	1.13	1.66	716	1	5069	2386.4	-1.200	0.133	0.87	1281	0.98	477	0.20	0.651	0.349	0.153	0.44
51.67	26.7	1.48	1.95	727	1	5167	2423.3	-1.228	0.136	0.87	1301	0.98	485	0.20	0.651	0.349	0.153	0.44
52.66	32.3	1.67	2.39	738	1	5266	2460.5	-1.256	0.139	0.86	1321	0.98	492	0.20	0.651	0.349	0.153	0.44
53.64	83.9	2.78	6.52	749	1	5364	2497.3	-1.284	0.142	0.86	1340	0.98	499	0.20	0.651	0.349	0.153	0.44
54.63	35.2	1.5	2.61	760	1	5463	2534.6	-1.312	0.145	0.86	1359	0.98	507	0.20	0.651	0.349	0.153	0.44
55.61	52.6	1.87	4	771	1	5561	2571.4	-1.340	0.148	0.85	1378	0.98	514	0.20	0.651	0.348	0.153	0.44
56.59	154.6	2.17				5659	2608.3	-1.367	0.151	0.85	1396	0.98	N/A	N/A	N/A	N/A	N/A	N/A
57.58	121.4	0.97				5758	2645.5	-1.394	0.154	0.85	1415	0.98	N/A	N/A	N/A	N/A	N/A	N/A
58.56	149.4	1.85				5856	2682.3	-1.421	0.156	0.84	1433	0.98	N/A	N/A	N/A	N/A	N/A	N/A
59.55	383.2	4.45				5955	2719.6	-1.448	0.159	0.84	1451	0.98	N/A	N/A	N/A	N/A	N/A	N/A
60.53	326.2	3.64				6053	2756.4	-1.474	0.162	0.84	1469	0.98	N/A	N/A	N/A	N/A	N/A	N/A
61.52	304	3.22				6152	2793.6	-1.501	0.165	0.83	1487	0.98	N/A	N/A	N/A	N/A	N/A	N/A
62.42	180	4.43				6242	2827.5	-1.524	0.167	0.83	1503	0.98	N/A	N/A	N/A	N/A	N/A	N/A
63.32	36.8	1.76	2.7	858	1	6332	2861.3	-1.547	0.170	0.83	1519	0.98	572	0.20	0.651	0.345	0.153	0.44
64.3	25.6	0.66	1.8	869	1	6430	2898.2	-1.573	0.172	0.82	1536	0.98	580	0.20	0.651	0.344	0.153	0.44
65.29	49.2	2.35	3.69	881	1	6529	2935.4	-1.597	0.175	0.82	1553	0.98	587	0.20	0.651	0.344	0.153	0.44
66.27	117.6	5.3				6627	2972.2	-1.622	0.177	0.82	1570	0.98	N/A	N/A	N/A	N/A	N/A	N/A
67.26	212.5	5.07				6726	3009.5	-1.646	0.180	0.81	1586	0.98	N/A	N/A	N/A	N/A	N/A	N/A
68.24	188.4	3.77				6824	3046.3	-1.669	0.182	0.81	1603	0.98	N/A	N/A	N/A	N/A	N/A	N/A
69.22	87.8	3.92				6922	3083.2	-1.692	0.185	0.81	1619	0.98	N/A	N/A	N/A	N/A	N/A	N/A
70.21	89.2	2.86	6.85	936	1	7021	3120.4	-1.715	0.187	0.80	1635	0.98	624	0.20	0.651	0.341	0.153	0.45
71.19	114.1	5.48				7119	3157.2	-1.738	0.189	0.80	1651	0.98	N/A	N/A	N/A	N/A	N/A	N/A
72.18	131.9	6.55				7218	3194.4	-1.759	0.191	0.80	1667	0.98	N/A	N/A	N/A	N/A	N/A	N/A
73.16	152.4	6.65				7316	3231.3	-1.781	0.194	0.79	1682	0.98	N/A	N/A	N/A	N/A	N/A	N/A
74.15	128.3	5.31				7415	3268.5	-1.802	0.196	0.79	1698	0.98	N/A	N/A	N/A	N/A	N/A	N/A

POTENTIAL FOR CYCLIC SOFTENING OF CLAYS AND PLASTIC SILTS

References:

Referenc Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-58**

CPT Information:

Ground elevation		1 ft
Water table elevation		0 ft
Depth to ground water table		1 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g

Factor of safety from slope stability analysis	F	1.5

Factor of Safety Against Liquefaction

Based on Idriss & Boulanger (2008)

Depth, Z (ft)	q_t (tsf)	f_s (tsf)	S_u Gregg (tsf)	S_u $0.3\sigma'_{vc}$ (psf)	OCR	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	τ_{peak} (psf)	MSF	$\tau_s = S_u/F$ (psf)	$\alpha = \tau_s/\sigma'_{vc}$	K_α	CSR_M	CRR_M	FS
0.328	2.893	0.065				32.8	32.8	0.012	-0.001	1.00	10	1.13	N/A	N/A				
0.656	2.452	0.058				65.6	65.6	0.008	0.000	1.00	19	1.13	N/A	N/A				
0.984	1.887	0.04				98.4	98.4	0.004	0.000	1.00	29	1.13	N/A	N/A				
1.312	1.083	0.025	0.07	110	4	135.88	116.4112	0.000	0.001	1.00	39	1.13	73	0.63	0.650	0.220	0.555	2.52
1.64	1.274	0.019	0.08	110	3	173.6	133.664	-0.005	0.001	1.00	50	1.13	73	0.55	0.650	0.244	0.483	1.98
1.969	3.123	0.031				211.435	150.9694	-0.009	0.001	0.99	61	1.13	N/A	N/A	N/A	N/A	N/A	N/A
2.297	8.746	0.059				249.155	168.2222	-0.013	0.002	0.99	71	1.13	N/A	N/A	N/A	N/A	N/A	N/A
2.625	9.244	0.102				286.875	185.475	-0.018	0.002	0.98	82	1.13	N/A	N/A	N/A	N/A	N/A	N/A
2.953	7.031	0.099				324.595	202.7278	-0.022	0.003	0.98	92	1.13	N/A	N/A	N/A	N/A	N/A	N/A
3.281	5.268	0.075				362.315	219.9806	-0.027	0.003	0.97	102	1.13	N/A	N/A	N/A	N/A	N/A	N/A
3.609	3.468	0.056	0.22	110	2	400.035	237.2334	-0.032	0.004	0.97	112	1.13	73	0.31	0.650	0.308	0.273	0.89
3.937	3.276	0.065	0.21	110	1	437.755	254.4862	-0.036	0.005	0.96	122	1.13	73	0.29	0.650	0.313	0.254	0.81
4.265	2.96	0.049	0.19	110	1	475.475	271.739	-0.041	0.005	0.96	132	1.13	73	0.27	0.650	0.316	0.238	0.75
4.593	3.353	0.051	0.21	110	1	513.195	288.9918	-0.046	0.006	0.95	142	1.13	73	0.25	0.650	0.320	0.224	0.70
4.921	3.123	0.053	0.2	110	1	550.915	306.2446	-0.051	0.006	0.95	152	1.13	73	0.24	0.650	0.322	0.211	0.66
5.249	1.504	0.052	0.09	110	1	588.635	323.4974	-0.056	0.007	0.95	161	1.13	73	0.23	0.651	0.324	0.200	0.62
5.577	1.552	0.047	0.09	110	1	626.355	340.7502	-0.061	0.007	0.94	171	1.13	73	0.22	0.651	0.326	0.190	0.58
5.906	1.427	0.04	0.08	110	1	664.19	358.0556	-0.067	0.008	0.94	180	1.13	73	0.20	0.651	0.327	0.181	0.55
6.234	1.303	0.041	0.07	113	1	701.91	375.3084	-0.072	0.008	0.93	189	1.13	75	0.20	0.651	0.328	0.176	0.54
6.562	1.446	0.04	0.08	118	1	739.63	392.5612	-0.077	0.009	0.93	199	1.13	79	0.20	0.651	0.329	0.176	0.54
6.89	1.408	0.04	0.08	123	1	777.35	409.814	-0.082	0.010	0.92	208	1.13	82	0.20	0.651	0.329	0.176	0.54
7.218	1.609	0.044	0.09	128	1	815.07	427.0668	-0.088	0.010	0.92	216	1.13	85	0.20	0.651	0.329	0.176	0.54
7.546	1.542	0.048	0.09	133	1	852.79	444.3196	-0.093	0.011	0.91	225	1.13	89	0.20	0.651	0.330	0.176	0.54
7.874	1.523	0.049	0.09	138	1	890.51	461.5724	-0.099	0.012	0.91	234	1.13	92	0.20	0.651	0.329	0.176	0.54
8.202	1.58	0.047	0.09	144	1	928.23	478.8252	-0.105	0.012	0.90	242	1.13	96	0.20	0.651	0.329	0.176	0.54
8.53	1.6	0.047	0.09	149	1	965.95	496.078	-0.110	0.013	0.90	251	1.13	99	0.20	0.651	0.329	0.176	0.54
8.858	1.714	0.048	0.1	154	1	1003.67	513.3308	-0.116	0.013	0.89	259	1.13	103	0.20	0.651	0.328	0.176	0.54
9.186	2.002	0.051	0.12	159	1	1041.39	530.5836	-0.122	0.014	0.89	267	1.13	106	0.20	0.651	0.327	0.176	0.54

9.514	1.973	0.054	0.11	164	1	1079.11	547.8364	-0.128	0.015	0.88	275	1.13	110	0.20	0.651	0.327	0.176	0.54
9.843	1.657	0.047	0.09	170	1	1116.945	565.1418	-0.134	0.015	0.87	283	1.13	113	0.20	0.651	0.326	0.176	0.54
10.171	1.619	0.037	0.09	175	1	1154.665	582.3946	-0.140	0.016	0.87	291	1.13	116	0.20	0.651	0.325	0.176	0.54
10.499	2.261	0.041	0.13	180	1	1192.385	599.6474	-0.146	0.017	0.86	299	1.13	120	0.20	0.651	0.324	0.176	0.54
10.827	2.242	0.04	0.12	185	1	1230.105	616.9002	-0.152	0.017	0.86	306	1.13	123	0.20	0.651	0.323	0.176	0.55
11.155	1.839	0.044	0.1	190	1	1267.825	634.153	-0.158	0.018	0.85	314	1.13	127	0.20	0.651	0.322	0.176	0.55
11.483	1.753	0.041	0.09	195	1	1305.545	651.4058	-0.165	0.019	0.85	321	1.13	130	0.20	0.651	0.320	0.176	0.55
11.811	1.581	0.031	0.08	201	1	1343.265	668.6586	-0.171	0.020	0.84	328	1.13	134	0.20	0.651	0.319	0.176	0.55
12.139	1.581	0.031	0.08	206	1	1380.985	685.9114	-0.178	0.020	0.84	335	1.13	137	0.20	0.651	0.318	0.176	0.56
12.467	1.552	0.034	0.08	211	1	1418.705	703.1642	-0.184	0.021	0.83	342	1.13	141	0.20	0.651	0.316	0.176	0.56
12.795	1.58	0.03	0.08	216	1	1456.425	720.417	-0.191	0.022	0.83	349	1.13	144	0.20	0.651	0.315	0.176	0.56
13.123	1.657	0.028	0.08	221	1	1494.145	737.6698	-0.197	0.022	0.82	356	1.13	148	0.20	0.651	0.313	0.176	0.56
13.451	1.877	0.028	0.1	226	1	1531.865	754.9226	-0.204	0.023	0.82	362	1.13	151	0.20	0.651	0.312	0.176	0.57
13.78	1.906	0.034	0.1	232	1	1569.7	772.228	-0.211	0.024	0.81	369	1.13	154	0.20	0.651	0.310	0.176	0.57
14.108	2.098	0.039	0.11	237	1	1607.42	789.4808	-0.217	0.025	0.80	375	1.13	158	0.20	0.651	0.309	0.176	0.57
14.436	2.155	0.041	0.11	242	1	1645.14	806.7336	-0.224	0.025	0.80	381	1.13	161	0.20	0.651	0.307	0.176	0.57
14.764	1.868	0.036	0.09	247	1	1682.86	823.9864	-0.231	0.026	0.79	387	1.13	165	0.20	0.651	0.306	0.176	0.58
15.092	2.079	0.038	0.1	252	1	1720.58	841.2392	-0.238	0.027	0.79	393	1.13	168	0.20	0.651	0.304	0.176	0.58
15.42	2.117	0.041	0.11	258	1	1758.3	858.492	-0.245	0.028	0.78	399	1.13	172	0.20	0.651	0.302	0.176	0.58
15.748	2.222	0.039	0.11	263	1	1796.02	875.7448	-0.252	0.029	0.78	405	1.13	175	0.20	0.651	0.300	0.176	0.59
16.076	2.222	0.046	0.11	268	1	1833.74	892.9976	-0.259	0.029	0.77	410	1.13	179	0.20	0.651	0.299	0.176	0.59
16.404	2.155	0.044	0.11	273	1	1871.46	910.2504	-0.266	0.030	0.77	416	1.13	182	0.20	0.651	0.297	0.176	0.59
16.732	2.203	0.042	0.11	278	1	1909.18	927.5032	-0.274	0.031	0.76	421	1.13	186	0.20	0.651	0.295	0.176	0.60
17.06	2.213	0.043	0.11	283	1	1946.9	944.756	-0.281	0.032	0.76	426	1.13	189	0.20	0.651	0.293	0.176	0.60
17.388	2.174	0.043	0.1	289	1	1984.62	962.0088	-0.288	0.033	0.75	431	1.13	192	0.20	0.651	0.292	0.176	0.61
17.717	2.127	0.041	0.1	294	1	2022.455	979.3142	-0.296	0.033	0.74	436	1.13	196	0.20	0.651	0.290	0.176	0.61
18.045	2.146	0.039	0.1	299	1	2060.175	996.567	-0.303	0.034	0.74	441	1.13	199	0.20	0.651	0.288	0.176	0.61
18.373	2.194	0.039	0.1	304	1	2097.895	1013.8198	-0.310	0.035	0.73	446	1.13	203	0.20	0.651	0.286	0.176	0.62
18.701	2.309	0.036	0.11	309	1	2135.615	1031.0726	-0.318	0.036	0.73	451	1.13	206	0.20	0.651	0.284	0.176	0.62
19.029	2.548	0.035	0.13	314	1	2173.335	1048.3254	-0.326	0.037	0.72	455	1.13	210	0.20	0.651	0.282	0.176	0.63
19.357	2.443	0.049	0.12	320	1	2211.055	1065.5782	-0.333	0.038	0.72	460	1.13	213	0.20	0.651	0.280	0.176	0.63
19.685	2.654	0.045	0.13	325	1	2248.775	1082.831	-0.341	0.038	0.71	464	1.13	217	0.20	0.651	0.278	0.176	0.63
20.013	2.663	0.039	0.13	330	1	2286.495	1100.0838	-0.349	0.039	0.71	468	1.13	220	0.20	0.651	0.276	0.176	0.64
20.341	2.826	0.042	0.14	335	1	2324.215	1117.3366	-0.356	0.040	0.70	472	1.13	223	0.20	0.651	0.275	0.176	0.64
20.669	2.845	0.049	0.14	340	1	2361.935	1134.5894	-0.364	0.041	0.69	476	1.13	227	0.20	0.651	0.273	0.176	0.65
20.997	2.807	0.045	0.14	346	1	2399.655	1151.8422	-0.372	0.042	0.69	480	1.13	230	0.20	0.651	0.271	0.176	0.65
21.325	2.692	0.042	0.13	351	1	2437.375	1169.095	-0.380	0.043	0.68	483	1.13	234	0.20	0.651	0.269	0.176	0.66
21.654	2.711	0.049	0.13	356	1	2475.21	1186.4004	-0.388	0.044	0.68	487	1.13	237	0.20	0.651	0.267	0.176	0.66
21.982	2.788	0.052	0.13	361	1	2512.93	1203.6532	-0.396	0.045	0.67	490	1.13	241	0.20	0.651	0.265	0.176	0.67
22.31	2.845	0.05	0.14	366	1	2550.65	1220.906	-0.404	0.046	0.67	494	1.13	244	0.20	0.651	0.263	0.176	0.67
22.638	2.778	0.045	0.13	371	1	2588.37	1238.1588	-0.412	0.046	0.66	497	1.13	248	0.20	0.651	0.261	0.176	0.68
22.966	2.778	0.042	0.13	377	1	2626.09	1255.4116	-0.420	0.047	0.66	500	1.13	251	0.20	0.651	0.259	0.176	0.68
23.294	2.606	0.039	0.12	382	1	2663.81	1272.6644	-0.429	0.048	0.65	503	1.13	255	0.20	0.651	0.257	0.176	0.69
23.622	2.605	0.045	0.12	387	1	2701.53	1289.9172	-0.437	0.049	0.65	506	1.13	258	0.20	0.651	0.255	0.176	0.69
23.95	2.864	0.049	0.13	392	1	2739.25	1307.17	-0.445	0.050	0.64	509	1.13	261	0.20	0.651	0.253	0.176	0.70
24.278	2.826	0.044	0.13	397	1	2776.97	1324.4228	-0.453	0.051	0.64	512	1.13	265	0.20	0.651	0.251	0.176	0.70
24.606	2.826	0.04	0.13	403	1	2814.69	1341.6756	-0.462	0.052	0.63	514	1.13	268	0.20	0.651	0.249	0.176	0.71

24.934	2.941	0.044	0.14	408	1	2852.41	1358.9284	-0.470	0.053	0.62	517	1.13	272	0.20	0.651	0.247	0.176	0.71
25.262	2.931	0.045	0.13	413	1	2890.13	1376.1812	-0.479	0.054	0.62	519	1.13	275	0.20	0.651	0.245	0.176	0.72
25.591	2.95	0.047	0.13	418	1	2927.965	1393.4866	-0.487	0.055	0.61	522	1.13	279	0.20	0.651	0.243	0.176	0.73
25.919	2.941	0.049	0.13	423	1	2965.685	1410.7394	-0.496	0.056	0.61	524	1.13	282	0.20	0.651	0.241	0.176	0.73
26.247	2.922	0.041	0.13	428	1	3003.405	1427.9922	-0.504	0.057	0.60	526	1.13	286	0.20	0.651	0.239	0.176	0.74
26.575	2.97	0.041	0.13	434	1	3041.125	1445.245	-0.513	0.058	0.60	528	1.13	289	0.20	0.651	0.238	0.176	0.74
26.903	3.065	0.046	0.14	439	1	3078.845	1462.4978	-0.521	0.059	0.59	530	1.13	292	0.20	0.651	0.236	0.176	0.75
27.231	3.161	0.051	0.14	444	1	3116.565	1479.7506	-0.530	0.059	0.59	532	1.13	296	0.20	0.651	0.234	0.176	0.76
27.559	3.18	0.051	0.14	449	1	3154.285	1497.0034	-0.539	0.060	0.58	534	1.13	299	0.20	0.651	0.232	0.176	0.76
27.887	3.075	0.051	0.14	454	1	3192.005	1514.2562	-0.547	0.061	0.58	535	1.13	303	0.20	0.651	0.230	0.176	0.77
28.215	3.238	0.046	0.15	459	1	3229.725	1531.509	-0.556	0.062	0.57	537	1.13	306	0.20	0.651	0.228	0.176	0.77
28.543	3.334	0.049	0.15	465	1	3267.445	1548.7618	-0.565	0.063	0.57	539	1.13	310	0.20	0.651	0.226	0.176	0.78
28.871	3.477	0.05	0.16	470	1	3305.165	1566.0146	-0.574	0.064	0.56	540	1.13	313	0.20	0.651	0.224	0.176	0.79
29.199	3.429	0.049	0.16	475	1	3342.885	1583.2674	-0.583	0.065	0.56	541	1.13	317	0.20	0.651	0.222	0.176	0.79
29.528	3.429	0.052	0.16	480	1	3380.72	1600.5728	-0.592	0.066	0.55	543	1.13	320	0.20	0.651	0.220	0.176	0.80
29.856	3.42	0.064	0.16	485	1	3418.44	1617.8256	-0.600	0.067	0.55	544	1.13	324	0.20	0.651	0.218	0.176	0.81
30.184	3.496	0.059	0.16	491	1	3456.16	1635.0784	-0.609	0.068	0.54	545	1.13	327	0.20	0.651	0.217	0.176	0.81
30.512	4.043	0.048	0.2	496	1	3493.88	1652.3312	-0.618	0.069	0.54	546	1.13	330	0.20	0.651	0.215	0.176	0.82
30.84	6.926	0.056	0.38	501	1	3531.6	1669.584	-0.627	0.070	0.53	547	1.13	334	0.20	0.651	0.213	0.176	0.83
31.168	8.841	0.043	0.51	506	1	3569.32	1686.8368	-0.636	0.071	0.53	548	1.13	337	0.20	0.651	0.211	0.176	0.84
31.496	6.265	0.059	0.33	511	1	3607.04	1704.0896	-0.645	0.072	0.52	549	1.13	341	0.20	0.651	0.209	0.176	0.84
31.824	6.791	0.063	0.37	516	1	3644.76	1721.3424	-0.655	0.073	0.52	549	1.13	344	0.20	0.651	0.207	0.176	0.85
32.152	8.322	0.081	0.47	522	1	3682.48	1738.5952	-0.664	0.074	0.51	550	1.13	348	0.20	0.651	0.206	0.176	0.86
32.48	6.159	0.088	0.32	527	1	3720.2	1755.848	-0.673	0.075	0.51	551	1.13	351	0.20	0.651	0.204	0.176	0.87
32.808	6.006	0.074	0.32	532	1	3757.92	1773.1008	-0.682	0.076	0.51	551	1.13	355	0.20	0.651	0.202	0.176	0.87
33.136	6.916	0.056	0.37	537	1	3795.64	1790.3536	-0.691	0.077	0.50	551	1.13	358	0.20	0.651	0.200	0.176	0.88
33.465	4.617	0.055	0.22	542	1	3833.475	1807.659	-0.700	0.078	0.50	552	1.13	362	0.20	0.651	0.198	0.176	0.89
33.793	4.1	0.052	0.19	547	1	3871.195	1824.9118	-0.710	0.079	0.49	552	1.13	365	0.20	0.651	0.197	0.176	0.90
34.121	4.253	0.055	0.2	553	1	3908.915	1842.1646	-0.719	0.080	0.49	552	1.13	368	0.20	0.651	0.195	0.176	0.91
34.449	3.774	0.052	0.17	558	1	3946.635	1859.4174	-0.728	0.081	0.48	553	1.13	372	0.20	0.651	0.193	0.176	0.91
34.777	3.937	0.051	0.18	563	1	3984.355	1876.6702	-0.737	0.082	0.48	553	1.13	375	0.20	0.651	0.191	0.176	0.92
35.105	3.994	0.052	0.18	568	1	4022.075	1893.923	-0.747	0.083	0.47	553	1.13	379	0.20	0.651	0.190	0.176	0.93
35.433	4.167	0.053	0.19	573	1	4059.795	1911.1758	-0.756	0.084	0.47	553	1.13	382	0.20	0.651	0.188	0.176	0.94
35.761	4.933	0.06	0.24	579	1	4097.515	1928.4286	-0.765	0.085	0.47	553	1.13	386	0.20	0.651	0.186	0.176	0.95
36.089	20.078	0.11				4135.235	1945.6814	-0.775	0.087	0.46	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A
36.417	20.7	0.267	1.26	589	1	4172.955	1962.9342	-0.784	0.088	0.46	552	1.13	393	0.20	0.651	0.183	0.176	0.96
36.745	7.941	0.214	0.42	594	1	4210.675	1980.187	-0.794	0.089	0.45	552	1.13	396	0.20	0.651	0.181	0.176	0.97
37.073	5.767	0.102	0.28	599	1	4248.395	1997.4398	-0.803	0.090	0.45	552	1.13	399	0.20	0.651	0.180	0.176	0.98
37.402	5.211	0.089	0.25	604	1	4286.23	2014.7452	-0.813	0.091	0.44	552	1.13	403	0.20	0.651	0.178	0.176	0.99
37.73	10.757	0.077	0.62	610	1	4323.95	2031.998	-0.822	0.092	0.44	551	1.13	406	0.20	0.651	0.176	0.176	1.00
38.058	40.883	0.156				4361.67	2049.2508	-0.831	0.093	0.44	551	1.13	N/A	N/A	N/A	N/A	N/A	N/A
38.386	48.997	0.409				4399.39	2066.5036	-0.841	0.094	0.43	550	1.13	N/A	N/A	N/A	N/A	N/A	N/A
38.714	77.963	0.468				4437.11	2083.7564	-0.850	0.095	0.43	550	1.13	N/A	N/A	N/A	N/A	N/A	N/A
39.042	137.899	0.459				4474.83	2101.0092	-0.860	0.096	0.42	549	1.13	N/A	N/A	N/A	N/A	N/A	N/A
39.37	109.191	0.562				4512.55	2118.262	-0.869	0.097	0.42	549	1.13	N/A	N/A	N/A	N/A	N/A	N/A
39.698	50.912	0.625				4550.27	2135.5148	-0.879	0.098	0.42	548	1.13	N/A	N/A	N/A	N/A	N/A	N/A

POTENTIAL FOR CYCLIC SOFTENING OF CLAYS AND PLASTIC SILTS

References:

Referenc Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-60**

CPT Information:

Ground elevation		1.3 ft
Water table elevation		0 ft
Depth to ground water table		1.3 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g

Factor of safety from slope stability analysis	F	1.5

Depth, Z (ft)	q_t (tsf)	f_s (tsf)	S_u Gregg (tsf)	S_u $0.3\sigma'_{vc}$ (psf)	OCR	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	τ_{peak} (psf)	MSF	$\tau_s = S_u/F$ (psf)	$\alpha = \tau_s/\sigma'_{vc}$	K_α	CSR_M	CRR_M	FS
0.328	2.165	0.021				32.8	32.8	0.012	-0.001	1.00	10	1.13	N/A	N/A				
0.656	1.533	0.012				65.6	65.6	0.008	0.000	1.00	19	1.13	N/A	N/A				
0.984	1.092	0.011				98.4	98.4	0.004	0.000	1.00	29	1.13	N/A	N/A				
1.312	0.958	0.016	0.06	110	3	131.38	130.6312	0.000	0.001	1.00	38	1.13	73	0.56	0.650	0.190	0.495	2.61
1.64	3.947	0.042				169.1	147.884	-0.005	0.001	1.00	49	1.13	N/A	N/A	N/A	N/A	N/A	N/A
1.969	3.926	0.053				206.935	165.1894	-0.009	0.001	0.99	59	1.13	N/A	N/A	N/A	N/A	N/A	N/A
2.297	1.494	0.035	0.09	110	2	244.655	182.4422	-0.013	0.002	0.99	70	1.13	73	0.40	0.650	0.249	0.354	1.42
2.625	1.025	0.011	0.06	110	2	282.375	199.695	-0.018	0.002	0.98	80	1.13	73	0.37	0.650	0.262	0.324	1.24
2.953	0.651	0.001	0.04	110	2	320.095	216.9478	-0.022	0.003	0.98	91	1.13	73	0.34	0.650	0.272	0.298	1.10
3.281	0.728	0.001	0.04	110	2	357.815	234.2006	-0.027	0.003	0.97	101	1.13	73	0.31	0.650	0.280	0.276	0.98
3.609	0.852	0.008	0.05	110	2	395.535	251.4534	-0.032	0.004	0.97	111	1.13	73	0.29	0.650	0.287	0.257	0.90
3.937	3.697	0.008				433.255	268.7062	-0.036	0.005	0.96	121	1.13	N/A	N/A	N/A	N/A	N/A	N/A
4.265	6.859	0.06				470.975	285.959	-0.041	0.005	0.96	131	1.13	N/A	N/A	N/A	N/A	N/A	N/A
4.593	2.002	0.077	0.12	110	1	508.695	303.2118	-0.046	0.006	0.95	141	1.13	73	0.24	0.650	0.302	0.213	0.71
4.921	0.632	0.048	0.03	110	1	546.415	320.4646	-0.051	0.006	0.95	151	1.13	73	0.23	0.651	0.305	0.202	0.66
5.249	0.689	0.047	0.04	110	1	584.135	337.7174	-0.056	0.007	0.95	160	1.13	73	0.22	0.651	0.308	0.192	0.62
5.577	0.488	0.016	0.02	110	1	621.855	354.9702	-0.061	0.007	0.94	170	1.13	73	0.21	0.651	0.311	0.182	0.59
5.906	0.747	0.001	0.04	112	1	659.69	372.2756	-0.067	0.008	0.94	179	1.13	74	0.20	0.651	0.313	0.176	0.56
6.234	1.13	0.009	0.07	117	1	697.41	389.5284	-0.072	0.008	0.93	188	1.13	78	0.20	0.651	0.314	0.176	0.56
6.562	0.891	0.02	0.05	122	1	735.13	406.7812	-0.077	0.009	0.93	197	1.13	81	0.20	0.651	0.315	0.176	0.56
6.89	0.967	0.015	0.06	127	1	772.85	424.034	-0.082	0.010	0.92	206	1.13	85	0.20	0.651	0.316	0.176	0.56
7.218	0.958	0.017	0.06	132	1	810.57	441.2868	-0.088	0.010	0.92	215	1.13	88	0.20	0.651	0.317	0.176	0.56
7.546	0.996	0.019	0.06	138	1	848.29	458.5396	-0.093	0.011	0.91	224	1.13	92	0.20	0.651	0.318	0.176	0.56
7.874	1.245	0.02	0.07	143	1	886.01	475.7924	-0.099	0.012	0.91	233	1.13	95	0.20	0.651	0.318	0.176	0.56
8.202	2.395	0.039	0.15	148	1	923.73	493.0452	-0.105	0.012	0.90	241	1.13	99	0.20	0.651	0.318	0.176	0.55
8.53	2.634	0.044	0.16	153	1	961.45	510.298	-0.110	0.013	0.90	250	1.13	102	0.20	0.651	0.318	0.176	0.55
8.858	1.916	0.03	0.12	158	1	999.17	527.5508	-0.116	0.013	0.89	258	1.13	106	0.20	0.651	0.318	0.176	0.56
9.186	1.351	0.028	0.08	163	1	1036.89	544.8036	-0.122	0.014	0.89	266	1.13	109	0.20	0.651	0.318	0.176	0.56
9.514	1.513	0.037	0.09	169	1	1074.61	562.0564	-0.128	0.015	0.88	274	1.13	112	0.20	0.651	0.317	0.176	0.56
9.843	1.456	0.035	0.08	174	1	1112.445	579.3618	-0.134	0.015	0.87	282	1.13	116	0.20	0.651	0.317	0.176	0.56
10.171	1.561	0.035	0.09	179	1	1150.165	596.6146	-0.140	0.016	0.87	290	1.13	119	0.20	0.651	0.316	0.176	0.56
10.499	1.724	0.032	0.1	184	1	1187.885	613.8674	-0.146	0.017	0.86	298	1.13	123	0.20	0.651	0.315	0.176	0.56
10.827	1.695	0.031	0.1	189	1	1225.605	631.1202	-0.152	0.017	0.86	305	1.13	126	0.20	0.651	0.314	0.176	0.56

11.155	1.686	0.031	0.1	195	1	1263.325	648.373	-0.158	0.018	0.85	313	1.13	130	0.20	0.651	0.313	0.176	0.56
11.483	1.877	0.035	0.11	200	1	1301.045	665.6258	-0.165	0.019	0.85	320	1.13	133	0.20	0.651	0.312	0.176	0.56
11.811	1.887	0.039	0.11	205	1	1338.765	682.8786	-0.171	0.020	0.84	327	1.13	137	0.20	0.651	0.311	0.176	0.57
12.139	2.011	0.037	0.12	210	1	1376.485	700.1314	-0.178	0.020	0.84	334	1.13	140	0.20	0.651	0.310	0.176	0.57
12.467	2.012	0.046	0.12	215	1	1414.205	717.3842	-0.184	0.021	0.83	341	1.13	143	0.20	0.651	0.309	0.176	0.57
12.795	2.088	0.051	0.12	220	1	1451.925	734.637	-0.191	0.022	0.83	348	1.13	147	0.20	0.651	0.308	0.176	0.57
13.123	2.06	0.041	0.12	226	1	1489.645	751.8898	-0.197	0.022	0.82	355	1.13	150	0.20	0.651	0.307	0.176	0.58
13.451	2.002	0.039	0.11	231	1	1527.365	769.1426	-0.204	0.023	0.82	361	1.13	154	0.20	0.651	0.305	0.176	0.58
13.78	2.117	0.045	0.12	236	1	1565.2	786.448	-0.211	0.024	0.81	368	1.13	157	0.20	0.651	0.304	0.176	0.58
14.108	2.021	0.041	0.11	241	1	1602.92	803.7008	-0.217	0.025	0.80	374	1.13	161	0.20	0.651	0.303	0.176	0.58
14.436	2.021	0.042	0.11	246	1	1640.64	820.9536	-0.224	0.025	0.80	380	1.13	164	0.20	0.651	0.301	0.176	0.59
14.764	2.289	0.05	0.13	251	1	1678.36	838.2064	-0.231	0.026	0.79	386	1.13	168	0.20	0.651	0.300	0.176	0.59
15.092	2.433	0.052	0.14	257	1	1716.08	855.4592	-0.238	0.027	0.79	392	1.13	171	0.20	0.651	0.298	0.176	0.59
15.42	2.576	0.049	0.15	262	1	1753.8	872.712	-0.245	0.028	0.78	398	1.13	175	0.20	0.651	0.297	0.176	0.60
15.748	2.5	0.057	0.14	267	1	1791.52	889.9648	-0.252	0.029	0.78	404	1.13	178	0.20	0.651	0.295	0.176	0.60
16.076	2.51	0.051	0.14	272	1	1829.24	907.2176	-0.259	0.029	0.77	409	1.13	181	0.20	0.651	0.293	0.176	0.60
16.404	2.807	0.052	0.16	277	1	1866.96	924.4704	-0.266	0.030	0.77	415	1.13	185	0.20	0.651	0.292	0.176	0.60
16.732	2.759	0.057	0.15	283	1	1904.68	941.7232	-0.274	0.031	0.76	420	1.13	188	0.20	0.651	0.290	0.176	0.61
17.06	2.539	0.056	0.14	288	1	1942.4	958.976	-0.281	0.032	0.76	425	1.13	192	0.20	0.651	0.288	0.176	0.61
17.388	2.519	0.054	0.14	293	1	1980.12	976.2288	-0.288	0.033	0.75	430	1.13	195	0.20	0.651	0.287	0.176	0.62
17.717	2.452	0.048	0.13	298	1	2017.955	993.5342	-0.296	0.033	0.74	435	1.13	199	0.20	0.651	0.285	0.176	0.62
18.045	2.439	0.047	0.13	303	1	2055.675	1010.787	-0.303	0.034	0.74	440	1.13	202	0.20	0.651	0.283	0.176	0.62
18.373	2.564	0.047	0.14	308	1	2093.395	1028.0398	-0.310	0.035	0.73	445	1.13	206	0.20	0.651	0.281	0.176	0.63
18.701	2.606	0.051	0.14	314	1	2131.115	1045.2926	-0.318	0.036	0.73	450	1.13	209	0.20	0.651	0.280	0.176	0.63
19.029	2.692	0.054	0.14	319	1	2168.835	1062.5454	-0.326	0.037	0.72	454	1.13	213	0.20	0.651	0.278	0.176	0.64
19.357	2.826	0.054	0.15	324	1	2206.555	1079.7982	-0.333	0.038	0.72	459	1.13	216	0.20	0.651	0.276	0.176	0.64
19.685	2.902	0.051	0.16	329	1	2244.275	1097.051	-0.341	0.038	0.71	463	1.13	219	0.20	0.651	0.274	0.176	0.64
20.013	2.606	0.062	0.13	334	1	2281.995	1114.3038	-0.349	0.039	0.71	467	1.13	223	0.20	0.651	0.272	0.176	0.65
20.341	2.625	0.068	0.13	339	1	2319.715	1131.5566	-0.356	0.040	0.70	471	1.13	226	0.20	0.651	0.271	0.176	0.65
20.669	2.835	0.059	0.15	345	1	2357.435	1148.8094	-0.364	0.041	0.69	475	1.13	230	0.20	0.651	0.269	0.176	0.66
20.997	2.874	0.06	0.15	350	1	2395.155	1166.0622	-0.372	0.042	0.69	479	1.13	233	0.20	0.651	0.267	0.176	0.66
21.325	2.874	0.061	0.15	355	1	2432.875	1183.315	-0.380	0.043	0.68	482	1.13	237	0.20	0.651	0.265	0.176	0.67
21.654	2.778	0.058	0.14	360	1	2470.71	1200.6204	-0.388	0.044	0.68	486	1.13	240	0.20	0.651	0.263	0.176	0.67
21.982	2.701	0.057	0.14	365	1	2508.43	1217.8732	-0.396	0.045	0.67	490	1.13	244	0.20	0.651	0.261	0.176	0.68
22.31	3.008	0.062	0.16	371	1	2546.15	1235.126	-0.404	0.046	0.67	493	1.13	247	0.20	0.651	0.259	0.176	0.68
22.638	3.257	0.073	0.17	376	1	2583.87	1252.3788	-0.412	0.046	0.66	496	1.13	250	0.20	0.651	0.258	0.176	0.69
22.966	2.988	0.067	0.15	381	1	2621.59	1269.6316	-0.420	0.047	0.66	499	1.13	254	0.20	0.651	0.256	0.176	0.69
23.294	2.845	0.057	0.14	386	1	2659.31	1286.8844	-0.429	0.048	0.65	502	1.13	257	0.20	0.651	0.254	0.176	0.70
23.622	2.912	0.06	0.14	391	1	2697.03	1304.1372	-0.437	0.049	0.65	505	1.13	261	0.20	0.651	0.252	0.176	0.70
23.95	3.085	0.058	0.16	396	1	2734.75	1321.39	-0.445	0.050	0.64	508	1.13	264	0.20	0.651	0.250	0.176	0.71
24.278	3.257	0.062	0.17	402	1	2772.47	1338.6428	-0.453	0.051	0.64	511	1.13	268	0.20	0.651	0.248	0.176	0.71
24.606	3.257	0.065	0.17	407	1	2810.19	1355.8956	-0.462	0.052	0.63	514	1.13	271	0.20	0.651	0.246	0.176	0.72
24.934	3.238	0.058	0.16	412	1	2847.91	1373.1484	-0.470	0.053	0.62	516	1.13	275	0.20	0.651	0.244	0.176	0.72
25.262	3.4	0.063	0.18	417	1	2885.63	1390.4012	-0.479	0.054	0.62	519	1.13	278	0.20	0.651	0.242	0.176	0.73
25.591	3.621	0.068	0.19	422	1	2923.465	1407.7066	-0.487	0.055	0.61	521	1.13	282	0.20	0.651	0.241	0.176	0.73
25.919	3.64	0.07	0.19	427	1	2961.185	1424.9594	-0.496	0.056	0.61	523	1.13	285	0.20	0.651	0.239	0.176	0.74
26.247	3.381	0.066	0.17	433	1	2998.905	1442.2122	-0.504	0.057	0.60	525	1.13	288	0.20	0.651	0.237	0.176	0.75
26.575	3.285	0.066	0.16	438	1	3036.625	1459.465	-0.513	0.058	0.60	527	1.13	292	0.20	0.651	0.235	0.176	0.75
26.903	3.458	0.072	0.17	443	1	3074.345	1476.7178	-0.521	0.059	0.59	529	1.13	295	0.20	0.651	0.233	0.176	0.76
27.231	3.611	0.072	0.18	448	1	3112.065	1493.9706	-0.530	0.059	0.59	531	1.13	299	0.20	0.651	0.231	0.176	0.76

27.559	3.573	0.071	0.18	453	1	3149.785	1511.2234	-0.539	0.060	0.58	533	1.13	302	0.20	0.651	0.229	0.176	0.77
27.887	3.611	0.072	0.18	459	1	3187.505	1528.4762	-0.547	0.061	0.58	535	1.13	306	0.20	0.651	0.227	0.176	0.78
28.215	3.736	0.072	0.19	464	1	3225.225	1545.729	-0.556	0.062	0.57	536	1.13	309	0.20	0.651	0.226	0.176	0.78
28.543	3.841	0.07	0.2	469	1	3262.945	1562.9818	-0.565	0.063	0.57	538	1.13	313	0.20	0.651	0.224	0.176	0.79
28.871	3.908	0.07	0.2	474	1	3300.665	1580.2346	-0.574	0.064	0.56	539	1.13	316	0.20	0.651	0.222	0.176	0.80
29.199	3.956	0.071	0.2	479	1	3338.385	1597.4874	-0.583	0.065	0.56	541	1.13	319	0.20	0.651	0.220	0.176	0.80
29.528	3.956	0.066	0.2	484	1	3376.22	1614.7928	-0.592	0.066	0.55	542	1.13	323	0.20	0.651	0.218	0.176	0.81
29.856	4.789	0.084	0.26	490	1	3413.94	1632.0456	-0.600	0.067	0.55	543	1.13	326	0.20	0.651	0.216	0.176	0.82
30.184	13.276	0.131	0.81	495	1	3451.66	1649.2984	-0.609	0.068	0.54	544	1.13	330	0.20	0.651	0.214	0.176	0.82
30.512	13.046	0.157	0.79	500	1	3489.38	1666.5512	-0.618	0.069	0.54	545	1.13	333	0.20	0.651	0.213	0.176	0.83
30.84	8.247	0.145	0.47	505	1	3527.1	1683.804	-0.627	0.070	0.53	546	1.13	337	0.20	0.651	0.211	0.176	0.84
31.168	16.102	0.197	1	510	1	3564.82	1701.0568	-0.636	0.071	0.53	547	1.13	340	0.20	0.651	0.209	0.176	0.84
31.496	20.24	0.455	1.26	515	1	3602.54	1718.3096	-0.645	0.072	0.52	548	1.13	344	0.20	0.651	0.207	0.176	0.85
31.824	9.406	0.34	0.54	521	1	3640.26	1735.5624	-0.655	0.073	0.52	549	1.13	347	0.20	0.651	0.205	0.176	0.86
32.152	9.656	0.23	0.56	526	1	3677.98	1752.8152	-0.664	0.074	0.51	549	1.13	351	0.20	0.651	0.204	0.176	0.87
32.48	6.782	0.163	0.37	531	1	3715.7	1770.068	-0.673	0.075	0.51	550	1.13	354	0.20	0.651	0.202	0.176	0.87
32.808	4.464	0.069	0.23	536	1	3753.42	1787.3208	-0.682	0.076	0.51	550	1.13	357	0.20	0.651	0.200	0.176	0.88
33.136	4.215	0.051	0.22	541	1	3791.14	1804.5736	-0.691	0.077	0.50	551	1.13	361	0.20	0.651	0.198	0.176	0.89
33.465	4.243	0.056	0.22	547	1	3828.975	1821.879	-0.700	0.078	0.50	551	1.13	364	0.20	0.651	0.197	0.176	0.90
33.793	4.31	0.064	0.22	552	1	3866.695	1839.1318	-0.710	0.079	0.49	551	1.13	368	0.20	0.651	0.195	0.176	0.91
34.121	4.339	0.059	0.22	557	1	3904.415	1856.3846	-0.719	0.080	0.49	552	1.13	371	0.20	0.651	0.193	0.176	0.91
34.449	4.54	0.052	0.23	562	1	3942.135	1873.6374	-0.728	0.081	0.48	552	1.13	375	0.20	0.651	0.191	0.176	0.92
34.777	4.272	0.05	0.21	567	1	3979.855	1890.8902	-0.737	0.082	0.48	552	1.13	378	0.20	0.651	0.190	0.176	0.93
35.105	4.531	0.047	0.23	572	1	4017.575	1908.143	-0.747	0.083	0.47	552	1.13	382	0.20	0.651	0.188	0.176	0.94
35.433	4.646	0.059	0.24	578	1	4055.295	1925.3958	-0.756	0.084	0.47	552	1.13	385	0.20	0.651	0.186	0.176	0.95
35.761	4.598	0.072	0.23	583	1	4093.015	1942.6486	-0.765	0.085	0.47	552	1.13	389	0.20	0.651	0.185	0.176	0.96
36.089	4.77	0.064	0.24	588	1	4130.735	1959.9014	-0.775	0.087	0.46	552	1.13	392	0.20	0.651	0.183	0.176	0.96
36.417	6.609	0.062	0.36	593	1	4168.455	1977.1542	-0.784	0.088	0.46	552	1.13	395	0.20	0.651	0.181	0.176	0.97
36.745	17.635	0.125				4206.175	1994.407	-0.794	0.089	0.45	552	1.13	N/A	N/A	N/A	N/A	N/A	N/A
37.073	31.879	0.237				4243.895	2011.6598	-0.803	0.090	0.45	551	1.13	N/A	N/A	N/A	N/A	N/A	N/A
37.402	47.397	0.677				4281.73	2028.9652	-0.813	0.091	0.44	551	1.13	N/A	N/A	N/A	N/A	N/A	N/A
37.73	64.007	0.701				4319.45	2046.218	-0.822	0.092	0.44	551	1.13	N/A	N/A	N/A	N/A	N/A	N/A
38.058	69.199	0.508				4357.17	2063.4708	-0.831	0.093	0.44	550	1.13	N/A	N/A	N/A	N/A	N/A	N/A
38.386	71.057	1.524				4394.89	2080.7236	-0.841	0.094	0.43	550	1.13	N/A	N/A	N/A	N/A	N/A	N/A
38.714	83.366	3.227	5.43	629	1	4432.61	2097.9764	-0.850	0.095	0.43	549	1.13	420	0.20	0.651	0.170	0.176	1.04
39.042	68.221	3.741	4.41	635	1	4470.33	2115.2292	-0.860	0.096	0.42	549	1.13	423	0.20	0.651	0.169	0.176	1.05
39.37	44.245	2.658	2.81	640	1	4508.05	2132.482	-0.869	0.097	0.42	548	1.13	426	0.20	0.651	0.167	0.176	1.06
39.698	23.325	1.988	1.43	645	1	4545.77	2149.7348	-0.879	0.098	0.42	547	1.13	430	0.20	0.651	0.165	0.176	1.07
40.026	16.054	1.288	0.97	650	1	4583.49	2166.9876	-0.889	0.099	0.41	547	1.13	433	0.20	0.651	0.164	0.176	1.08
40.354	16.811	1.344	1.04	655	1	4621.21	2184.2404	-0.898	0.100	0.41	546	1.13	437	0.20	0.651	0.162	0.176	1.09
40.682	37.741	2.058	2.41	660	1	4658.93	2201.4932	-0.908	0.101	0.40	545	1.13	440	0.20	0.651	0.161	0.176	1.10
41.011	53.508	2.65	3.43	666	1	4696.765	2218.7986	-0.917	0.102	0.40	544	1.13	444	0.20	0.651	0.159	0.176	1.11
41.339	68.931	2.373	4.45	671	1	4734.485	2236.0514	-0.927	0.103	0.40	543	1.13	447	0.20	0.651	0.158	0.176	1.12
41.667	80.282	1.668				4772.205	2253.3042	-0.936	0.104	0.39	543	1.13	N/A	N/A	N/A	N/A	N/A	N/A
41.995	76.345	2.202				4809.925	2270.557	-0.946	0.105	0.39	542	1.13	N/A	N/A	N/A	N/A	N/A	N/A
42.323	55.836	3.389	3.56	686	1	4847.645	2287.8098	-0.956	0.106	0.38	541	1.13	458	0.20	0.651	0.154	0.176	1.15
42.651	106.528	4.349	6.96	692	1	4885.365	2305.0626	-0.965	0.107	0.38	540	1.13	461	0.20	0.651	0.152	0.176	1.16
42.979	242.961	5.368				4923.085	2322.3154	-0.975	0.108	0.38	539	1.13	N/A	N/A	N/A	N/A	N/A	N/A

POTENTIAL FOR CYCLIC SOFTENING OF CLAYS AND PLASTIC SILTS

References:

Referenc Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

Project	**Hunter's Point, Parcel E-2**
Test Boring No	**CPT-61**

CPT Information:

Ground elevation		1 ft
Water table elevation		0 ft
Depth to ground water table		1 ft
Moist unit weight of soil	γ_m	100 pcf
Saturated unit weight of soil	γ_{sat}	115 pcf

Earthquake Information:

Earthquake magnitude	M_w	8
Peak horizontal ground surface acceleration	a_{max}	0.29 g

Factor of safety from slope stability analysis	F	1.5

Depth, Z (ft)	q_t (tsf)	f_s (tsf)	S_u Gregg (tsf)	S_u $0.3\sigma'_{vc}$ (psf)	OCR	σ_{vc} (psf)	σ'_{vc} (psf)	$\alpha(z)$	$\beta(z)$	r_d	τ_{peak} (psf)	MSF	$\tau_s = S_u/F$ (psf)	$\alpha = \tau_s/\sigma'_{vc}$	K_α	CSR_M	CRR_M	FS
0.33	5.10	0.05				32.8	32.8	0.012	-0.001	1.00	10	1.13	N/A	N/A				
0.66	9.60	0.03				65.6	65.6	0.008	0.000	1.00	19	1.13	N/A	N/A				
0.98	13.32	0.04				98.4	98.4	0.004	0.000	1.00	29	1.13	N/A	N/A				
1.31	11.85	0.04				135.88	116.4112	0.000	0.001	1.00	39	1.13	N/A	N/A	N/A	N/A	N/A	N/A
1.64	6.74	0.05				173.6	133.664	-0.005	0.001	1.00	50	1.13	N/A	N/A	N/A	N/A	N/A	N/A
1.97	2.70	0.05	0.17	110	3	211.435	150.9694	-0.009	0.001	0.99	61	1.13	73	0.49	0.650	0.262	0.428	1.64
2.30	2.00	0.02	0.13	110	2	249.155	168.2222	-0.013	0.002	0.99	71	1.13	73	0.44	0.650	0.275	0.384	1.39
2.63	2.03	0.02				286.875	185.475	-0.018	0.002	0.98	82	1.13	N/A	N/A	N/A	N/A	N/A	N/A
2.95	2.32	0.02				324.595	202.7278	-0.022	0.003	0.98	92	1.13	N/A	N/A	N/A	N/A	N/A	N/A
3.28	2.13	0.01	0.13	110	2	362.315	219.9806	-0.027	0.003	0.97	102	1.13	73	0.33	0.650	0.302	0.294	0.97
3.61	1.76	0.01	0.11	110	2	400.035	237.2334	-0.032	0.004	0.97	112	1.13	73	0.31	0.650	0.308	0.273	0.89
3.94	1.75	0.01	0.11	110	1	437.755	254.4862	-0.036	0.005	0.96	122	1.13	73	0.29	0.650	0.313	0.254	0.81
4.27	2.06	0.01	0.13	110	1	475.475	271.739	-0.041	0.005	0.96	132	1.13	73	0.27	0.650	0.316	0.238	0.75
4.59	1.77	0.01	0.11	110	1	513.195	288.9918	-0.046	0.006	0.95	142	1.13	73	0.25	0.650	0.320	0.224	0.70
4.92	1.87	0.01	0.11	110	1	550.915	306.2446	-0.051	0.006	0.95	152	1.13	73	0.24	0.650	0.322	0.211	0.66
5.25	2.37	0.03	0.14	110	1	588.635	323.4974	-0.056	0.007	0.95	161	1.13	73	0.23	0.651	0.324	0.200	0.62
5.58	2.82	0.03	0.17	110	1	626.355	340.7502	-0.061	0.007	0.94	171	1.13	73	0.22	0.651	0.326	0.190	0.58
5.91	2.45	0.03	0.15	110	1	664.19	358.0556	-0.067	0.008	0.94	180	1.13	73	0.20	0.651	0.327	0.181	0.55
6.23	2.70	0.02	0.16	113	1	701.91	375.3084	-0.072	0.008	0.93	189	1.13	75	0.20	0.651	0.328	0.176	0.54
6.56	2.55	0.02	0.15	118	1	739.63	392.5612	-0.077	0.009	0.93	199	1.13	79	0.20	0.651	0.329	0.176	0.54
6.89	1.87	0.02	0.11	123	1	777.35	409.814	-0.082	0.010	0.92	208	1.13	82	0.20	0.651	0.329	0.176	0.54
7.22	1.58	0.02	0.09	128	1	815.07	427.0668	-0.088	0.010	0.92	216	1.13	85	0.20	0.651	0.329	0.176	0.54
7.55	1.77	0.03	0.10	133	1	852.79	444.3196	-0.093	0.011	0.91	225	1.13	89	0.20	0.651	0.330	0.176	0.54
7.87	1.75	0.04	0.10	138	1	890.51	461.5724	-0.099	0.012	0.91	234	1.13	92	0.20	0.651	0.329	0.176	0.54
8.20	1.62	0.05	0.09	144	1	928.23	478.8252	-0.105	0.012	0.90	242	1.13	96	0.20	0.651	0.329	0.176	0.54
8.53	1.51	0.05	0.08	149	1	965.95	496.078	-0.110	0.013	0.90	251	1.13	99	0.20	0.651	0.329	0.176	0.54
8.86	1.45	0.05	0.07	154	1	1003.67	513.3308	-0.116	0.013	0.89	259	1.13	103	0.20	0.651	0.328	0.176	0.54
9.19	2.82	0.08	0.16	159	1	1041.39	530.5836	-0.122	0.014	0.89	267	1.13	106	0.20	0.651	0.327	0.176	0.54

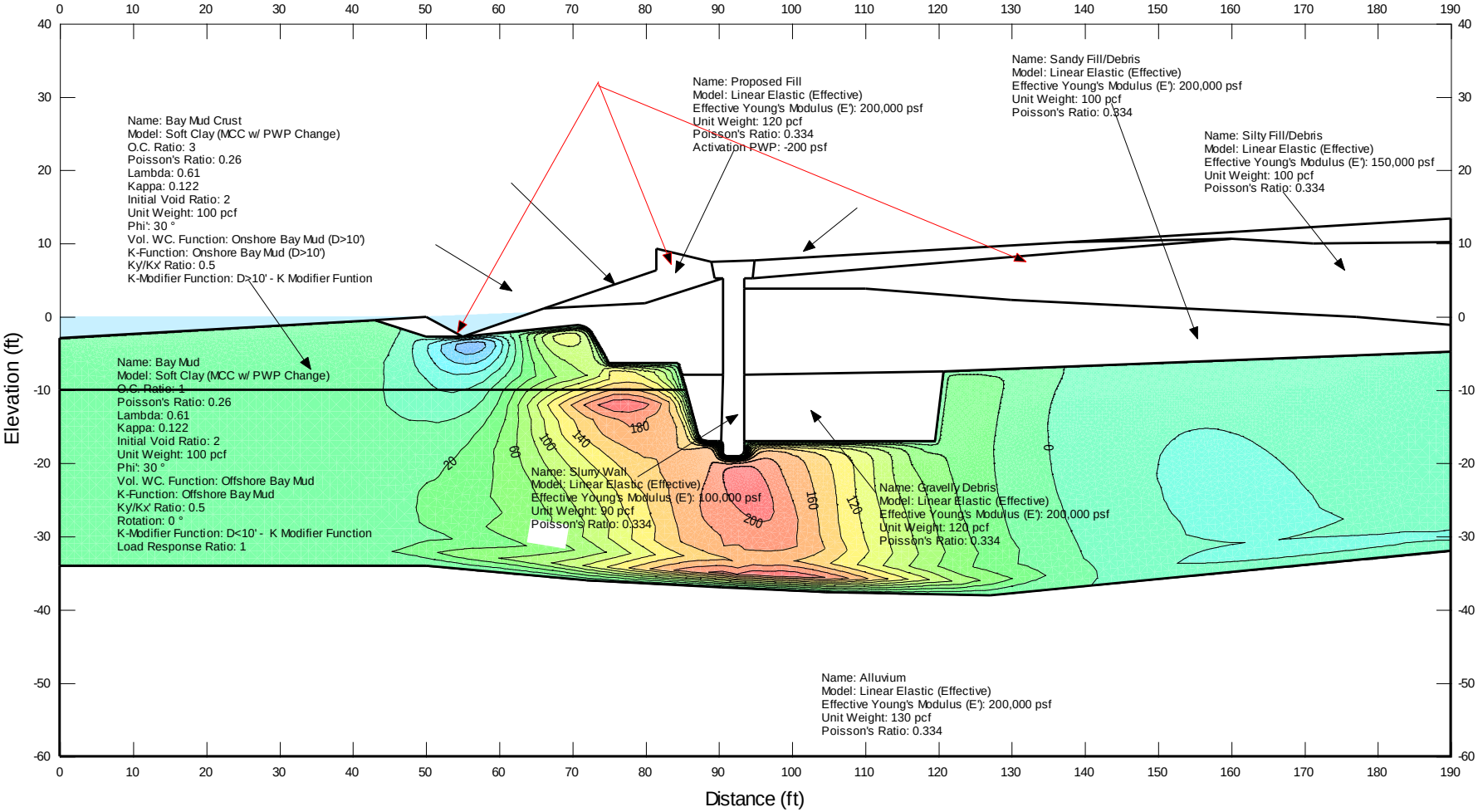
9.51	2.89	0.09	0.17	164	1	1079.11	547.8364	-0.128	0.015	0.88	275	1.13	110	0.20	0.651	0.327	0.176	0.54
9.84	1.76	0.05	0.09	170	1	1116.945	565.1418	-0.134	0.015	0.87	283	1.13	113	0.20	0.651	0.326	0.176	0.54
10.17	1.77	0.04	0.09	175	1	1154.665	582.3946	-0.140	0.016	0.87	291	1.13	116	0.20	0.651	0.325	0.176	0.54
10.50	1.97	0.06	0.10	180	1	1192.385	599.6474	-0.146	0.017	0.86	299	1.13	120	0.20	0.651	0.324	0.176	0.54
10.83	2.33	0.06	0.13	185	1	1230.105	616.9002	-0.152	0.017	0.86	306	1.13	123	0.20	0.651	0.323	0.176	0.55
11.16	2.68	0.05	0.15	190	1	1267.825	634.153	-0.158	0.018	0.85	314	1.13	127	0.20	0.651	0.322	0.176	0.55
11.48	2.16	0.05	0.11	195	1	1305.545	651.4058	-0.165	0.019	0.85	321	1.13	130	0.20	0.651	0.320	0.176	0.55
11.81	1.91	0.05	0.10	201	1	1343.265	668.6586	-0.171	0.020	0.84	328	1.13	134	0.20	0.651	0.319	0.176	0.55
12.14	1.75	0.04	0.09	206	1	1380.985	685.9114	-0.178	0.020	0.84	335	1.13	137	0.20	0.651	0.318	0.176	0.56
12.47	1.51	0.03	0.07	211	1	1418.705	703.1642	-0.184	0.021	0.83	342	1.13	141	0.20	0.651	0.316	0.176	0.56
12.80	1.52	0.04	0.07	216	1	1456.425	720.417	-0.191	0.022	0.83	349	1.13	144	0.20	0.651	0.315	0.176	0.56
13.12	1.75	0.04	0.08	221	1	1494.145	737.6698	-0.197	0.022	0.82	356	1.13	148	0.20	0.651	0.313	0.176	0.56
13.45	1.70	0.04	0.08	226	1	1531.865	754.9226	-0.204	0.023	0.82	362	1.13	151	0.20	0.651	0.312	0.176	0.57
13.78	1.67	0.05	0.08	232	1	1569.7	772.228	-0.211	0.024	0.81	369	1.13	154	0.20	0.651	0.310	0.176	0.57
14.11	1.72	0.05	0.08	237	1	1607.42	789.4808	-0.217	0.025	0.80	375	1.13	158	0.20	0.651	0.309	0.176	0.57
14.44	1.97	0.05	0.09	242	1	1645.14	806.7336	-0.224	0.025	0.80	381	1.13	161	0.20	0.651	0.307	0.176	0.57
14.76	2.08	0.05	0.10	247	1	1682.86	823.9864	-0.231	0.026	0.79	387	1.13	165	0.20	0.651	0.306	0.176	0.58
15.09	1.88	0.05	0.09	252	1	1720.58	841.2392	-0.238	0.027	0.79	393	1.13	168	0.20	0.651	0.304	0.176	0.58
15.42	1.69	0.04	0.07	258	1	1758.3	858.492	-0.245	0.028	0.78	399	1.13	172	0.20	0.651	0.302	0.176	0.58
15.75	1.86	0.04	0.08	263	1	1796.02	875.7448	-0.252	0.029	0.78	405	1.13	175	0.20	0.651	0.300	0.176	0.59
16.08	1.85	0.05	0.08	268	1	1833.74	892.9976	-0.259	0.029	0.77	410	1.13	179	0.20	0.651	0.299	0.176	0.59
16.40	1.76	0.05	0.07	273	1	1871.46	910.2504	-0.266	0.030	0.77	416	1.13	182	0.20	0.651	0.297	0.176	0.59
16.73	1.99	0.04	0.09	278	1	1909.18	927.5032	-0.274	0.031	0.76	421	1.13	186	0.20	0.651	0.295	0.176	0.60
17.06	2.29	0.05	0.11	283	1	1946.9	944.756	-0.281	0.032	0.76	426	1.13	189	0.20	0.651	0.293	0.176	0.60
17.39	2.35	0.05	0.11	289	1	1984.62	962.0088	-0.288	0.033	0.75	431	1.13	192	0.20	0.651	0.292	0.176	0.61
17.72	2.19	0.05	0.10	294	1	2022.455	979.3142	-0.296	0.033	0.74	436	1.13	196	0.20	0.651	0.290	0.176	0.61
18.05	2.07	0.05	0.09	299	1	2060.175	996.567	-0.303	0.034	0.74	441	1.13	199	0.20	0.651	0.288	0.176	0.61
18.37	2.11	0.04	0.09	304	1	2097.895	1013.8198	-0.310	0.035	0.73	446	1.13	203	0.20	0.651	0.286	0.176	0.62
18.70	2.01	0.04	0.09	309	1	2135.615	1031.0726	-0.318	0.036	0.73	451	1.13	206	0.20	0.651	0.284	0.176	0.62
19.03	2.36	0.04	0.11	314	1	2173.335	1048.3254	-0.326	0.037	0.72	455	1.13	210	0.20	0.651	0.282	0.176	0.63
19.36	2.38	0.05	0.11	320	1	2211.055	1065.5782	-0.333	0.038	0.72	460	1.13	213	0.20	0.651	0.280	0.176	0.63
19.69	2.33	0.05	0.10	325	1	2248.775	1082.831	-0.341	0.038	0.71	464	1.13	217	0.20	0.651	0.278	0.176	0.63
20.01	2.40	0.05	0.11	330	1	2286.495	1100.0838	-0.349	0.039	0.71	468	1.13	220	0.20	0.651	0.276	0.176	0.64
20.34	2.64	0.05	0.12	335	1	2324.215	1117.3366	-0.356	0.040	0.70	472	1.13	223	0.20	0.651	0.275	0.176	0.64
20.67	2.86	0.05	0.14	340	1	2361.935	1134.5894	-0.364	0.041	0.69	476	1.13	227	0.20	0.651	0.273	0.176	0.65
21.00	2.78	0.05	0.13	346	1	2399.655	1151.8422	-0.372	0.042	0.69	480	1.13	230	0.20	0.651	0.271	0.176	0.65
21.33	2.57	0.05	0.12	351	1	2437.375	1169.095	-0.380	0.043	0.68	483	1.13	234	0.20	0.651	0.269	0.176	0.66
21.65	2.39	0.05	0.10	356	1	2475.21	1186.4004	-0.388	0.044	0.68	487	1.13	237	0.20	0.651	0.267	0.176	0.66
21.98	2.69	0.05	0.12	361	1	2512.93	1203.6532	-0.396	0.045	0.67	490	1.13	241	0.20	0.651	0.265	0.176	0.67
22.31	2.90	0.05	0.14	366	1	2550.65	1220.906	-0.404	0.046	0.67	494	1.13	244	0.20	0.651	0.263	0.176	0.67
22.64	2.57	0.05	0.11	371	1	2588.37	1238.1588	-0.412	0.046	0.66	497	1.13	248	0.20	0.651	0.261	0.176	0.68
22.97	2.56	0.05	0.11	377	1	2626.09	1255.4116	-0.420	0.047	0.66	500	1.13	251	0.20	0.651	0.259	0.176	0.68
23.29	2.58	0.05	0.11	382	1	2663.81	1272.6644	-0.429	0.048	0.65	503	1.13	255	0.20	0.651	0.257	0.176	0.69
23.62	2.74	0.05	0.12	387	1	2701.53	1289.9172	-0.437	0.049	0.65	506	1.13	258	0.20	0.651	0.255	0.176	0.69
23.95	2.78	0.05	0.12	392	1	2739.25	1307.17	-0.445	0.050	0.64	509	1.13	261	0.20	0.651	0.253	0.176	0.70

24.28	2.77	0.05	0.12	397	1	2776.97	1324.4228	-0.453	0.051	0.64	512	1.13	265	0.20	0.651	0.251	0.176	0.70
24.61	2.90	0.05	0.13	403	1	2814.69	1341.6756	-0.462	0.052	0.63	514	1.13	268	0.20	0.651	0.249	0.176	0.71
24.93	2.95	0.05	0.13	408	1	2852.41	1358.9284	-0.470	0.053	0.62	517	1.13	272	0.20	0.651	0.247	0.176	0.71
25.26	2.91	0.05	0.13	413	1	2890.13	1376.1812	-0.479	0.054	0.62	519	1.13	275	0.20	0.651	0.245	0.176	0.72
25.59	3.04	0.06	0.14	418	1	2927.965	1393.4866	-0.487	0.055	0.61	522	1.13	279	0.20	0.651	0.243	0.176	0.73
25.92	3.03	0.05	0.14	423	1	2965.685	1410.7394	-0.496	0.056	0.61	524	1.13	282	0.20	0.651	0.241	0.176	0.73
26.25	3.00	0.05	0.13	428	1	3003.405	1427.9922	-0.504	0.057	0.60	526	1.13	286	0.20	0.651	0.239	0.176	0.74
26.58	3.11	0.06	0.14	434	1	3041.125	1445.245	-0.513	0.058	0.60	528	1.13	289	0.20	0.651	0.238	0.176	0.74
26.90	3.22	0.05	0.15	439	1	3078.845	1462.4978	-0.521	0.059	0.59	530	1.13	292	0.20	0.651	0.236	0.176	0.75
27.23	3.13	0.05	0.14	444	1	3116.565	1479.7506	-0.530	0.059	0.59	532	1.13	296	0.20	0.651	0.234	0.176	0.76
27.56	3.15	0.05	0.14	449	1	3154.285	1497.0034	-0.539	0.060	0.58	534	1.13	299	0.20	0.651	0.232	0.176	0.76
27.89	3.21	0.05	0.14	454	1	3192.005	1514.2562	-0.547	0.061	0.58	535	1.13	303	0.20	0.651	0.230	0.176	0.77
28.22	3.30	0.05	0.15	459	1	3229.725	1531.509	-0.556	0.062	0.57	537	1.13	306	0.20	0.651	0.228	0.176	0.77
28.54	3.38	0.06	0.15	465	1	3267.445	1548.7618	-0.565	0.063	0.57	539	1.13	310	0.20	0.651	0.226	0.176	0.78
28.87	3.49	0.06	0.16	470	1	3305.165	1566.0146	-0.574	0.064	0.56	540	1.13	313	0.20	0.651	0.224	0.176	0.79
29.20	3.32	0.05	0.15	475	1	3342.885	1583.2674	-0.583	0.065	0.56	541	1.13	317	0.20	0.651	0.222	0.176	0.79
29.53	3.45	0.06	0.16	480	1	3380.72	1600.5728	-0.592	0.066	0.55	543	1.13	320	0.20	0.651	0.220	0.176	0.80
29.86	3.72	0.06	0.18	485	1	3418.44	1617.8256	-0.600	0.067	0.55	544	1.13	324	0.20	0.651	0.218	0.176	0.81
30.18	5.26	0.06	0.28	491	1	3456.16	1635.0784	-0.609	0.068	0.54	545	1.13	327	0.20	0.651	0.217	0.176	0.81
30.51	7.72	0.07	0.43	496	1	3493.88	1652.3312	-0.618	0.069	0.54	546	1.13	330	0.20	0.651	0.215	0.176	0.82
30.84	9.25	0.08	0.53	501	1	3531.6	1669.584	-0.627	0.070	0.53	547	1.13	334	0.20	0.651	0.213	0.176	0.83
31.17	13.50	0.09				3569.32	1686.8368	-0.636	0.071	0.53	548	1.13	N/A	N/A	N/A	N/A	N/A	N/A
31.50	15.39	0.15	0.93	511	1	3607.04	1704.0896	-0.645	0.072	0.52	549	1.13	341	0.20	0.651	0.209	0.176	0.84
31.82	15.04	0.12				3644.76	1721.3424	-0.655	0.073	0.52	549	1.13	N/A	N/A	N/A	N/A	N/A	N/A
32.15	18.45	0.15				3682.48	1738.5952	-0.664	0.074	0.51	550	1.13	N/A	N/A	N/A	N/A	N/A	N/A
32.48	6.97	0.20	0.37	527	1	3720.2	1755.848	-0.673	0.075	0.51	551	1.13	351	0.20	0.651	0.204	0.176	0.87
32.81	4.01	0.09	0.18	532	1	3757.92	1773.1008	-0.682	0.076	0.51	551	1.13	355	0.20	0.651	0.202	0.176	0.87
33.14	3.92	0.05	0.18	537	1	3795.64	1790.3536	-0.691	0.077	0.50	551	1.13	358	0.20	0.651	0.200	0.176	0.88
33.47	4.00	0.05	0.19	542	1	3833.475	1807.659	-0.700	0.078	0.50	552	1.13	362	0.20	0.651	0.198	0.176	0.89
33.79	4.13	0.06	0.19	547	1	3871.195	1824.9118	-0.710	0.079	0.49	552	1.13	365	0.20	0.651	0.197	0.176	0.90
34.12	10.79	0.09	0.64	553	1	3908.915	1842.1646	-0.719	0.080	0.49	552	1.13	368	0.20	0.651	0.195	0.176	0.91
34.45	55.64	0.15				3946.635	1859.4174	-0.728	0.081	0.48	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A
34.78	74.10	0.22				3984.355	1876.6702	-0.737	0.082	0.48	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A
35.11	58.77	0.31				4022.075	1893.923	-0.747	0.083	0.47	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A
35.43	44.01	0.54				4059.795	1911.1758	-0.756	0.084	0.47	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A
35.76	44.64	0.75				4097.515	1928.4286	-0.765	0.085	0.47	553	1.13	N/A	N/A	N/A	N/A	N/A	N/A

ATTACHMENT E6

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure after Soil Fill Placement

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure after Soil Fill Placement



Pore Pressure after Soil Fill Placement

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 3:41:46 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Pore Pressure after Soil Fill Placement

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability
Kind: SIGMA/W
Parent: Excavation at Toe
Method: Coupled Stress/PWP
Settings
- Initial Stress: Parent Analysis
- Initial PWP: Parent Analysis
- Exclude cumulative values: No

Control
- Apply Body Force in All Steps: No
- Saturated Zone Only: No

Convergence
- Maximum Number of Iterations: 50
- Minimum Pressure Head Difference: 0.001
- Minimum Displacement Difference: 0.001
- Significant Digits: 3
- Hydraulic Under-Relaxation Criteria
  - Under-Relaxation Initial Rate: 1

Under-Relaxation Min. Rate: 0.1
Under-Relaxation Reduction Rate: 0.65
Under-Relaxation Iterations: 10
Equation Solver: Parallel Direct
Time
Starting Time: 7 days
Duration: 14 days
# of Steps: 1
Step Generation Method: Linear
Save Steps Every: 1

Materials

Proposed Fill

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 120 pcf
Poisson's Ratio: 0.334
Activation PWP: -200 psf

Slurry Wall

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 100,000 psf
Unit Weight: 90 pcf
Poisson's Ratio: 0.334

Sandy Fill/Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Gravelly Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 120 pcf
Poisson's Ratio: 0.334

Bay Mud

Model: Soft Clay (MCC w/ PWP Change)
Stress Strain
O.C. Ratio: 1

Poisson's Ratio: 0.26
Lambda: 0.61
Kappa: 0.122
Initial Void Ratio: 2
Unit Weight: 100 pcf
Phi': 30 °

Hydraulic

Vol. WC. Function: Offshore Bay Mud
K-Function: Offshore Bay Mud
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
K-Modifier Function: D<10' - K Modifier Function
Load Response Ratio: 1

Alluvium

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 130 pcf
Poisson's Ratio: 0.334

Silty Fill/Debris

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 150,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Bay Mud Crust

Model: Soft Clay (MCC w/ PWP Change)

Stress Strain

O.C. Ratio: 3
Poisson's Ratio: 0.26
Lambda: 0.61
Kappa: 0.122
Initial Void Ratio: 2
Unit Weight: 100 pcf
Phi': 30 °

Hydraulic

Vol. WC. Function: Onshore Bay Mud (D>10')
K-Function: Onshore Bay Mud (D>10')
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
K-Modifier Function: D>10' - K Modifier Funtion
Load Response Ratio: 1

Boundary Conditions

Fixed X

X: X-Displacement 0

Fixed X/Y

X: X-Displacement 0
Y: Y-Displacement 0

Bay Water Level

Type: Head (H) 0
Review: No

Initial Water Tables

Initial Water Table 1

Max. negative head: 5
Coordinates
- Coordinate 1: (0, 0) ft
- Coordinate 2: (50, 0) ft
- Coordinate 3: (55, 0.5) ft
- Coordinate 4: (100, 2) ft
- Coordinate 5: (190, 3) ft

K Functions

Offshore Bay Mud

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 100 %

K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
- Data Point: (0.01, 0.0004)
- Data Point: (0.018329807, 0.00038967277)
- Data Point: (0.033598183, 0.00037792234)
- Data Point: (0.061584821, 0.00036462391)
- Data Point: (0.11288379, 0.00034960021)
- Data Point: (0.20691381, 0.00033268641)
- Data Point: (0.37926902, 0.00031372429)
- Data Point: (0.6951928, 0.00029257292)
- Data Point: (1.274275, 0.00026912696)
- Data Point: (2.3357215, 0.0002433421)
- Data Point: (4.2813324, 0.00021527057)

Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Vol. Water Content Function 3
Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
Data Point: (0.01, 0.0004)
Data Point: (0.018329807, 0.00038967277)
Data Point: (0.033598183, 0.00037792234)
Data Point: (0.061584821, 0.00036462391)
Data Point: (0.11288379, 0.00034960021)
Data Point: (0.20691381, 0.00033268641)
Data Point: (0.37926902, 0.00031372429)
Data Point: (0.6951928, 0.00029257292)
Data Point: (1.274275, 0.00026912696)
Data Point: (2.3357215, 0.0002433421)
Data Point: (4.2813324, 0.00021527057)
Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Onshore Bay Mud (D>10')

Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Hydraulic K Modifier Functions

D>10' - K Modifier Funtion

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 100 %
Y-Intercept: 0.96838408
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (750, 1)
Data Point: (1,300, 0.6)
Data Point: (2,200, 0.3)
Data Point: (2,750, 0.2)

D<10' - K Modifier Function

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 0 %
Y-Intercept: 1
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (150, 1)
Data Point: (800, 0.55)
Data Point: (1,300, 0.375)
Data Point: (2,200, 0.1875)

Vol. Water Content Functions

Offshore Bay Mud

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.72999997)

Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)
Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)

Estimation Properties

Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure

Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %

Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)

Data Point: (0.01, 0.72999997)
Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)

Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)

Estimation Properties

Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	81.5	6.2
Point 15	80	1.7
Point 16	90.5	5.2

Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8
Point 30	90.4	-17.1
Point 31	90.5	-8
Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	0	-60
Point 52	190	-60

Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3
Point 66	92.9	-19
Point 67	93.5	-17.4
Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Lines

	Start Point	End Point	Hydraulic Boundary	Stress/Strain Boundary
Line 1	3	5		
Line 2	5	6		
Line 3	6	10		
Line 4	10	9		
Line 5	4	3		
Line 6	6	14		
Line 7	14	13		
Line 8	13	12	Bay Water Level	
Line 9	12	3	Bay Water Level	
Line 10	18	17		
Line 11	17	16		
Line 12	18	19		
Line 13	37	53		
Line 14	53	36		

Line 15	36	35		
Line 16	35	34		
Line 17	30	31		
Line 18	31	16		
Line 19	6	7		
Line 20	7	21		
Line 21	21	20		
Line 22	20	19		
Line 23	18	6		
Line 24	16	15		
Line 25	15	13		
Line 26	2	3	Bay Water Level	
Line 27	12	11		
Line 28	11	2		
Line 29	31	28		
Line 30	28	27		
Line 31	27	26		
Line 32	19	37		
Line 33	20	22		
Line 34	22	37		
Line 35	21	24		Fixed X
Line 36	24	23		
Line 37	23	22		
Line 38	24	41		Fixed X
Line 39	41	40		
Line 40	40	39		
Line 41	39	38		
Line 42	38	36		
Line 43	41	44		Fixed X
Line 44	44	43		
Line 45	43	35		
Line 46	43	42		
Line 47	50	49	Bay Water Level	
Line 48	49	48	Bay Water Level	
Line 49	47	46	Bay Water Level	
Line 50	46	45	Bay Water Level	

Line 51	51	45		Fixed X
Line 52	50	52		Fixed X
Line 53	52	51		Fixed X/Y
Line 54	26	55		
Line 55	1	2	Bay Water Level	
Line 56	54	1		Fixed X
Line 57	56	28		
Line 58	54	56		
Line 59	48	57	Bay Water Level	
Line 60	57	47	Bay Water Level	
Line 61	45	54		Fixed X
Line 62	44	50		Fixed X
Line 63	9	58		
Line 64	58	4		
Line 65	13	58		
Line 66	4	8		
Line 67	8	58		
Line 68	25	59		
Line 69	59	12		
Line 70	55	60		
Line 71	60	25		
Line 72	29	61		
Line 73	61	56		
Line 74	62	29		
Line 75	32	63		
Line 76	64	32		
Line 77	65	33		
Line 78	33	66		
Line 79	66	64		
Line 80	34	67		
Line 81	67	65		
Line 82	42	68		
Line 83	30	69		
Line 84	69	62		
Line 85	63	70		
Line 86	70	30		

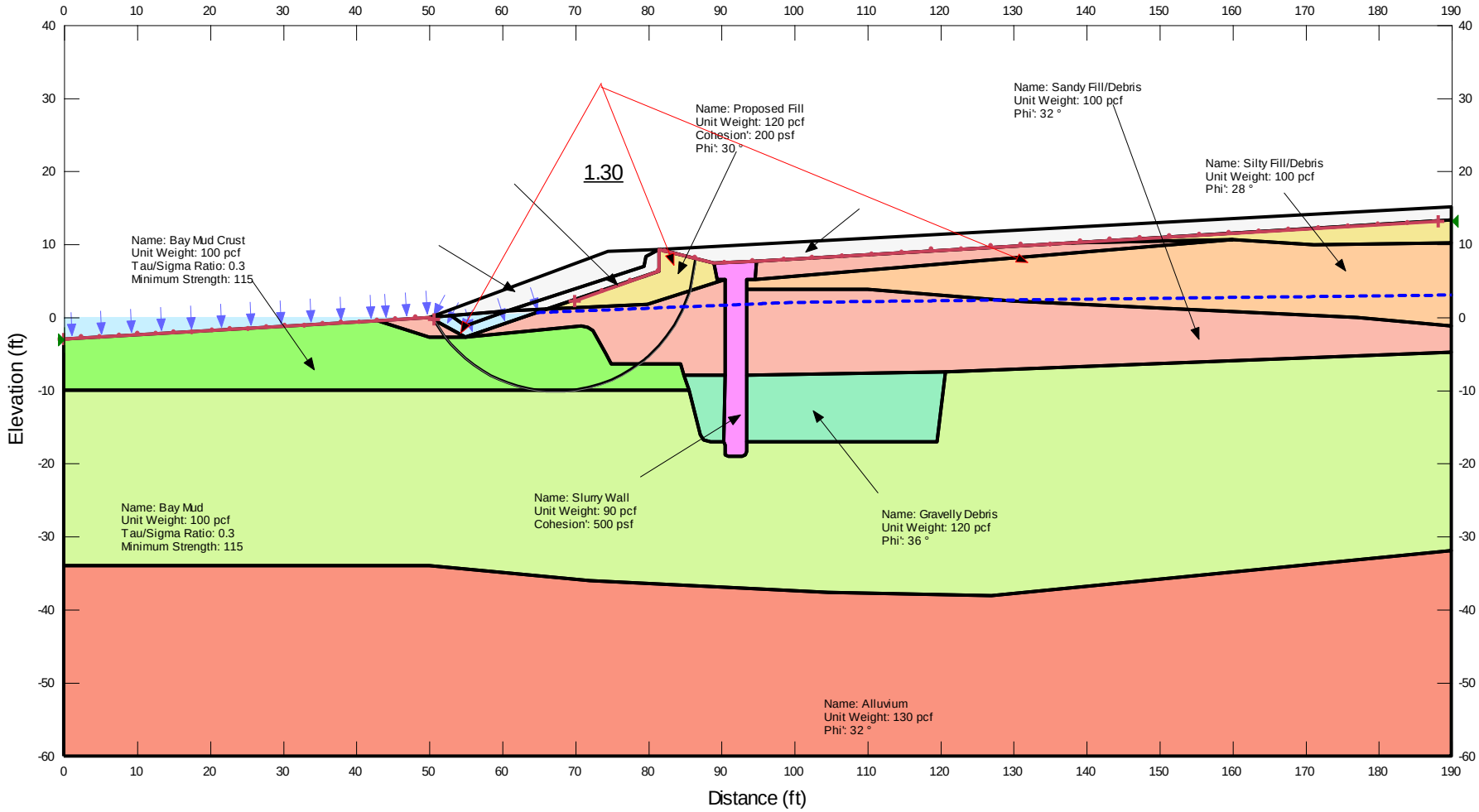
Line 87	68	34		

Regions

	Points	Area (ft²)	Material
Region 1	3,5,6,10,9,58,4	81.219	
Region 2	58,9,10,6,14,13	29.596	
Region 3	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405	Slurry Wall
Region 4	6,7,21,20,19,18	227.95	
Region 5	13,14,6,18,17,16,15	71.425	Proposed Fill
Region 6	2,3,12,11	16.2	Sandy Fill/Debris
Region 7	12,13,15,16,31,28,27,26,55,60,25,59	197.36	Sandy Fill/Debris
Region 8	28,31,30,69,62,29,61,56	37.66	Gravelly Debris
Region 9	37,19,20,22	101.74	Sandy Fill/Debris
Region 10	20,21,24,23,22	76.005	Proposed Fill
Region 11	36,53,37,22,23,24,41,40,39,38	658.68	Silty Fill/Debris
Region 12	36,38,39,40,41,44,43,35	802.12	Sandy Fill/Debris
Region 13	35,43,42,68,34	245.48	Gravelly Debris
Region 14	51,45,46,47,57,48,49,50,52	4,678.9	Alluvium
Region 15	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8	Bay Mud Crust
Region 16	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7	Bay Mud
Region 17	4,8,58	5.7112	
Region 18	3,4,8,58,13,12	18.519	

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', After Additional Fill, Before Geogrid Placement

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', After Additional Fill, Before Geogrid Placement



After Additional Fill, Before Geogrid Placement

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 3:48:38 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

After Additional Fill, Before Geogrid Placement

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Parent: Pore Pressure after Soil Fill Placement
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8

Lambda 11: 1
PWP Conditions Source: Parent Analysis
Slip Surface
Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °

Sandy Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Gravelly Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °

Bay Mud

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.3
Minimum Strength: 115

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Bay Mud Crust

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.3
Minimum Strength: 115

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0, -3) ft
Left-Zone Right Coordinate: (50.59943, -0.323692) ft
Left-Zone Increment: 20
Right Projection: Range
Right-Zone Left Coordinate: (70, 2.316883) ft
Right-Zone Right Coordinate: (188.11518, 13.09126) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, -3) ft
Right Coordinate: (190, 13.2) ft

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	81.5	6.2
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8

Point 30	90.4	-17.1
Point 31	90.5	-8
Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	0	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3

Point 66	92.9	-19
Point 67	93.5	-17.4
Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Regions

	Points	Area (ft²)	Material
Region 1	3,5,6,10,9,58,4	81.219	
Region 2	58,9,10,6,14,13	29.596	
Region 3	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405	Slurry Wall
Region 4	6,7,21,20,19,18	227.95	
Region 5	13,14,6,18,17,16,15	71.425	Proposed Fill
Region 6	2,3,12,11	16.2	Sandy Fill/Debris
Region 7	12,13,15,16,31,28,27,26,55,60,25,59	197.36	Sandy Fill/Debris
Region 8	28,31,30,69,62,29,61,56	37.66	Gravelly Debris
Region 9	37,19,20,22	101.74	Sandy Fill/Debris
Region 10	20,21,24,23,22	76.005	Proposed Fill
Region 11	36,53,37,22,23,24,41,40,39,38	658.68	Silty Fill/Debris
Region 12	36,38,39,40,41,44,43,35	802.12	Sandy Fill/Deb

			ris
Region 13	35,43,42,68,34	245.48	Gravelly Debris
Region 14	51,45,46,47,57,48,49,50,52	4,678.9	Alluvium
Region 15	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8	Bay Mud Crust
Region 16	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7	Bay Mud
Region 17	4,8,58	5.7112	
Region 18	3,4,8,58,13,12	18.519	

Current Slip Surface

Slip Surface: 6,886
F of S: 1.30
Volume: 320.45834 ft³
Weight: 33,251.332 lbs
Resisting Moment: 161,688.07 lbs-ft
Activating Moment: 124,362.64 lbs-ft
Resisting Force: 5,995.8215 lbs
Activating Force: 4,650.9166 lbs
F of S Rank: 1
Exit: (50.59943, -0.32369215) ft
Entry: (86.480346, 8.0383123) ft
Radius: 19.160024 ft
Center: (67.343928, 8.9891124) ft

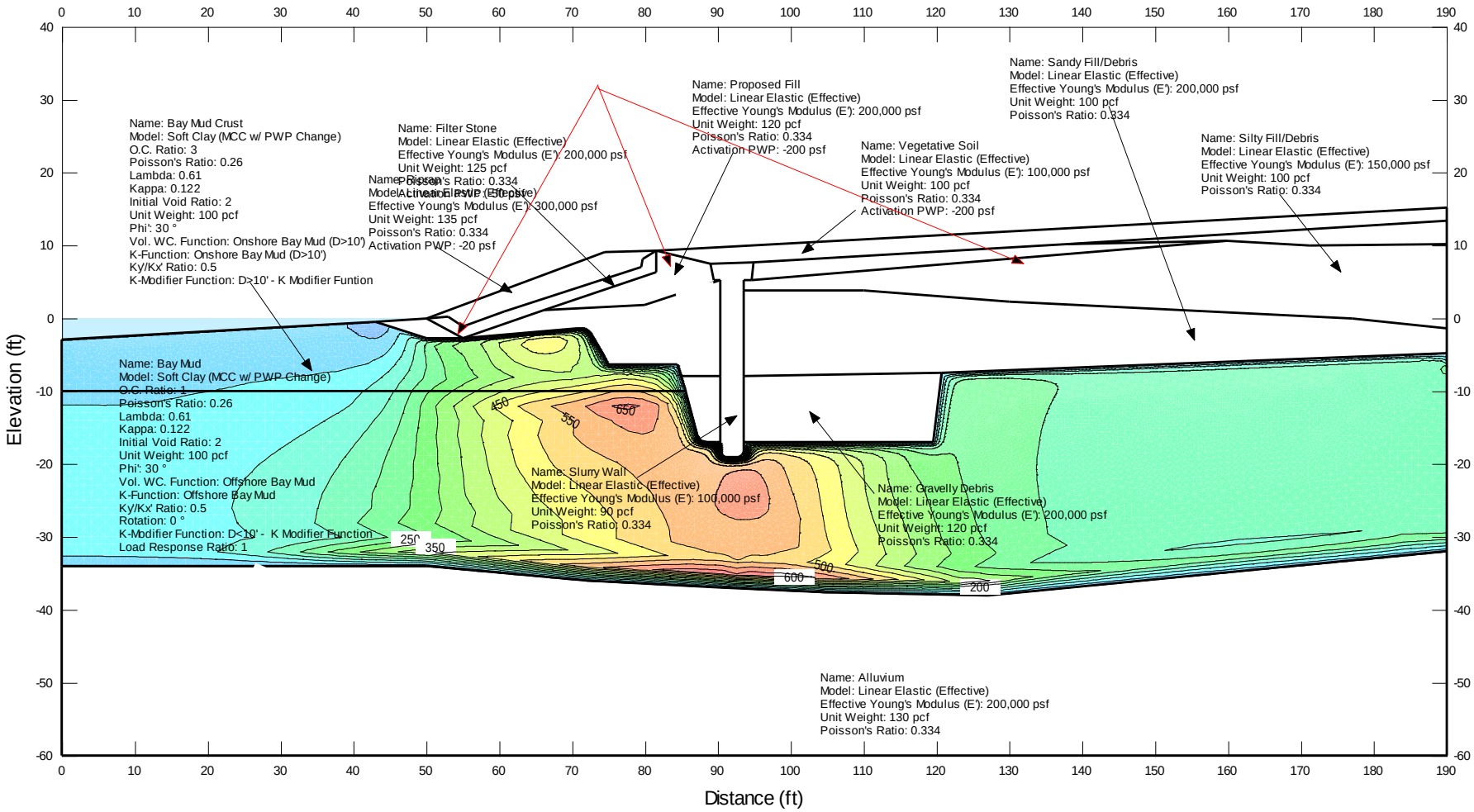
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	51.38104	-1.5118461	97.786271	214.16725	72.722909	0
Slice 2	52.581325	-3.2067876	162.41229	389.77067	0	115
Slice 3	53.5	-4.2369337	197.80739	465.93888	0	115
Slice 4	54.5	-5.2124921	262.02255	536.8613	0	115
Slice 5	55.58	-6.116387	331.34998	623.45023	0	115
Slice 6	56.74	-6.9538495	401.67612	719.38988	0	115

Slice 7	57.9	-7.6684455	466.10334	803.07639	0	115
Slice 8	59.06	-8.2755691	525.35735	875.48145	0	115
Slice 9	60.22	-8.7863132	576.97548	937.37909	0	115
Slice 10	61.465079	-9.2333273	627.4124	992.52293	0	115
Slice 11	62.795238	-9.6105427	674.35209	1,040.0286	0	115
Slice 12	64.125397	-9.8865969	713.64251	1,076.067	0	115
Slice 13	65.445238	-10.065245	744.23313	1,111.6107	0	115
Slice 14	66.732896	-10.150695	766.67146	1,154.2667	0	115
Slice 15	67.998689	-10.149247	781.85815	1,191.0183	0	122.42643
Slice 16	69.264482	-10.063797	789.67897	1,218.0632	0	132.52101
Slice 17	70.348689	-9.9283166	789.9878	1,234.0091	0	141.21579
Slice 18	71.3	-9.751082	784.52415	1,241.544	0	148.81438
Slice 19	72.15263	-9.554086	776.51627	1,244.0822	0	155.41367
Slice 20	72.953945	-9.3251998	765.32652	1,241.8342	0	161.40255
Slice 21	73.851315	-9.0256831	748.88382	1,234.7075	0	167.987
Slice 22	74.4	-8.8239953	736.86261	1,228.3145	0	172.04667
Slice 23	74.75	-8.6795928	727.82561	1,222.6259	0	174.57449
Slice 24	75.648606	-8.2625737	709.87168	1,204.1369	0	178.10188
Slice 25	76.945818	-7.5743464	670.38409	1,167.895	0	184.67809
Slice 26	78.24303	-6.7491737	561.602	1,108.621	0	207.93428
Slice 27	79.195818	-6.0604495	451.04481	989.8057	336.65517	0
Slice 28	79.6	-5.737676	431.91259	964.72455	332.93786	0
Slice 29	79.85	-5.5252075	419.27855	947.9285	330.33715	0
Slice 30	80.75	-4.6592777	367.49093	874.4329	316.7725	0
Slice 31	82.029217	-3.2896548	285.21939	965.55836	425.12297	0
Slice 32	83.087651	-1.8909239	200.58043	780.81536	362.57103	0
Slice 33	84.146085	-0.15243045	94.740289	564.40004	293.47599	0
Slice 34	85.20452	2.2157582	-50.392828	313.69893	196.02084	0
Slice 35	86.107041	5.824779	-193.03993	-173.84414	-100.36896	200

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure After Placement of Filter & Revetment

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure After Placement of Filter & Revetment



Pore Pressure After Placement of Filter & Revetment

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 3:42:00 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Pore Pressure After Placement of Filter & Revetment

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability
Kind: SIGMA/W
Parent: Pore Pressure after Soil Fill Placement
Method: Coupled Stress/PWP
Settings
- Initial Stress: Parent Analysis
- Initial PWP: Parent Analysis
- Exclude cumulative values: No

Control
- Apply Body Force in All Steps: No
- Saturated Zone Only: No

Convergence
- Maximum Number of Iterations: 50
- Minimum Pressure Head Difference: 0.001
- Minimum Displacement Difference: 0.001

Significant Digits: 3
Hydraulic Under-Relaxation Criteria
Under-Relaxation Initial Rate: 1
Under-Relaxation Min. Rate: 0.1
Under-Relaxation Reduction Rate: 0.65
Under-Relaxation Iterations: 10
Equation Solver: Parallel Direct
Time
Starting Time: 21 days
Duration: 14 days
# of Steps: 1
Step Generation Method: Linear
Save Steps Every: 1

Materials

Riprap

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 300,000 psf
Unit Weight: 135 pcf
Poisson's Ratio: 0.334
Activation PWP: -20 psf

Filter Stone

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 125 pcf
Poisson's Ratio: 0.334
Activation PWP: -50 psf

Proposed Fill

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 120 pcf
Poisson's Ratio: 0.334
Activation PWP: -200 psf

Vegetative Soil

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 100,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Activation PWP: -200 psf

Slurry Wall

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 100,000 psf
Unit Weight: 90 pcf
Poisson's Ratio: 0.334

Sandy Fill/Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Gravelly Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 120 pcf
Poisson's Ratio: 0.334

Bay Mud

Model: Soft Clay (MCC w/ PWP Change)
Stress Strain
O.C. Ratio: 1
Poisson's Ratio: 0.26
Lambda: 0.61
Kappa: 0.122
Initial Void Ratio: 2
Unit Weight: 100 pcf
Phi': 30 °
Hydraulic
Vol. WC. Function: Offshore Bay Mud
K-Function: Offshore Bay Mud
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
K-Modifier Function: D<10' - K Modifier Function
Load Response Ratio: 1

Alluvium

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 130 pcf
Poisson's Ratio: 0.334

Silty Fill/Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 150,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Bay Mud Crust

Model: Soft Clay (MCC w/ PWP Change)
Stress Strain
O.C. Ratio: 3
Poisson's Ratio: 0.26
Lambda: 0.61
Kappa: 0.122
Initial Void Ratio: 2
Unit Weight: 100 pcf
Phi': 30 °
Hydraulic
Vol. WC. Function: Onshore Bay Mud (D>10')
K-Function: Onshore Bay Mud (D>10')
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
K-Modifier Function: D>10' - K Modifier Funtion
Load Response Ratio: 1

Boundary Conditions

Fixed X

X: X-Displacement 0

Fixed X/Y

X: X-Displacement 0
Y: Y-Displacement 0

Bay Water Level

Type: Head (H) 0
Review: No

Initial Water Tables

Initial Water Table 1

Max. negative head: 5
Coordinates
Coordinate 1: (0, 0) ft
Coordinate 2: (50, 0) ft

Coordinate 3: (55, 0.5) ft
Coordinate 4: (100, 2) ft
Coordinate 5: (190, 3) ft

K Functions

Offshore Bay Mud

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
Data Point: (0.01, 0.0004)
Data Point: (0.018329807, 0.00038967277)
Data Point: (0.033598183, 0.00037792234)
Data Point: (0.061584821, 0.00036462391)
Data Point: (0.11288379, 0.00034960021)
Data Point: (0.20691381, 0.00033268641)
Data Point: (0.37926902, 0.00031372429)
Data Point: (0.6951928, 0.00029257292)
Data Point: (1.274275, 0.00026912696)
Data Point: (2.3357215, 0.0002433421)
Data Point: (4.2813324, 0.00021527057)
Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Vol. Water Content Function 3
Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %

Segment Curvature: 100 %
K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
Data Point: (0.01, 0.0004)
Data Point: (0.018329807, 0.00038967277)
Data Point: (0.033598183, 0.00037792234)
Data Point: (0.061584821, 0.00036462391)
Data Point: (0.11288379, 0.00034960021)
Data Point: (0.20691381, 0.00033268641)
Data Point: (0.37926902, 0.00031372429)
Data Point: (0.6951928, 0.00029257292)
Data Point: (1.274275, 0.00026912696)
Data Point: (2.3357215, 0.0002433421)
Data Point: (4.2813324, 0.00021527057)
Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Onshore Bay Mud (D>10')
Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Hydraulic K Modifier Functions

D>10' - K Modifier Funtion

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 100 %
Y-Intercept: 0.96838408
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (750, 1)
Data Point: (1,300, 0.6)
Data Point: (2,200, 0.3)
Data Point: (2,750, 0.2)

D<10' - K Modifier Function

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 0 %
Y-Intercept: 1
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (150, 1)
Data Point: (800, 0.55)
Data Point: (1,300, 0.375)
Data Point: (2,200, 0.1875)

Vol. Water Content Functions

Offshore Bay Mud

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.72999997)
Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)
Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)
Estimation Properties
Vol. WC Estimation Method: Sample functions

Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.72999997)
Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)
Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01

Num. Points: 20

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	81.5	6.2
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8
Point 30	90.4	-17.1
Point 31	90.5	-8

Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	0	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3
Point 66	92.9	-19
Point 67	93.5	-17.4

Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Lines

	Start Point	End Point	Hydraulic Boundary	Stress/Strain Boundary
Line 1	3	5		
Line 2	5	6		
Line 3	6	10		
Line 4	10	9		
Line 5	4	3		
Line 6	6	14		
Line 7	14	13		
Line 8	13	12		
Line 9	12	3		
Line 10	18	17		
Line 11	17	16		
Line 12	18	19		
Line 13	37	53		
Line 14	53	36		
Line 15	36	35		
Line 16	35	34		
Line 17	30	31		
Line 18	31	16		
Line 19	6	7		
Line 20	7	21		
Line 21	21	20		
Line 22	20	19		
Line 23	18	6		
Line 24	16	15		
Line 25	15	13		
Line 26	2	3	Bay Water Level	
Line 27	12	11		
Line 28	11	2		
Line 29	31	28		

Line 30	28	27		
Line 31	27	26		
Line 32	19	37		
Line 33	20	22		
Line 34	22	37		
Line 35	21	24		Fixed X
Line 36	24	23		
Line 37	23	22		
Line 38	24	41		Fixed X
Line 39	41	40		
Line 40	40	39		
Line 41	39	38		
Line 42	38	36		
Line 43	41	44		Fixed X
Line 44	44	43		
Line 45	43	35		
Line 46	43	42		
Line 47	50	49	Bay Water Level	
Line 48	49	48	Bay Water Level	
Line 49	47	46	Bay Water Level	
Line 50	46	45	Bay Water Level	
Line 51	51	45		Fixed X
Line 52	50	52		Fixed X
Line 53	52	51		Fixed X/Y
Line 54	26	55		
Line 55	1	2	Bay Water Level	
Line 56	54	1		Fixed X
Line 57	56	28		
Line 58	54	56		
Line 59	48	57	Bay Water Level	
Line 60	57	47	Bay Water Level	
Line 61	45	54		Fixed X
Line 62	44	50		Fixed X
Line 63	9	58		
Line 64	58	4		
Line 65	13	58		

Line 66	4	8		
Line 67	8	58		
Line 68	25	59		
Line 69	59	12		
Line 70	55	60		
Line 71	60	25		
Line 72	29	61		
Line 73	61	56		
Line 74	62	29		
Line 75	32	63		
Line 76	64	32		
Line 77	65	33		
Line 78	33	66		
Line 79	66	64		
Line 80	34	67		
Line 81	67	65		
Line 82	42	68		
Line 83	30	69		
Line 84	69	62		
Line 85	63	70		
Line 86	70	30		
Line 87	68	34		

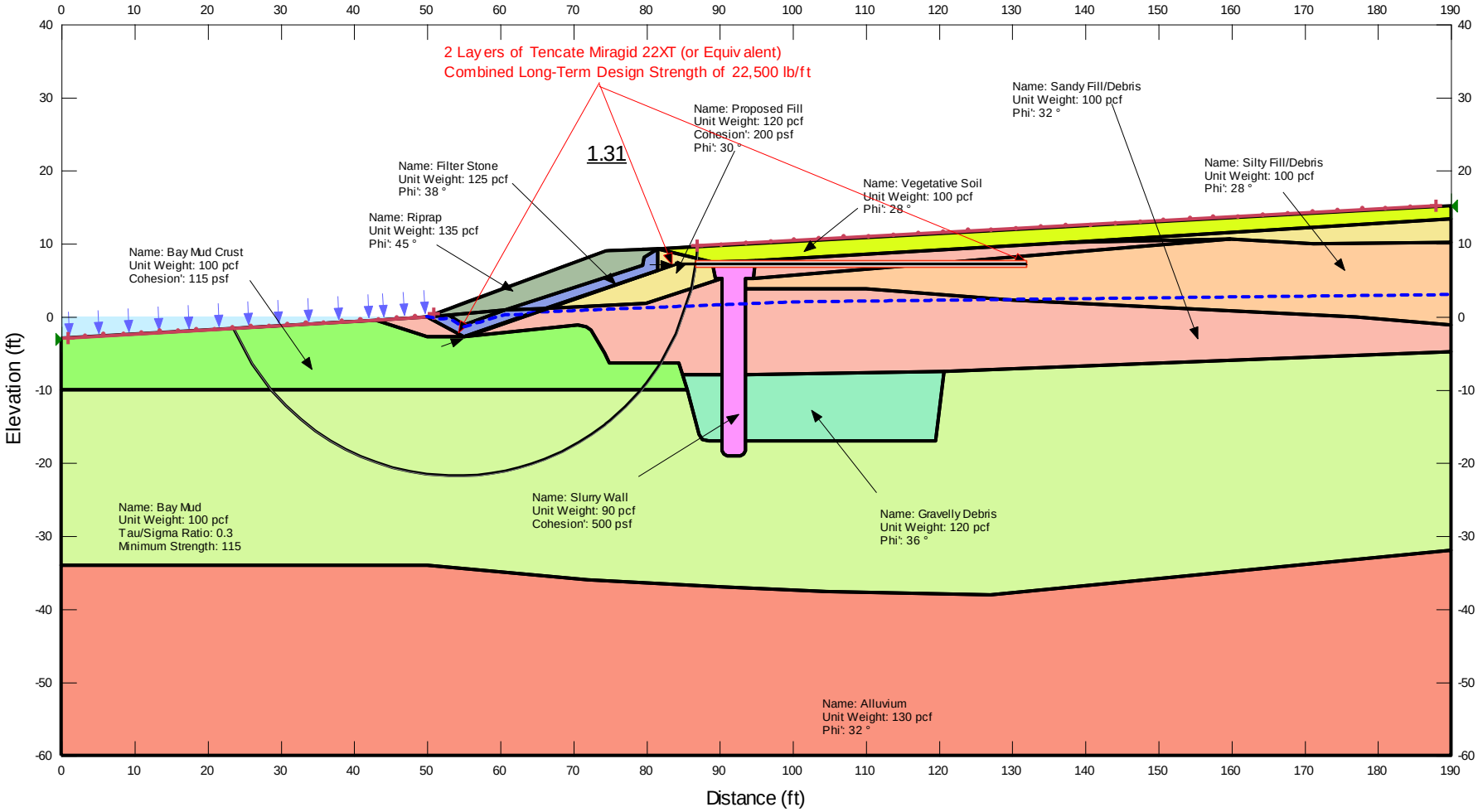
Regions

	Material	Points	Area (ft^2)
Region 1	Riprap	3,5,6,10,9,58,4	81.219
Region 2	Filter Stone	58,9,10,6,14,13	29.596
Region 3	Slurry Wall	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	71.425
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,60,25,59	197.36

Region 8	Gravelly Debris	28,31,30,69,62,29,61,56	37.66
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,68,34	245.48
Region 14	Alluvium	51,45,46,47,57,48,49,50,52	4,678.9
Region 15	Bay Mud Crust	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8
Region 16	Bay Mud	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7
Region 17	Riprap	4,8,58	5.7112
Region 18	Filter Stone	3,4,8,58,13,12	18.519

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', End-of-Construction, with Geogrids

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', End-of-Construction, with Geogrids



End-of-Construction, with Geogrids

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 4:37:44 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

End-of-Construction, with Geogrids

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Parent: Pore Pressure After Placement of Filter & Revetment
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8
  - Lambda 11: 1
- PWP Conditions Source: Parent Analysis

Slip Surface

Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Riprap

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °

Filter Stone

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °

Vegetative Soil

Model: Mohr-Coulomb

Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °

Sandy Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Gravelly Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °

Bay Mud

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.3
Minimum Strength: 115

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Bay Mud Crust

Model: Mohr-Coulomb

Unit Weight: 100 pcf
Cohesion': 115 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (1, -2.94186) ft
Left-Zone Right Coordinate: (51, 0.367347) ft
Left-Zone Increment: 20
Right Projection: Range
Right-Zone Left Coordinate: (87, 9.599078) ft
Right-Zone Right Coordinate: (187.9998, 15.091233) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, -3) ft
Right Coordinate: (190, 15.2) ft

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (55.49826, -2.70365) ft
Inside Point: (84.3, 7.1) ft
Slip Surface Intersection: () ft
Total Length: 30.424526 ft
Reinforcement Direction: 198.8 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft

Governing Component: (none)

Reinforcement 2

Type: Geosynthetic
Outside Point: (84.2, 7.2) ft
Inside Point: (132, 7.2) ft
Slip Surface Intersection: (86.751706, 7.2) ft
Total Length: 47.8 ft
Reinforcement Direction: 180 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 20,015.175 lbs
Pullout Force per Length: 442.34099 lbs/ft
Available Length: 45.248294 ft
Required Length: 45.248294 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	81.5	6.2

Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8
Point 30	90.4	-17.1
Point 31	90.5	-8
Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32

Point 51	0	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3
Point 66	92.9	-19
Point 67	93.5	-17.4
Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Regions

	Material	Points	Area (ft²)
Region 1	Riprap	3,5,6,10,9,58,4	81.219
Region 2	Filter Stone	58,9,10,6,14,13	29.596
Region 3	Slurry Wall	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	71.425
Region 6	Sandy Fill/Debris	2,3,12,11	16.2

Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,60,25,59	197.36
Region 8	Gravelly Debris	28,31,30,69,62,29,61,56	37.66
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,68,34	245.48
Region 14	Alluvium	51,45,46,47,57,48,49,50,52	4,678.9
Region 15	Bay Mud Crust	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8
Region 16	Bay Mud	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7
Region 17	Riprap	4,8,58	5.7112
Region 18	Filter Stone	3,4,8,58,13,12	18.519

Current Slip Surface

Slip Surface: 3,080
F of S: 1.31
Volume: 1,180.9384 ft^3
Weight: 123,580.56 lbs
Resisting Moment: 586,655.87 lbs-ft
Activating Moment: 446,245.36 lbs-ft
Resisting Force: 13,150.738 lbs
Activating Force: 10,029.757 lbs
F of S Rank: 1

Exit: (23.531295, -1.6319014) ft
Entry: (87, 9.5990783) ft
Radius: 33.063734 ft
Center: (53.978022, 11.26024) ft

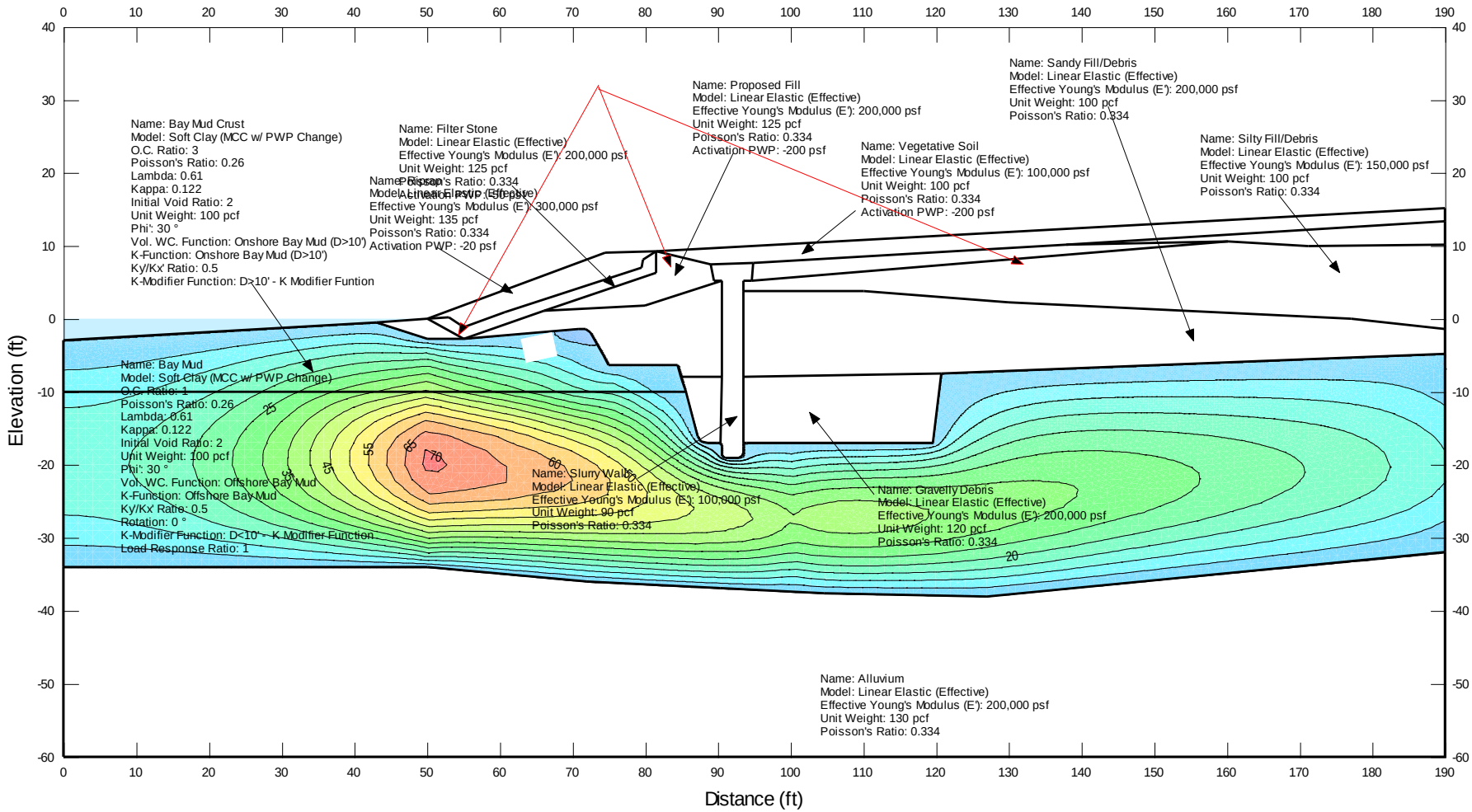
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	24.812433	-4.0693522	270.98266	442.40699	0	115
Slice 2	27.374707	-8.2534017	563.74257	666.70143	0	115
Slice 3	29.680427	-11.112723	756.22887	808.73988	0	115
Slice 4	31.729592	-13.158946	899.55509	910.53925	0	115
Slice 5	33.778757	-14.884048	1,025.6139	1,006.1567	0	127.14985
Slice 6	35.827922	-16.349196	1,135.9398	1,095.3078	0	139.35038
Slice 7	37.877087	-17.594461	1,233.7751	1,182.344	0	148.70162
Slice 8	39.926252	-18.647564	1,320.4848	1,271.2536	0	155.62568
Slice 9	41.975417	-19.528373	1,397.3708	1,364.8787	0	160.328
Slice 10	44.166667	-20.290593	1,469.0706	1,472.5841	0	163.2966
Slice 11	46.5	-20.924463	1,535.1553	1,598.67	0	164.36729
Slice 12	48.833333	-21.379425	1,594.9669	1,736.8406	0	161.9527
Slice 13	51.5	-21.676171	1,652.6948	1,983.6737	0	182.71802
Slice 14	54	-21.788361	1,704.4801	2,295.1707	0	219.667
Slice 15	55.966667	-21.729424	1,734.6337	2,529.4497	0	240.72473
Slice 16	57.9	-21.555622	1,754.4361	2,735.7099	0	251.55864
Slice 17	59.833333	-21.266074	1,766.2938	2,939.3043	0	261.30359
Slice 18	61.683333	-20.880288	1,771.2385	3,124.8834	0	269.28754
Slice 19	63.45	-20.404283	1,769.0532	3,284.3472	0	275.75612
Slice 20	65.216667	-19.820639	1,757.3312	3,416.2614	0	281.85654
Slice 21	67.275	-18.98465	1,733.7769	3,524.9593	0	289.24088
Slice 22	69.625	-17.836198	1,694.9721	3,570.3132	0	297.13107
Slice 23	71.3	-16.89673	1,659.2118	2,787.4269	0	301.55868
Slice 24	72.15263	-16.357072	1,637.8522	2,513.6266	0	302.91629
Slice 25	73.40263	-15.472973	1,599.72	3,139.8957	0	304.16398
Slice 26	74.4	-14.742397	1,567.9359	180.6247	0	304.81239
Slice 27	74.75	-14.461972	1,555.7788	2,204.4511	0	301.33398
Slice 28	76.07505	-13.292561	1,515.4772	3,030.426	0	278.24008

Slice 29	78.225149	-11.162519	1,384.1828	2,616.5171	0	253.56158
Slice 30	79.4001	-9.8798655	1,230.0986	701.61246	-0	115
Slice 31	79.6	-9.6371213	1,199.0291	755.91508	-0	115
Slice 32	79.85	-9.3259985	1,156.6176	1,445.2463	0	115
Slice 33	80.75	-8.10038	982.95597	2,243.1292	0	115
Slice 34	81.746585	-6.6816378	631.80833	1,567.4931	0	115
Slice 35	83.039833	-4.3516125	354.00804	1,017.8539	414.81692	0
Slice 36	85.13316	0.67835806	45.362823	425.89415	237.78237	0
Slice 37	86.527147	5.8492043	-194.41355	-156.9588	-90.620207	200
Slice 38	86.937235	8.7687729	-200	13.124152	6.9782356	

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure after 5-Year Dissipation

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability, Pore Pressure after 5-Year Dissipation



Pore Pressure after 5-Year Dissipation

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 9:30:04 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Pore Pressure after 5-Year Dissipation

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Short-Term Stability
Kind: SIGMA/W
Parent: Pore Pressure After Placement of Filter & Revetment
Method: Coupled Stress/PWP
Settings
- Initial Stress: Parent Analysis
- Initial PWP: Parent Analysis
- Exclude cumulative values: No

Control
- Apply Body Force in All Steps: No
- Saturated Zone Only: No

Convergence
- Maximum Number of Iterations: 50
- Minimum Pressure Head Difference: 0.001
- Minimum Displacement Difference: 0.001
- Significant Digits: 3
- Hydraulic Under-Relaxation Criteria
  - Under-Relaxation Initial Rate: 1

Under-Relaxation Min. Rate: 0.1
Under-Relaxation Reduction Rate: 0.65
Under-Relaxation Iterations: 10
Equation Solver: Parallel Direct
Time
Starting Time: 35 days
Duration: 10,950 days
# of Steps: 100
Step Generation Method: Exponential
Initial Increment Size: 30 days
Save Steps Every: 5

Materials

Riprap

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 300,000 psf
Unit Weight: 135 pcf
Poisson's Ratio: 0.334
Activation PWP: -20 psf

Filter Stone

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 125 pcf
Poisson's Ratio: 0.334
Activation PWP: -50 psf

Proposed Fill

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 200,000 psf
Unit Weight: 125 pcf
Poisson's Ratio: 0.334
Activation PWP: -200 psf

Vegetative Soil

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 100,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334
Activation PWP: -200 psf

Slurry Wall

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 100,000 psf

Unit Weight: 90 pcf

Poisson's Ratio: 0.334

Sandy Fill/Debris

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 200,000 psf

Unit Weight: 100 pcf

Poisson's Ratio: 0.334

Gravelly Debris

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 200,000 psf

Unit Weight: 120 pcf

Poisson's Ratio: 0.334

Bay Mud

Model: Soft Clay (MCC w/ PWP Change)

Stress Strain

O.C. Ratio: 1

Poisson's Ratio: 0.26

Lambda: 0.61

Kappa: 0.122

Initial Void Ratio: 2

Unit Weight: 100 pcf

Phi': 30 °

Hydraulic

Vol. WC. Function: Offshore Bay Mud

K-Function: Offshore Bay Mud

Ky'/Kx' Ratio: 0.5

Rotation: 0 °

K-Modifier Function: D<10' - K Modifier Function

Load Response Ratio: 1

Alluvium

Model: Linear Elastic (Effective)

Stress Strain

Effective Young's Modulus (E'): 200,000 psf

Unit Weight: 130 pcf

Poisson's Ratio: 0.334

Silty Fill/Debris

Model: Linear Elastic (Effective)
Stress Strain
Effective Young's Modulus (E'): 150,000 psf
Unit Weight: 100 pcf
Poisson's Ratio: 0.334

Bay Mud Crust

Model: Soft Clay (MCC w/ PWP Change)
Stress Strain
O.C. Ratio: 3
Poisson's Ratio: 0.26
Lambda: 0.61
Kappa: 0.122
Initial Void Ratio: 2
Unit Weight: 100 pcf
Phi': 30 °
Hydraulic
Vol. WC. Function: Onshore Bay Mud (D>10')
K-Function: Onshore Bay Mud (D>10')
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
K-Modifier Function: D>10' - K Modifier Funtion
Load Response Ratio: 1

Boundary Conditions

Fixed X

X: X-Displacement 0

Fixed X/Y

X: X-Displacement 0
Y: Y-Displacement 0

Bay Water Level

Type: Head (H) 0
Review: No

Initial Water Tables

Initial Water Table 1

Max. negative head: 5
Coordinates
Coordinate 1: (0, 0) ft
Coordinate 2: (50, 0) ft

Coordinate 3: (55, 0.5) ft
Coordinate 4: (100, 2) ft
Coordinate 5: (190, 3) ft

K Functions

Offshore Bay Mud

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
Data Point: (0.01, 0.0004)
Data Point: (0.018329807, 0.00038967277)
Data Point: (0.033598183, 0.00037792234)
Data Point: (0.061584821, 0.00036462391)
Data Point: (0.11288379, 0.00034960021)
Data Point: (0.20691381, 0.00033268641)
Data Point: (0.37926902, 0.00031372429)
Data Point: (0.6951928, 0.00029257292)
Data Point: (1.274275, 0.00026912696)
Data Point: (2.3357215, 0.0002433421)
Data Point: (4.2813324, 0.00021527057)
Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Vol. Water Content Function 3
Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Hyd K Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %

Segment Curvature: 100 %
K-Saturation: 0.0004
Data Points: Matric Suction (psf), X-Conductivity (ft/days)
Data Point: (0.01, 0.0004)
Data Point: (0.018329807, 0.00038967277)
Data Point: (0.033598183, 0.00037792234)
Data Point: (0.061584821, 0.00036462391)
Data Point: (0.11288379, 0.00034960021)
Data Point: (0.20691381, 0.00033268641)
Data Point: (0.37926902, 0.00031372429)
Data Point: (0.6951928, 0.00029257292)
Data Point: (1.274275, 0.00026912696)
Data Point: (2.3357215, 0.0002433421)
Data Point: (4.2813324, 0.00021527057)
Data Point: (7.8475997, 0.00018511983)
Data Point: (14.384499, 0.00015333266)
Data Point: (26.366509, 0.000120709)
Data Point: (48.329302, 8.8567249e-005)
Data Point: (88.586679, 5.8869341e-005)
Data Point: (162.37767, 3.4104101e-005)
Data Point: (297.63514, 1.6474635e-005)
Data Point: (545.55948, 6.422923e-006)
Data Point: (1,000, 2.0258119e-006)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Onshore Bay Mud (D>10')
Hydraulic K Sat: 0.0004 ft/days
Residual Water Content: 0.2 ft^3/ft^3
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Hydraulic K Modifier Functions

D>10' - K Modifier Funtion

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 100 %
Y-Intercept: 0.96838408
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (750, 1)
Data Point: (1,300, 0.6)
Data Point: (2,200, 0.3)
Data Point: (2,750, 0.2)

D<10' - K Modifier Function

Model: Spline Data Point Function (Y Log)
Function: K-Modifier vs. Y-Effective Stress
Curve Fit to Data: 0 %
Segment Curvature: 0 %
Y-Intercept: 1
Data Points: Y-Effective Stress (psf), K-Modifier
Data Point: (150, 1)
Data Point: (800, 0.55)
Data Point: (1,300, 0.375)
Data Point: (2,200, 0.1875)

Vol. Water Content Functions

Offshore Bay Mud

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.72999997)
Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)
Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)
Estimation Properties
Vol. WC Estimation Method: Sample functions

Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01
Num. Points: 20

Onshore Bay Mud (D>10')

Model: Vol WC Data Point Function
Function: Vol. Water Content vs. Pore-Water Pressure
Mv: 0.00012 /psf
Saturated Water Content: 0.74073295 ft^3/ft^3
Residual Water Content: 0.074073295 ft^3/ft^3
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.74073295
Data Points: Matric Suction (psf), Vol. Water Content (ft^3/ft^3)
Data Point: (0.01, 0.72999997)
Data Point: (0.018329807, 0.72999995)
Data Point: (0.033598183, 0.7299999)
Data Point: (0.061584821, 0.72999979)
Data Point: (0.11288379, 0.72999957)
Data Point: (0.20691381, 0.72999907)
Data Point: (0.37926902, 0.72999797)
Data Point: (0.6951928, 0.72999548)
Data Point: (1.274275, 0.72998974)
Data Point: (2.3357215, 0.7299763)
Data Point: (4.2813324, 0.72994451)
Data Point: (7.8475997, 0.72986859)
Data Point: (14.384499, 0.72968594)
Data Point: (26.366509, 0.72924431)
Data Point: (48.329302, 0.7281738)
Data Point: (88.586679, 0.72558263)
Data Point: (162.37767, 0.71936939)
Data Point: (297.63514, 0.7048642)
Data Point: (545.55948, 0.67310241)
Data Point: (1,000, 0.612308)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.73 ft^3/ft^3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum: 1,000
Minimum: 0.01

Num. Points: 20

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	81.5	6.2
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8
Point 30	90.4	-17.1
Point 31	90.5	-8

Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	0	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3
Point 66	92.9	-19
Point 67	93.5	-17.4

Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Lines

	Start Point	End Point	Hydraulic Boundary	Stress/Strain Boundary
Line 1	3	5		
Line 2	5	6		
Line 3	6	10		
Line 4	10	9		
Line 5	4	3		
Line 6	6	14		
Line 7	14	13		
Line 8	13	12		
Line 9	12	3		
Line 10	18	17		
Line 11	17	16		
Line 12	18	19		
Line 13	37	53		
Line 14	53	36		
Line 15	36	35		
Line 16	35	34		
Line 17	30	31		
Line 18	31	16		
Line 19	6	7		
Line 20	7	21		
Line 21	21	20		
Line 22	20	19		
Line 23	18	6		
Line 24	16	15		
Line 25	15	13		
Line 26	2	3	Bay Water Level	
Line 27	12	11		
Line 28	11	2		
Line 29	31	28		

Line 30	28	27		
Line 31	27	26		
Line 32	19	37		
Line 33	20	22		
Line 34	22	37		
Line 35	21	24		Fixed X
Line 36	24	23		
Line 37	23	22		
Line 38	24	41		Fixed X
Line 39	41	40		
Line 40	40	39		
Line 41	39	38		
Line 42	38	36		
Line 43	41	44		Fixed X
Line 44	44	43		
Line 45	43	35		
Line 46	43	42		
Line 47	50	49	Bay Water Level	
Line 48	49	48	Bay Water Level	
Line 49	47	46	Bay Water Level	
Line 50	46	45	Bay Water Level	
Line 51	51	45		Fixed X
Line 52	50	52		Fixed X
Line 53	52	51		Fixed X/Y
Line 54	26	55		
Line 55	1	2	Bay Water Level	
Line 56	54	1		Fixed X
Line 57	56	28		
Line 58	54	56		
Line 59	48	57	Bay Water Level	
Line 60	57	47	Bay Water Level	
Line 61	45	54		Fixed X
Line 62	44	50		Fixed X
Line 63	9	58		
Line 64	58	4		
Line 65	13	58		

Line 66	4	8		
Line 67	8	58		
Line 68	25	59		
Line 69	59	12		
Line 70	55	60		
Line 71	60	25		
Line 72	29	61		
Line 73	61	56		
Line 74	62	29		
Line 75	32	63		
Line 76	64	32		
Line 77	65	33		
Line 78	33	66		
Line 79	66	64		
Line 80	34	67		
Line 81	67	65		
Line 82	42	68		
Line 83	30	69		
Line 84	69	62		
Line 85	63	70		
Line 86	70	30		
Line 87	68	34		

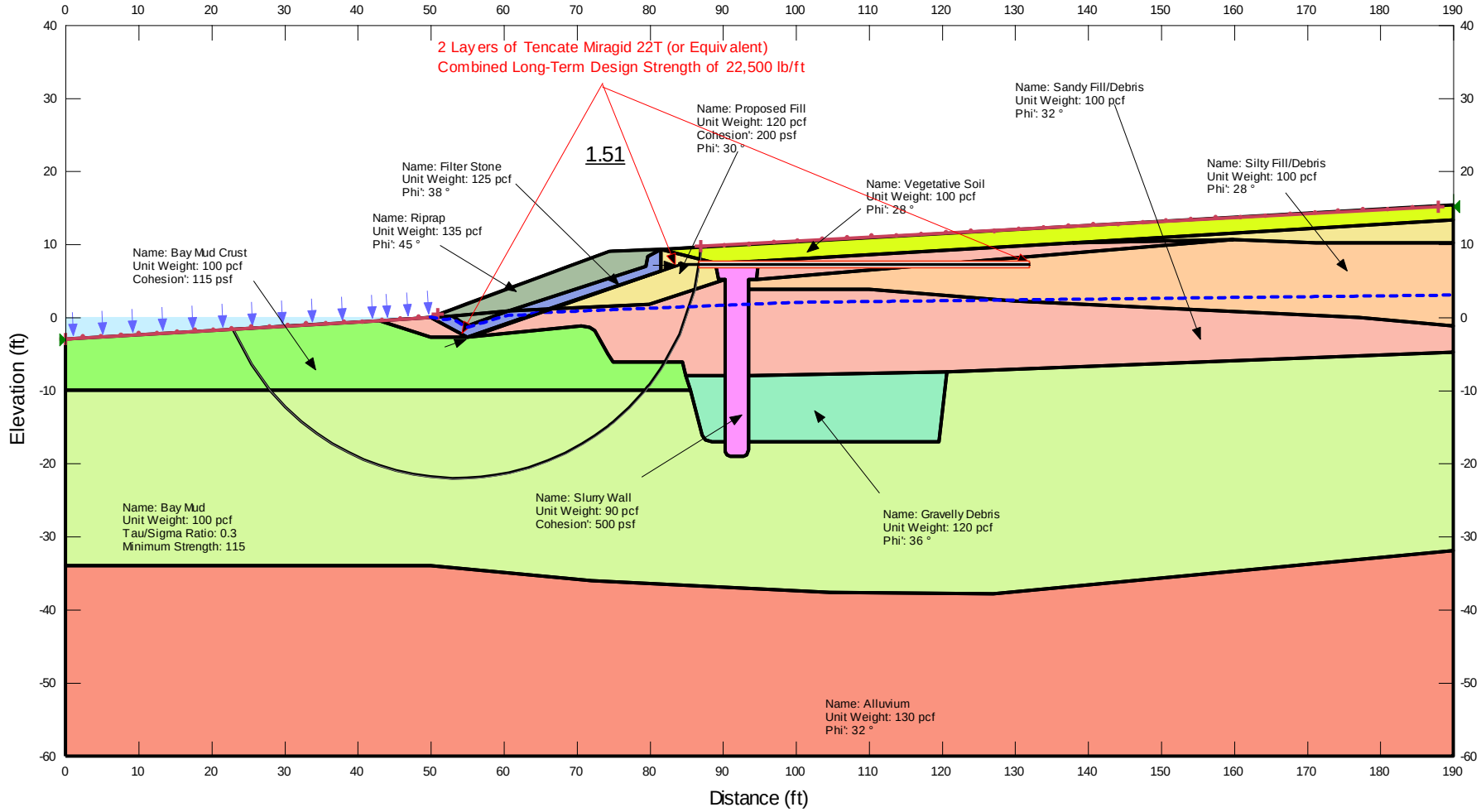
Regions

	Material	Points	Area (ft^2)
Region 1	Riprap	3,5,6,10,9,58,4	81.219
Region 2	Filter Stone	58,9,10,6,14,13	29.596
Region 3	Slurry Wall	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	71.425
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,60,25,59	197.36

Region 8	Gravelly Debris	28,31,30,69,62,29,61,56	37.66
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,68,34	245.48
Region 14	Alluvium	51,45,46,47,57,48,49,50,52	4,678.9
Region 15	Bay Mud Crust	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8
Region 16	Bay Mud	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7
Region 17	Riprap	4,8,58	5.7112
Region 18	Filter Stone	3,4,8,58,13,12	18.519

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', With Sloping Geogrids, 5-Years after Construction

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', With Sloping Geogrids, 5-Years after Construction



With Sloping Geogrids, 5-Years after Construction

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File Information

File Name: A-A'_with Geogrids _Short-Term_2.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\Short-Term\
Last Solved Date: 3/20/2013
Last Solved Time: 3:55:46 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Days
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

With Sloping Geogrids, 5-Years after Construction

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Parent: Pore Pressure after 5-Year Dissipation
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8

Lambda 11: 1
PWP Conditions Source: Parent Analysis
Slip Surface
Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Riprap

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °

Filter Stone

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °

Vegetative Soil

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °

Sandy Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Gravelly Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °

Bay Mud

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.3
Minimum Strength: 115

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Bay Mud Crust

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 115 psf
Phi': 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0, -3) ft
Left-Zone Right Coordinate: (51, 0.367347) ft
Left-Zone Increment: 20
Right Projection: Range
Right-Zone Left Coordinate: (87, 9.599078) ft
Right-Zone Right Coordinate: (187.9998, 15.091233) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, -3) ft
Right Coordinate: (190, 15.2) ft

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (55.49826, -2.70365) ft
Inside Point: (84.3, 7.1) ft
Slip Surface Intersection: () ft
Total Length: 30.424526 ft
Reinforcement Direction: 198.8 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft

Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 2

Type: Geosynthetic
Outside Point: (84.2, 7.2) ft
Inside Point: (132, 7.2) ft
Slip Surface Intersection: (86.75277, 7.2) ft
Total Length: 47.8 ft
Reinforcement Direction: 180 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 20,010.44 lbs
Pullout Force per Length: 442.24675 lbs/ft
Available Length: 45.24723 ft
Required Length: 45.24723 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0.1
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1

Point 14	81.5	6.2
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	71.8	-1.4
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.6	-16.8
Point 30	90.4	-17.1
Point 31	90.5	-8
Point 32	90.6	-18.8
Point 33	93.4	-18.8
Point 34	93.6	-17.1
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38

Point 50	190	-32
Point 51	0	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001
Point 57	90.4	-36.89816
Point 58	60.8	0.741224
Point 59	70.8	-1.314035
Point 60	72.50526	-1.899999
Point 61	87.25	-16.1
Point 62	88.5	-17
Point 63	90.5	-18.4
Point 64	91.1	-19
Point 65	93.5	-18.3
Point 66	92.9	-19
Point 67	93.5	-17.4
Point 68	94	-17
Point 69	89.9	-17
Point 70	90.5	-17.4

Regions

	Material	Points	Area (ft²)
Region 1	Riprap	3,5,6,10,9,58,4	81.219
Region 2	Filter Stone	58,9,10,6,14,13	29.596
Region 3	Slurry Wall	18,19,37,53,36,35,34,67,65,33,66,64,32,63,70,30,31,16,17	86.405
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	71.425
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,60,25,59	197.36
Region 8	Gravelly Debris	28,31,30,69,62,29,61,56	37.66
Region 9	Sandy	37,19,20,22	101.74

	Fill/Debris		
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,68,34	245.48
Region 14	Alluvium	51,45,46,47,57,48,49,50,52	4,678.9
Region 15	Bay Mud Crust	1,2,11,12,59,25,60,55,26,27,28,56,54	642.8
Region 16	Bay Mud	54,56,61,29,62,69,30,70,63,32,64,66,33,65,67,34,68,42,43,44,50,49,48,57,47,46,45	4,848.7
Region 17	Riprap	4,8,58	5.7112
Region 18	Filter Stone	3,4,8,58,13,12	18.519

Current Slip Surface

Slip Surface: 3,080
F of S: 1.51
Volume: 1,201.3188 ft³
Weight: 125,618.81 lbs
Resisting Moment: 683,917.79 lbs-ft
Activating Moment: 454,353.99 lbs-ft
Resisting Force: 15,270.298 lbs
Activating Force: 10,189.491 lbs
F of S Rank: 1
Exit: (22.981295, -1.6638782) ft
Entry: (87, 9.5990783) ft
Radius: 33.336954 ft
Center: (53.705163, 11.2743) ft

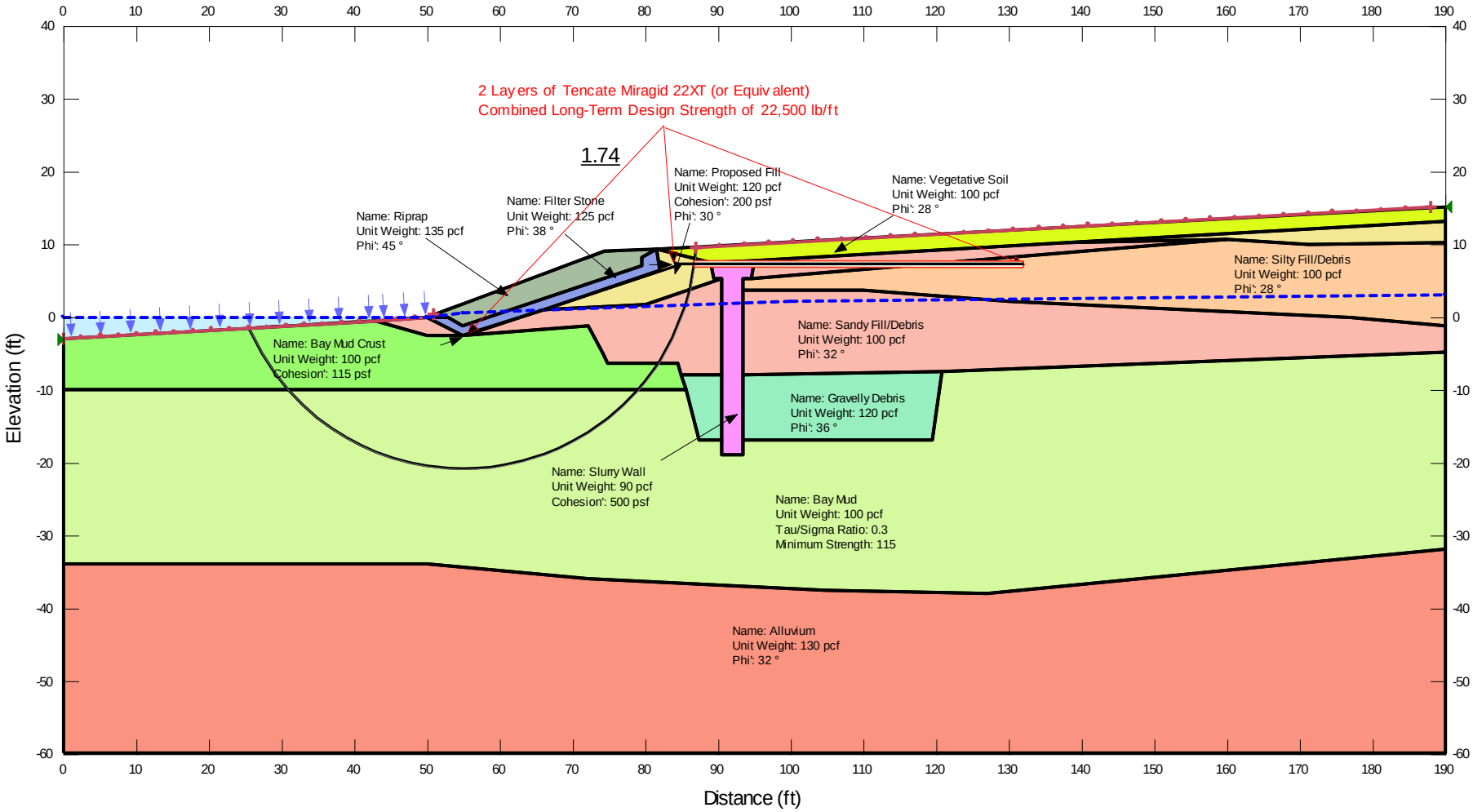
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	24.245698	-4.0884809	273.28234	429.53589	0	115
Slice 2	26.774505	-8.256542	567.14926	667.05527	0	115
Slice 3	29.107557	-11.171118	774.74938	819.59642	0	115
Slice 4	31.244856	-13.31823	930.02605	931.59193	0	115
Slice 5	33.382155	-15.11715	1,061.3929	1,034.0113	0	123.1491
Slice 6	35.519454	-16.636373	1,173.671	1,130.8487	0	136.44402
Slice 7	37.656753	-17.920116	1,270.3789	1,225.0866	0	147.34562

Slice 8	39.794052	-18.99863	1,352.53	1,320.8529	0	156.45742
Slice 9	41.931351	-19.893389	1,423.9107	1,421.02	0	163.28762
Slice 10	44.166667	-20.645708	1,486.0456	1,532.842	0	168.85757
Slice 11	46.5	-21.252769	1,540.3273	1,659.611	0	172.66489
Slice 12	48.833333	-21.683657	1,584.3442	1,796.3707	0	174.26645
Slice 13	51.5	-21.955654	1,620.8169	2,040.4563	0	200.66587
Slice 14	54	-22.046347	1,645.4499	2,347.3797	0	245.11564
Slice 15	55.966667	-21.971742	1,655.9051	2,575.3177	0	271.61285
Slice 16	57.9	-21.783322	1,658.8505	2,772.6618	0	287.06531
Slice 17	59.833333	-21.479797	1,654.3199	2,965.1917	0	301.30747
Slice 18	62.125	-20.95276	1,637.7118	3,173.8843	0	316.54299
Slice 19	64.775	-20.139671	1,603.1728	3,372.0761	0	332.65171
Slice 20	67.275	-19.148664	1,549.2725	3,493.6673	0	349.5126
Slice 21	69.625	-17.985262	1,477.7745	3,520.5848	0	366.76224
Slice 22	71.3	-17.035197	1,409.8581	2,767.7175	0	380.51882
Slice 23	72.15263	-16.490142	1,369.2254	2,501.3213	0	387.49642
Slice 24	73.40263	-15.598072	1,298.2551	3,076.2366	0	398.35643
Slice 25	74.4	-14.861116	1,234.1172	280.62254	0	408.51957
Slice 26	74.75	-14.578426	1,209.2029	2,175.6947	0	408.80038
Slice 27	76.092854	-13.382643	1,097.977	2,917.9879	0	406.19125
Slice 28	78.278563	-11.195184	878.77753	2,470.5321	0	406.15897
Slice 29	79.435709	-9.9219567	753.00527	-212.88774	-0	115
Slice 30	79.6	-9.7205737	735.93176	899.70697	0	115
Slice 31	79.85	-9.4076138	709.61462	1,542.8623	0	115
Slice 32	80.75	-8.1751007	610.13287	2,280.3203	0	115
Slice 33	81.766766	-6.7161043	502.16444	1,664.9552	0	115
Slice 34	83.071287	-4.3494556	353.95196	1,068.1161	446.25929	0
Slice 35	85.146796	0.68130287	45.213103	459.83342	259.08353	0
Slice 36	86.529671	5.8499516	-194.43371	-136.78667	-78.973822	200
Slice 37	86.937395	8.7687323	-200	14.667329	7.7987571	0

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-3a, Static, With Sloping Geogrids, Large Circular

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-3a, Static, With Sloping Geogrids, Large Circular



Run-3a, Static, With Sloping Geogrids, Large Circular

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File Information

File Name: Run-3a_Static_Sloping-Geogrids.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\
Last Solved Date: 3/21/2013
Last Solved Time: 9:03:58 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Run-3a, Static, With Sloping Geogrids, Large Circular

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8
  - Lambda 11: 1

PWP Conditions Source: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Slip Surface
Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Riprap

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Filter Stone

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Vegetative Soil

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sandy Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravelly Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bay Mud

Model: S=f(overburden)

Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.3
Minimum Strength: 115
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bay Mud Crust

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 115 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (0, -3) ft
Left-Zone Right Coordinate: (51, 0.367347) ft
Left-Zone Increment: 20
Right Projection: Range
Right-Zone Left Coordinate: (87, 9.599078) ft
Right-Zone Right Coordinate: (187.9998, 15.091233) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, -3) ft
Right Coordinate: (190, 15.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	0
Coordinate 2	50	0
Coordinate 3	55	0.5
Coordinate 4	100	2
Coordinate 5	190	3

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (55.49826, -2.70365) ft
Inside Point: (84.3, 7.1) ft
Slip Surface Intersection: () ft
Total Length: 30.424526 ft
Reinforcement Direction: 198.8 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 2

Type: Geosynthetic
Outside Point: (84.2, 7.2) ft
Inside Point: (132, 7.2) ft
Slip Surface Intersection: (86.747671, 7.2) ft
Total Length: 47.8 ft
Reinforcement Direction: 180 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 20,033.166 lbs
Pullout Force per Length: 442.69911 lbs/ft
Available Length: 45.252329 ft
Required Length: 45.252329 ft
Governing Component: Pullout Resistance

Points

	X (ft)	Y (ft)
Point 1	0	-3
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	82	6.4
Point 15	80	1.7

Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	72.1	-1.2
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.5	-17
Point 30	90.5	-17
Point 31	90.5	-8
Point 32	90.5	-19
Point 33	93.5	-19
Point 34	93.5	-17
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	0	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	0	-60

Point 52	190	-60
Point 53	93.5	5.2
Point 54	0	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001

Regions

	Material	Points	Area (ft²)
Region 1	Riprap	3,5,6,10,9,8,4	87.18
Region 2	Filter Stone	3,4,8,9,10,6,14,13,12	48.4
Region 3	Slurry Wall	18,19,37,53,36,35,34,33,32,30,31,16,17	85.65
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	70.89
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,25	197.1
Region 8	Gravelly Debris	28,31,30,29,56	38.25
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,34	245.9
Region 14	Alluvium	51,45,46,47,48,49,50,52	4,678.9
Region 15	Bay Mud Crust	1,2,11,12,25,55,26,27,28,56,54	643.06
Region 16	Bay Mud	45,54,56,29,30,32,33,34,42,43,44,50,49,48,47,46	4,848.4

Current Slip Surface

Slip Surface: 3,421
F of S: 1.74
Volume: 1,108.9894 ft³
Weight: 116,390.08 lbs
Resisting Moment: 728,432.72 lbs-ft
Activating Moment: 417,325.93 lbs-ft
Resisting Force: 17,421.57 lbs
Activating Force: 10,086.717 lbs
F of S Rank: 1
Exit: (25.534772, -1.5154202) ft
Entry: (87, 9.5990783) ft

Radius: 32.069067 ft
Center: (54.971371, 11.209035) ft

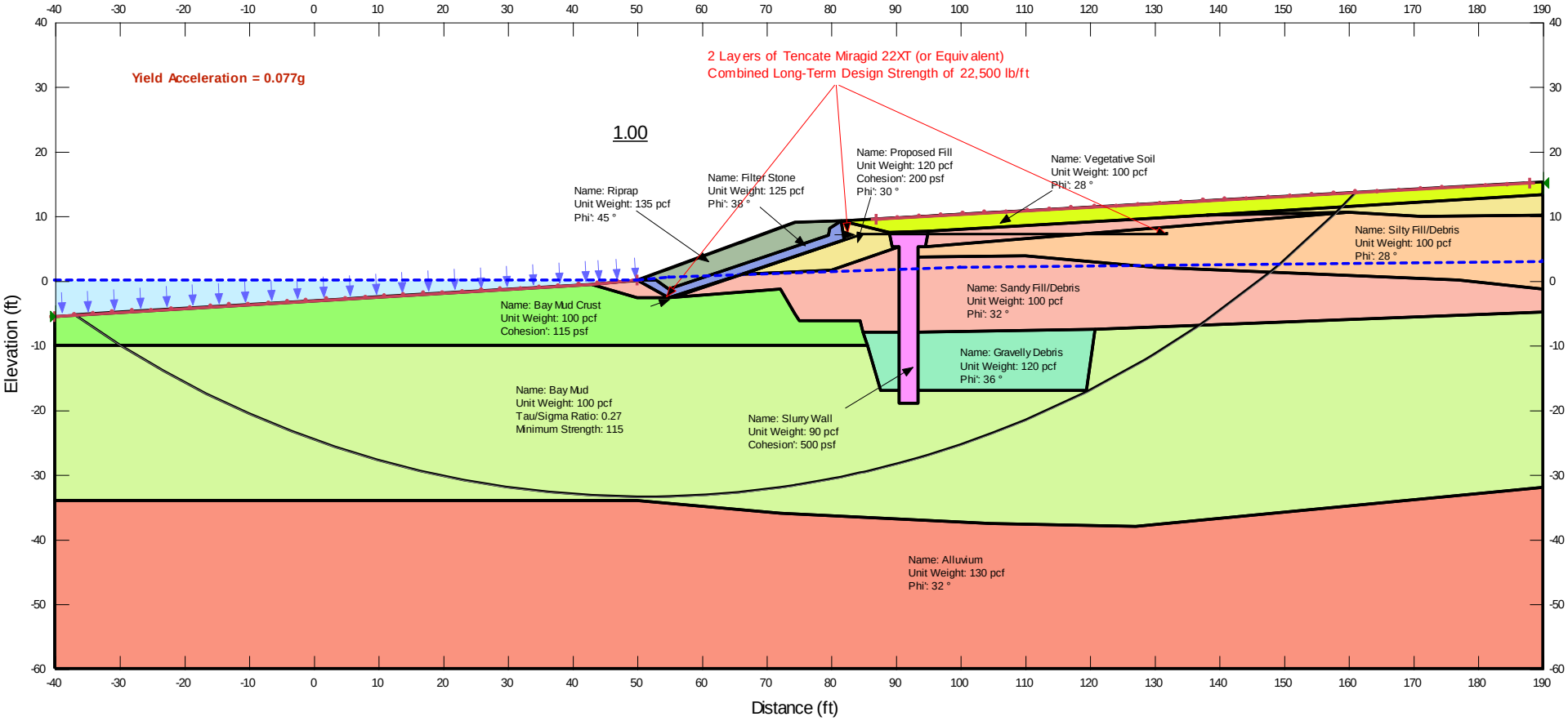
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	26.431848	-3.2821561	204.80654	354.5248	0	115
Slice 2	28.225999	-6.4105905	400.02085	532.07132	0	115
Slice 3	30.02015	-8.8861447	554.49543	657.20218	0	115
Slice 4	31.924124	-11.042887	689.07613	761.39655	0	115
Slice 5	33.937919	-12.961969	808.82686	861.47597	0	134.62797
Slice 6	35.951715	-14.58074	909.83819	949.82816	0	154.20839
Slice 7	37.965511	-15.953707	995.51133	1,032.9333	0	171.01613
Slice 8	39.979306	-17.117017	1,068.1019	1,115.8338	0	185.45894
Slice 9	41.993102	-18.095861	1,129.1817	1,202.0677	0	197.82097
Slice 10	44.166667	-18.95962	1,183.0803	1,301.8805	0	209.16451
Slice 11	46.5	-19.697236	1,229.1075	1,420.5617	0	219.36482
Slice 12	48.833333	-20.244687	1,263.2685	1,552.056	0	227.42007
Slice 13	51.5	-20.635869	1,297.0382	1,794.8472	0	258.35593
Slice 14	54	-20.829701	1,324.7333	2,107.941	0	304.98123
Slice 15	55.940181	-20.831591	1,333.0469	2,345.6542	0	333.96455
Slice 16	57.820542	-20.719265	1,329.9488	2,557.4666	0	352.91039
Slice 17	59.700903	-20.495113	1,319.8729	2,772.7349	0	370.59484
Slice 18	61.897479	-20.076716	1,298.3338	3,016.7995	0	389.48735
Slice 19	64.410271	-19.41128	1,262.0372	3,269.4111	0	408.99241
Slice 20	65.883333	-18.945584	1,236.0418	3,397.396	0	419.574
Slice 21	67.1	-18.458359	1,208.1696	3,477.3676	0	428.84503
Slice 22	69.1	-17.558406	1,156.1726	3,560.421	0	443.56932
Slice 23	71.1	-16.484885	1,093.3448	3,144.1886	0	456.33575
Slice 24	73.2	-15.141545	1,013.8884	3,154.8971	0	467.30243
Slice 25	74.4	-14.304444	964.14932	-275.79138	0	472.78538
Slice 26	74.75	-14.032399	947.90172	2,016.1407	0	470.78451
Slice 27	76.006379	-12.960648	883.6377	2,950.4919	0	457.81071
Slice 28	78.019136	-11.042396	768.12531	2,553.3318	0	434.75593
Slice 29	79.262757	-9.7247061	688.4882	1,876.6312	0	115
Slice 30	79.6	-9.329497	664.52862	562.47862	-0	115

Slice 31	79.85	-9.0251526	646.05752	1,353.178	0	115
Slice 32	80.75	-7.8249625	573.03766	2,275.4665	0	115
Slice 33	81.6694	-6.5546013	495.67947	1,273.2926	0	115
Slice 34	81.9194	-6.1750575	472.51594	463.00299	-5.9443515	0
Slice 35	82.88528	-4.4744703	368.40833	1,154.448	491.17208	0
Slice 36	84.655841	-0.69039411	135.96474	655.53441	324.66316	0
Slice 37	85.851492	2.6359959	-69.115041	290.28389	181.38951	0
Slice 38	86.517561	5.8463645	-268.05662	-112.08456	-64.712051	200
Slice 39	86.936629	8.7689264	-449.55282	16.755968	8.9093063	0

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-4a, Yield Acceleration, With Sloping Geogrids, Large Circular

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-4a, Yield Acceleration, With Sloping Geogrids, Large Circular



Run-4a, Yield Acceleration, With Sloping Geogrids, Large Circular

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File Information

File Name: Run-4a_Y-Acc_Sloping-Geogrids.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\
Last Solved Date: 3/21/2013
Last Solved Time: 9:08:09 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Run-4a, Yield Acceleration, With Sloping Geogrids, Large Circular

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8
  - Lambda 11: 1

PWP Conditions Source: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Slip Surface
Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Riprap

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Filter Stone

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Vegetative Soil

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sandy Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravelly Debris

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bay Mud

Model: S=f(overburden)

Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.27
Minimum Strength: 115
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bay Mud Crust

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 115 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-40, -5.4) ft
Left-Zone Right Coordinate: (50, 0) ft
Left-Zone Increment: 30
Right Projection: Range
Right-Zone Left Coordinate: (87, 9.599078) ft
Right-Zone Right Coordinate: (187.9998, 15.091233) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-40, -5.4) ft
Right Coordinate: (190, 15.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-40	0
Coordinate 2	50	0
Coordinate 3	55	0.5
Coordinate 4	100	2
Coordinate 5	190	3

Seismic Coefficients

Horz Seismic Coef.: 0.077
Vert Seismic Coef.: 0
Ignore seismic load in strength: Yes

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (55.49826, -2.70365) ft
Inside Point: (84.3, 7.1) ft
Slip Surface Intersection: () ft
Total Length: 30.424526 ft
Reinforcement Direction: 198.8 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs

Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 2

Type: Geosynthetic
Outside Point: (84.2, 7.2) ft
Inside Point: (132, 7.2) ft
Slip Surface Intersection: () ft
Total Length: 47.8 ft
Reinforcement Direction: 180 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	-40	-5.4
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7

Point 12	55	-2.7
Point 13	66.1	1
Point 14	82	6.4
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2
Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	72.1	-1.2
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.5	-17
Point 30	90.5	-17
Point 31	90.5	-8
Point 32	90.5	-19
Point 33	93.5	-19
Point 34	93.5	-17
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	-40	-34
Point 46	50	-34
Point 47	72.1	-36

Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	-40	-60
Point 52	190	-60
Point 53	93.5	5.2
Point 54	-40	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001

Regions

	Material	Points	Area (ft²)
Region 1	Riprap	3,5,6,10,9,8,4	87.18
Region 2	Filter Stone	3,4,8,9,10,6,14,13,12	48.4
Region 3	Slurry Wall	18,19,37,53,36,35,34,33,32,30,31,16,17	85.65
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	70.89
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,25	197.1
Region 8	Gravelly Debris	28,31,30,29,56	38.25
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,34	245.9
Region 14	Alluvium	51,45,46,47,48,49,50,52	5,718.9
Region 15	Bay Mud Crust	1,2,11,12,25,55,26,27,28,56,54	873.46
Region 16	Bay Mud	45,54,56,29,30,32,33,34,42,43,44,50,49,48,47,46	5,808.4

Current Slip Surface

Slip Surface: 588
F of S: 1.00
Volume: 5,070.6688 ft³
Weight: 517,759.57 lbs
Resisting Moment: 12,021,759 lbs-ft
Activating Moment: 12,040,309 lbs-ft

Resisting Force: 73,227.079 lbs
Activating Force: 73,569.858 lbs
F of S Rank: 1
Exit: (-36.999812, -5.2228805) ft
Entry: (161.06652, 13.626659) ft
Radius: 151.95639 ft
Center: (51.150914, 118.55189) ft

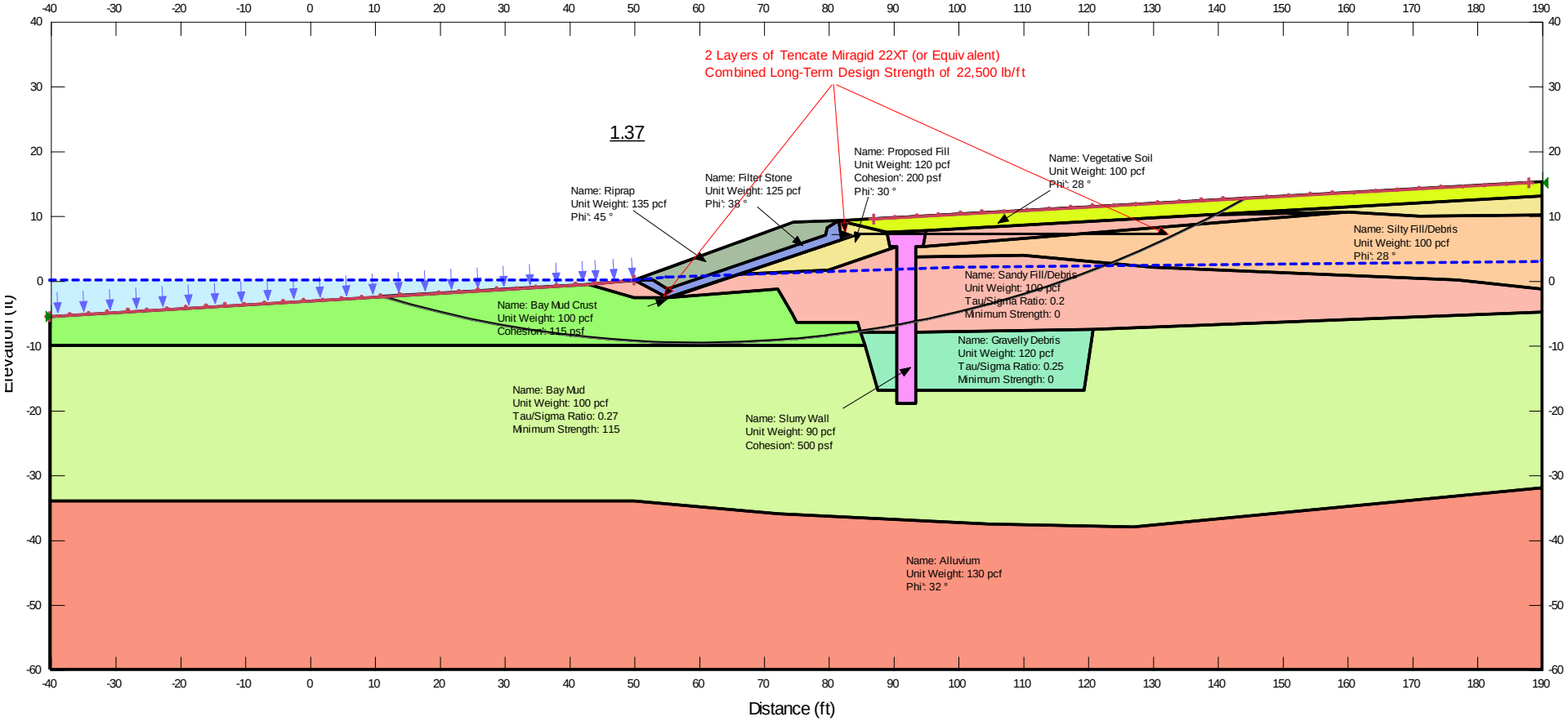
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-33.437274	-7.6114403	474.95387	634.13795	0	115
Slice 2	-26.562247	-11.972233	747.06731	1,126.1447	0	115
Slice 3	-19.937271	-15.698492	979.58588	1,563.7466	0	116.57458
Slice 4	-13.312295	-19.004849	1,185.9026	1,974.9865	0	154.11131
Slice 5	-6.6873196	-21.921062	1,367.8743	2,339.9936	0	187.68727
Slice 6	-0.062343616	-24.47107	1,526.9948	2,655.1635	0	217.54553
Slice 7	6.5626323	-26.674218	1,664.4712	2,918.1914	0	243.88247
Slice 8	13.187608	-28.546132	1,781.2787	3,128.2375	0	266.85673
Slice 9	19.812584	-30.099356	1,878.1998	3,285.9325	0	286.59564
Slice 10	26.43756	-31.343819	1,955.8543	3,393.2457	0	303.2
Slice 11	33.062536	-32.287178	2,014.7199	3,453.2458	0	316.74756
Slice 12	39.687512	-32.935071	2,055.1484	3,469.7986	0	327.29555
Slice 13	46.5	-33.292938	2,077.4793	3,447.3142	0	335.4519
Slice 14	51.5	-33.396695	2,093.3137	3,507.152	0	362.06824
Slice 15	54	-33.374495	2,107.5285	3,644.4677	0	401.83786
Slice 16	57.820542	-33.231803	2,110.7312	3,763.0431	0	444.64664
Slice 17	63.153875	-32.90873	2,101.6648	3,867.1586	0	492.96425
Slice 18	65.883333	-32.68849	2,093.5991	3,913.6371	0	517.13459
Slice 19	69.1	-32.310455	2,076.7004	3,973.1882	0	548.97519
Slice 20	73.2	-31.792202	2,052.8894	4,045.8733	0	589.60965
Slice 21	74.4	-31.615397	2,044.3528	4,064.6067	0	601.24763
Slice 22	74.75	-31.560612	2,041.6622	4,058.9536	0	601.65248
Slice 23	77.35	-31.10993	2,018.9476	3,982.304	0	595.5933
Slice 24	79.85	-30.669702	1,996.6774	3,896.8002	0	586.20556

Slice 25	80.75	-30.491908	1,987.4551	3,862.507	0	582.01265
Slice 26	81.75	-30.291568	1,977.0339	3,816.6708	0	575.16037
Slice 27	83.25	-29.970019	1,960.0892	3,753.0219	0	566.43179
Slice 28	84.75	-29.643184	1,942.8147	3,696.9904	0	559.72166
Slice 29	85.27778	-29.522483	1,936.3807	3,696.1032	0	562.70279
Slice 30	86.52778	-29.225721	1,920.4628	3,733.8784	0	581.16331
Slice 31	88.25	-28.804155	1,897.7393	3,733.3506	0	591.88895
Slice 32	89.25	-28.550582	1,883.9963	3,663.755	0	578.45153
Slice 33	90	-28.353608	1,873.2651	3,605.9337	0	566.77055
Slice 34	92	-27.802718	1,843.0496	3,146.4024	0	447.88112
Slice 35	94.05	-27.222196	1,811.089	3,481.8823	0	557.56404
Slice 36	94.8	-27.000362	1,798.8066	3,470.8617	0	559.34013
Slice 37	97.5	-26.139558	1,750.7084	3,398.0178	0	556.6651
Slice 38	102.5	-24.440976	1,651.6502	3,238.4284	0	545.38643
Slice 39	107.5	-22.544807	1,536.796	3,069.5033	0	533.03786
Slice 40	114.75	-19.355831	1,342.8305	2,800.1667	0	510.67031
Slice 41	120.1	-16.859759	1,190.7849	2,514.7995	0	467.06462
Slice 42	124.61829	-14.388874	1,039.7344	2,234.5793	0	422.1777
Slice 43	129.26829	-11.78495	880.47356	2,030.5007	0	401.69933
Slice 44	133.47312	-9.1067153	716.26707	1,819.7292	0	379.89629
Slice 45	137.47312	-6.5033408	556.58983	1,545.3346	617.83632	0
Slice 46	142.94246	-2.3884096	303.6102	1,202.5751	561.73561	0
Slice 47	148.59388	1.9553212	36.479714	865.04848	440.55783	0
Slice 48	153.63459	6.5100389	-244.23977	524.63095	278.95123	0
Slice 49	158.43463	10.939102	-517.28531	112.69406	65.063945	200
Slice 50	159.98471	12.516297	-614.62756	79.686683	42.370161	0

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-6a, Post-Liquefaction, With Sloping Geogrids

Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A', Run-6a, Post-Liquefaction, With Sloping Geogrids



Run-6a, Post-Liquefaction, With Sloping Geogrids

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File Information

File Name: Run-6a_Post-Liquef_Sloping-Geogrids.gsz
Directory: C:\PROJECTS\Hunter's Point\Stability\Cross Section A-A'\
Last Solved Date: 3/21/2013
Last Solved Time: 9:17:55 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Run-6a, Post-Liquefaction, With Sloping Geogrids

Description: Hunter's Point Shipyard, Parcel E-2, Slope Stability, Cross Section A-A'
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- Lambda
  - Lambda 1: -1
  - Lambda 2: -0.8
  - Lambda 3: -0.6
  - Lambda 4: -0.4
  - Lambda 5: -0.2
  - Lambda 6: 0
  - Lambda 7: 0.2
  - Lambda 8: 0.4
  - Lambda 9: 0.6
  - Lambda 10: 0.8
  - Lambda 11: 1

PWP Conditions Source: Piezometric Line
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Slip Surface
Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 2,000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

Materials

Riprap

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 0 psf
Phi': 45 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Filter Stone

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 0 psf
Phi': 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Proposed Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 200 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Vegetative Soil

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slurry Wall

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Cohesion': 500 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sandy Fill/Debris

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.2
Minimum Strength: 0
Pore Water Pressure
Piezometric Line: 1

Gravelly Debris

Model: S=f(overburden)
Unit Weight: 120 pcf
Tau/Sigma Ratio: 0.25
Minimum Strength: 0
Pore Water Pressure
Piezometric Line: 1

Bay Mud

Model: S=f(overburden)
Unit Weight: 100 pcf
Tau/Sigma Ratio: 0.27

Minimum Strength: 115
Pore Water Pressure
Piezometric Line: 1

Alluvium

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty Fill/Debris

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Bay Mud Crust

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 115 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-40, -5.4) ft
Left-Zone Right Coordinate: (50, 0) ft
Left-Zone Increment: 30
Right Projection: Range
Right-Zone Left Coordinate: (87, 9.599078) ft
Right-Zone Right Coordinate: (187.9998, 15.091233) ft
Right-Zone Increment: 30
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-40, -5.4) ft
Right Coordinate: (190, 15.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-40	0
Coordinate 2	50	0
Coordinate 3	55	0.5
Coordinate 4	100	2
Coordinate 5	190	3

Seismic Coefficients

Vert Seismic Coef.: 0

Reinforcements

Reinforcement 1

Type: Geosynthetic
Outside Point: (55.49826, -2.70365) ft
Inside Point: (84.3, 7.1) ft
Slip Surface Intersection: () ft
Total Length: 30.424526 ft
Reinforcement Direction: 198.8 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Reinforcement 2

Type: Geosynthetic

Outside Point: (84.2, 7.2) ft
Inside Point: (132, 7.2) ft
Slip Surface Intersection: () ft
Total Length: 47.8 ft
Reinforcement Direction: 180 °
F of S Dependent: No
Interface Adhesion: 0 psf
Interface Shear Angle: 28 °
Surface Area Factor: 2
Resistance Reduction Factor: 0.8
Force Distribution: Distributed
Tensile Capacity: 22,500 lbs
Reduction Factor: 1
Force Orientation: 0
Max. Pullout Force: 22,500 lbs
Pullout Force: 0 lbs
Pullout Force per Length: 0 lbs/ft
Available Length: 0 ft
Required Length: 0 ft
Governing Component: (none)

Points

	X (ft)	Y (ft)
Point 1	-40	-5.4
Point 2	43	-0.5
Point 3	50	0
Point 4	53	0
Point 5	74.5	9
Point 6	81.5	9.3
Point 7	190	15.2
Point 8	55	-1.2
Point 9	79.5	7
Point 10	79.7	8.2
Point 11	50	-2.7
Point 12	55	-2.7
Point 13	66.1	1
Point 14	82	6.4
Point 15	80	1.7
Point 16	90.5	5.2
Point 17	89.5	5.2

Point 18	89	7.4
Point 19	95	7.7
Point 20	138	10.2
Point 21	190	13.2
Point 22	160	10.5
Point 23	171.3	10
Point 24	190	10.2
Point 25	72.1	-1.2
Point 26	75	-6.3
Point 27	84.5	-6.3
Point 28	85	-8
Point 29	87.5	-17
Point 30	90.5	-17
Point 31	90.5	-8
Point 32	90.5	-19
Point 33	93.5	-19
Point 34	93.5	-17
Point 35	93.5	-8
Point 36	93.5	3.7
Point 37	94.6	5.2
Point 38	110	3.8
Point 39	130	2.2
Point 40	177	0
Point 41	190	-1.3
Point 42	119.5	-17
Point 43	120.7	-7.5
Point 44	190	-4.8
Point 45	-40	-34
Point 46	50	-34
Point 47	72.1	-36
Point 48	104.7	-37.6
Point 49	127	-38
Point 50	190	-32
Point 51	-40	-60
Point 52	190	-60
Point 53	93.5	5.2

Point 54	-40	-10
Point 55	74.3	-5
Point 56	85.55556	-10.000001

Regions

	Material	Points	Area (ft²)
Region 1	Riprap	3,5,6,10,9,8,4	87.18
Region 2	Filter Stone	3,4,8,9,10,6,14,13,12	48.4
Region 3	Slurry Wall	18,19,37,53,36,35,34,33,32,30,31,16,17	85.65
Region 4	Vegetative Soil	6,7,21,20,19,18	227.95
Region 5	Proposed Fill	13,14,6,18,17,16,15	70.89
Region 6	Sandy Fill/Debris	2,3,12,11	16.2
Region 7	Sandy Fill/Debris	12,13,15,16,31,28,27,26,55,25	197.1
Region 8	Gravelly Debris	28,31,30,29,56	38.25
Region 9	Sandy Fill/Debris	37,19,20,22	101.74
Region 10	Proposed Fill	20,21,24,23,22	76.005
Region 11	Silty Fill/Debris	36,53,37,22,23,24,41,40,39,38	658.68
Region 12	Sandy Fill/Debris	36,38,39,40,41,44,43,35	802.12
Region 13	Gravelly Debris	35,43,42,34	245.9
Region 14	Alluvium	51,45,46,47,48,49,50,52	5,718.9
Region 15	Bay Mud Crust	1,2,11,12,25,55,26,27,28,56,54	873.46
Region 16	Bay Mud	45,54,56,29,30,32,33,34,42,43,44,50,49,48,47,46	5,808.4

Current Slip Surface

Slip Surface: 5,987
F of S: 1.37
Volume: 1,369.0517 ft³
Weight: 142,106.17 lbs
Resisting Moment: 3,882,601.9 lbs-ft
Activating Moment: 2,839,424.7 lbs-ft
Resisting Force: 21,971.781 lbs
Activating Force: 16,074.121 lbs
F of S Rank: 1
Exit: (11.003194, -2.3889681) ft
Entry: (144.23322, 12.7113) ft
Radius: 170.07926 ft
Center: (60.014918, 160.47541) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	13.28868	-3.0420614	189.82463	244.68433	0	115
Slice 2	17.859653	-4.2799325	267.06779	378.85875	0	115
Slice 3	22.430625	-5.3826134	335.87508	499.80757	0	115
Slice 4	27.001597	-6.3527871	396.41392	607.44199	0	115
Slice 5	31.572569	-7.1927556	448.82795	701.69381	0	115
Slice 6	36.143542	-7.904469	493.23887	782.52704	0	115
Slice 7	40.714514	-8.4895494	529.74788	849.94504	0	115
Slice 8	44.75	-8.9083248	555.87947	899.83829	0	115
Slice 9	48.25	-9.1873855	573.29285	935.04208	0	115
Slice 10	51.5	-9.3839295	594.9172	1,051.9341	0	115
Slice 11	54	-9.4945115	617.41752	1,224.9337	0	115
Slice 12	57.820542	-9.5662985	634.00375	1,404.3748	0	115
Slice 13	63.153875	-9.5563087	644.47372	1,598.8914	0	115
Slice 14	65.883333	-9.5024397	646.78957	1,693.0036	0	115
Slice 15	69.1	-9.3344549	642.99799	1,809.827	0	115
Slice 16	73.2	-9.0884157	636.17314	1,956.5267	0	115
Slice 17	74.4	-8.9943927	632.80211	1,997.1623	0	115
Slice 18	74.75	-8.9641635	631.6438	1,997.8415	0	115
Slice 19	77.35	-8.7016249	620.66939	1,967.4283	0	115
Slice 20	79.85	-8.4432136	609.74453	1,924.8722	0	115
Slice 21	80.75	-8.3334763	604.76892	1,905.6773	0	115
Slice 22	81.75	-8.2091399	599.09033	1,876.1923	0	115
Slice 23	83.25	-8.0045397	589.44328	1,836.7317	0	115
Slice 24	84.715991	-7.8004469	579.75715	1,805.2661	0	115
Slice 25	86.965991	-7.4422799	562.08753	1,743.9395	0	243.94581
Slice 26	89.25	-7.072196	543.74503	1,658.204	0	230.96515
Slice 27	90	-6.9390205	536.99488	1,610.4462	0	222.79234
Slice 28	92	-6.5622406	517.64382	1,434.4909	0	500
Slice 29	94.05	-6.1626792	496.97518	1,543.3442	0	218.6024
Slice 30	94.8	-6.0085563	488.91791	1,542.7165	0	220.37206
Slice 31	97.5	-5.4018162	456.67333	1,505.3705	0	220.10258
Slice 32	102.5	-4.1918499	388.10476	1,406.4358	0	215.05475

Slice 33	107.5	-2.8198538	305.95888	1,292.892	0	209.4818
Slice 34	112.06588	-1.4287085	222.31709	1,176.8378	0	203.3529
Slice 35	116.19763	-0.041465633	138.61781	1,060.1673	0	196.84142
Slice 36	120.32938	1.465225	47.464993	932.54081	0	189.43168
Slice 37	122.9799	2.481836	-14.133834	846.07179	0	184.30183
Slice 38	125.73279	3.6232831	-83.451464	693.85909	368.93142	0
Slice 39	130.06926	5.5119249	-198.2961	545.67694	290.14157	0
Slice 40	134.40573	7.5468399	-322.26817	388.59172	206.61788	0
Slice 41	137.28699	8.9652066	-408.77658	280.68469	0	149.12274
Slice 42	138.85486	9.7760837	-458.28825	209.54015	0	144.66334
Slice 43	141.97147	11.467307	-561.65973	92.261481	49.0563	0

ATTACHMENT E7

```
  ******************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ---------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ---------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ---------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ---------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ******************************************************
  MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
  NECESSARY LENGTH OF BLANK COMMON X        =    204819
     Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 8
 **********************

 CURVE NO. 15:      #8 modulus for gravel Average (Seed et al., 1986)
 CURVE NO. 16:        damping gravelly soils (Seed et al., 1988)
```

CURVE NO.15		CURVE NO.16	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.50
0.0003	0.970	0.0003	1.00

0.0010	0.870	0.0010	1.75
0.0030	0.730	0.0030	3.00
0.0100	0.550	0.0100	5.50
0.0300	0.370	0.0300	9.50
0.1000	0.200	0.1000	15.50
0.3000	0.100	0.3000	21.00
1.0000	0.050	1.0000	26.00

```
 **********************
  MATERIAL TYPE NO. 5
 **********************

 CURVE NO.  9:      #5 modulus for Young Bay Mud, Sun et al., EERC-88/15)
 CURVE NO. 10:        damping for Young Bay Mud
```

CURVE NO. 9		CURVE NO.10	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	1.56
0.0010	1.000	0.0010	1.56
0.0030	0.991	0.0030	1.56
0.0100	0.942	0.0100	1.87
0.0300	0.840	0.0300	2.64
0.1000	0.647	0.1000	5.44
0.3000	0.451	0.3000	10.30
1.0000	0.304	1.0000	17.73
3.0000	0.135	3.0000	24.00
10.0000	0.085	10.0000	27.00

```
 **********************
  MATERIAL TYPE NO. 2
 **********************

 CURVE NO.  3:      #2 modulus for sand (seed & idriss 1970) - upper Range
 CURVE NO.  4:        damping for sand (Idriss 1990) - (about LRng from SI
```

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10

```
    0.1000     0.370         0.1000      9.80
    0.3000     0.180         0.3000     15.50
    1.0000     0.080         1.0000     21.00
    3.0000     0.050         3.0000     25.00
   10.0000     0.035        10.0000     28.00

 **********************
  MATERIAL TYPE NO. 6
 **********************

 CURVE NO. 11:      #6 modulus for Old Bay Mud (Clay PI=20-40, Sun et al.,
 CURVE NO. 12:        damping for clay (Dobry & Vucetic Curve, 4/9/91)


      CURVE NO.11              CURVE NO.12
  ===================       ==================
    STRAIN    G/Gmax          STRAIN    DAMPING
  --------   -------         --------  --------
    0.0001     1.000          0.0001      1.55
    0.0010     0.999          0.0010      1.55
    0.0030     0.980          0.0030      2.20
    0.0100     0.920          0.0100      3.70
    0.0300     0.780          0.0300      6.00
    0.1000     0.532          0.1000      8.70
    0.3000     0.293          0.3000     12.50
    1.0000     0.137          1.0000     17.00
    3.0000     0.075          3.0000     21.00
   10.0000     0.025         10.0000     22.75
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION   HPS, Parcel E-2, A-A', CHY029.acc
 NUMBER OF LAYERS                   16          DEPTH TO BEDROCK        186.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)             (kcf)    (fps)
   1    8      4.00      2.00      0.26       1453.   0.050    0.130     600.0
   2    5      5.00      6.50      0.77         23.   0.050    0.100      86.0
   3    5      5.00     11.50      1.27         41.   0.050    0.100     115.0
   4    5      5.00     16.50      1.77         64.   0.050    0.100     143.0
   5    5      5.00     21.50      2.27         90.   0.050    0.100     170.0
   6    5      5.00     26.50      2.77        119.   0.050    0.100     196.0
   7    5      7.00     32.50      3.37        160.   0.050    0.100     227.0
   8    2     10.00     41.00      4.37       3270.   0.050    0.130     900.0
   9    2     20.00     56.00      6.32       3270.   0.050    0.130     900.0
  10    6     20.00     76.00      8.92       3270.   0.050    0.130     900.0
  11    2     20.00     96.00     11.52       3270.   0.050    0.130     900.0
  12    2     20.00    116.00     14.12       3270.   0.050    0.130     900.0
```



```
  13    2     20.00    136.00     16.72       4037.   0.050    0.130    1000.0
  14    2     20.00    156.00     19.32       4885.   0.050    0.130    1100.0
  15    2     20.00    176.00     21.92       5814.   0.050    0.130    1200.0
  16   BASE                                  55163.   0.010    0.145    3500.0

  PERIOD = 0.90 FROM AVERAGE SHEAR VELOCITY =    831.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  21.28
 FOR FREQUENCY         =   1.01 C/SEC.
     PERIOD            =   0.99 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = chy029.acc
    NO. OF INPUT ACC. POINTS = 14500
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY =  (1F9.6)


  READING INPUT MOTION FROM ----> chy029.acc
  FORMAT OF INPUT MOTION USED -->  (1F9.6)

 ***** H E A D E R
NGA1211 CHY029 1999 Chi-Chi- Taiwan  EQ
Number of Points=14500, DT=0.005
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000188
     2 -0.000112
     3 -0.000428
     4 -0.000526
     5 -0.000416
   ........ INPUT MOTION READ NOT ECHOED...........
 14496 -0.000116
 14497 -0.000113
 14498 -0.000111
 14499 -0.000108
 14500 -0.000106

 MAXIMUM ACCELERATION =  0.40743
 AT TIME              = 37.17 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  0.712
```

```
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.29000
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.29000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  16 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.70


+              ITERATION NUMBER  1
     EARTHQUAKE   - chy029.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', CHY029.acc

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00853 0.052  0.050      3.3     833.8    1453.4    -74.3   1.000
  2  5    6.5 1.55145 0.202  0.050     75.3       5.4      23.0   -323.4   1.000
  3  5   11.5 1.24094 0.190  0.050     73.6      11.1      41.1   -269.7   1.000
  4  5   16.5 0.93319 0.173  0.050     71.1      19.8      63.5   -220.4   1.000
  5  5   21.5 0.69648 0.155  0.050     67.7      31.2      89.8   -187.4   1.000
  6  5   26.5 0.56972 0.143  0.050     64.9      44.4     119.3   -168.4   1.000
  7  5   32.5 0.43398 0.126  0.050     60.2      65.0     160.0   -146.3   1.000
  8  2   41.0 0.02278 0.045  0.050    -10.5    2265.1    3270.2    -44.4   1.000
  9  2   56.0 0.02856 0.050  0.050     -0.1    2123.6    3270.2    -54.0   1.000
 10  6   76.0 0.03642 0.064  0.050     22.3    2420.0    3270.2    -35.1   1.000
 11  2   96.0 0.04394 0.066  0.050     24.1    1813.1    3270.2    -80.4   1.000
 12  2  116.0 0.05081 0.072  0.050     30.1    1706.5    3270.2    -91.6   1.000
 13  2  136.0 0.04780 0.069  0.050     27.7    2162.0    4037.3    -86.7   1.000
 14  2  156.0 0.04481 0.067  0.050     25.0    2687.0    4885.1    -81.8   1.000
 15  2  176.0 0.04109 0.063  0.050     21.0    3310.5    5813.7    -75.6   1.000
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - chy029.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', CHY029.acc

  ITERATION NUMBER  2
```



```
  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00622 0.045  0.052    -14.5     902.5     833.8      7.6   0.574
  2  5    6.5 2.80558 0.236  0.202     14.3       3.3       5.4    -62.6   0.236
  3  5   11.5 1.66448 0.206  0.190      8.1       9.3      11.1    -20.0   0.270
  4  5   16.5 1.00531 0.178  0.173      2.6      19.2      19.8     -3.1   0.312
  5  5   21.5 0.86600 0.168  0.155      8.0      28.8      31.2     -8.3   0.348
  6  5   26.5 0.71929 0.157  0.143      9.2      41.0      44.4     -8.3   0.373
  7  5   32.5 0.54050 0.139  0.126      9.7      60.7      65.0     -7.1   0.406
  8  2   41.0 0.01910 0.042  0.045     -8.9    2375.1    2265.1      4.6   0.693
  9  2   56.0 0.03359 0.055  0.050      9.8    2010.1    2123.6     -5.6   0.649
 10  6   76.0 0.04469 0.069  0.064      6.7    2282.2    2420.0     -6.0   0.740
 11  2   96.0 0.07650 0.088  0.066     24.7    1406.4    1813.1    -28.9   0.554
 12  2  116.0 0.09847 0.097  0.072     26.5    1221.3    1706.5    -39.7   0.522
 13  2  136.0 0.08935 0.094  0.069     26.1    1595.7    2162.0    -35.5   0.536
 14  2  156.0 0.07902 0.089  0.067     24.9    2065.4    2687.0    -30.1   0.550
 15  2  176.0 0.06880 0.083  0.063     24.1    2638.5    3310.5    -25.5   0.569
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - chy029.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', CHY029.acc

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00472 0.039  0.045    -14.6     962.7     902.5      6.3   0.621
  2  5    6.5 3.82849 0.246  0.236      4.0       2.9       3.3    -16.3   0.145
  3  5   11.5 1.63849 0.205  0.206     -0.4       9.4       9.3      1.1   0.225
  4  5   16.5 1.05953 0.181  0.178      1.7      18.7      19.2     -2.7   0.303
  5  5   21.5 0.81795 0.165  0.168     -2.1      29.5      28.8      2.1   0.321
  6  5   26.5 0.68475 0.154  0.157     -2.0      41.8      41.0      1.7   0.344
  7  5   32.5 0.56557 0.142  0.139      2.0      59.8      60.7     -1.5   0.379
  8  2   41.0 0.01857 0.041  0.042     -1.5    2392.9    2375.1      0.7   0.726
  9  2   56.0 0.03537 0.057  0.055      3.5    1972.2    2010.1     -1.9   0.615
 10  6   76.0 0.04601 0.070  0.069      0.9    2262.7    2282.2     -0.9   0.698
 11  2   96.0 0.09503 0.096  0.088      8.8    1247.4    1406.4    -12.8   0.430
 12  2  116.0 0.12904 0.111  0.097     12.4    1065.8    1221.3    -14.6   0.373
 13  2  136.0 0.11233 0.104  0.094     10.0    1412.6    1595.7    -13.0   0.395
 14  2  156.0 0.09446 0.096  0.089      7.3    1870.0    2065.4    -10.5   0.423
 15  2  176.0 0.07843 0.089  0.083      5.8    2467.7    2638.5     -6.9   0.454
+              ITERATION NUMBER  4
1
```

EARTHQUAKE - chy029.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', CHY029.acc

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00409	0.036	0.039	-8.2	993.9	962.7	3.1	0.662
2	5	6.5	4.12987	0.248	0.246	0.8	2.8	2.9	-2.6	0.125
3	5	11.5	1.70173	0.208	0.205	1.0	9.1	9.4	-2.6	0.228
4	5	16.5	1.08662	0.182	0.181	0.8	18.5	18.7	-1.3	0.295
5	5	21.5	0.77180	0.161	0.165	-2.2	30.1	29.5	2.1	0.328
6	5	26.5	0.67817	0.153	0.154	-0.4	41.9	41.8	0.3	0.350
7	5	32.5	0.57717	0.143	0.142	0.9	59.4	59.8	-0.7	0.373
8	2	41.0	0.01803	0.040	0.041	-1.5	2411.3	2392.9	0.8	0.732
9	2	56.0	0.03489	0.057	0.057	-0.9	1982.2	1972.2	0.5	0.603
10	6	76.0	0.04460	0.069	0.070	-1.0	2283.7	2262.7	0.9	0.692
11	2	96.0	0.10294	0.100	0.096	3.5	1193.6	1247.4	-4.5	0.381
12	2	116.0	0.14330	0.117	0.111	4.7	1006.5	1065.8	-5.9	0.326
13	2	136.0	0.12116	0.108	0.104	3.6	1359.8	1412.6	-3.9	0.350
14	2	156.0	0.09830	0.097	0.096	1.6	1826.2	1870.0	-2.4	0.383
15	2	176.0	0.07890	0.089	0.089	0.3	2460.1	2467.7	-0.3	0.424

+ ITERATION NUMBER 5
1

EARTHQUAKE - chy029.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', CHY029.acc

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00387	0.035	0.036	-3.2	1005.9	993.9	1.2	0.684
2	5	6.5	4.13245	0.248	0.248	0.0	2.8	2.8	0.0	0.122
3	5	11.5	1.76422	0.210	0.208	1.0	8.9	9.1	-2.6	0.222
4	5	16.5	1.10172	0.183	0.182	0.4	18.3	18.5	-0.7	0.291
5	5	21.5	0.75186	0.160	0.161	-1.0	30.4	30.1	0.9	0.335
6	5	26.5	0.67313	0.153	0.153	-0.3	42.0	41.9	0.3	0.351
7	5	32.5	0.57912	0.144	0.143	0.1	59.3	59.4	-0.1	0.371
8	2	41.0	0.01773	0.040	0.040	-0.9	2421.8	2411.3	0.4	0.737
9	2	56.0	0.03428	0.056	0.057	-1.2	1995.1	1982.2	0.6	0.606
10	6	76.0	0.04358	0.068	0.069	-0.8	2299.3	2283.7	0.7	0.698
11	2	96.0	0.10642	0.101	0.100	1.7	1174.8	1193.6	-1.6	0.365
12	2	116.0	0.14977	0.119	0.117	1.9	981.5	1006.5	-2.5	0.308

13	2	136.0	0.12355	0.109	0.108	0.9	1346.1	1359.8	-1.0	0.337
14	2	156.0	0.09882	0.098	0.097	0.2	1820.5	1826.2	-0.3	0.374
15	2	176.0	0.07746	0.088	0.089	-0.8	2484.0	2460.1	1.0	0.423

+ ITERATION NUMBER 6
1

EARTHQUAKE - chy029.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', CHY029.acc

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00381	0.035	0.035	-0.8	1008.9	1005.9	0.3	0.692
2	5	6.5	4.10196	0.248	0.248	-0.1	2.8	2.8	0.3	0.122
3	5	11.5	1.81435	0.211	0.210	0.8	8.7	8.9	-2.0	0.216
4	5	16.5	1.11054	0.183	0.183	0.2	18.3	18.3	-0.4	0.289
5	5	21.5	0.74456	0.159	0.160	-0.4	30.5	30.4	0.4	0.339
6	5	26.5	0.66951	0.153	0.153	-0.2	42.1	42.0	0.2	0.352
7	5	32.5	0.57882	0.144	0.144	0.0	59.3	59.3	0.0	0.371
8	2	41.0	0.01761	0.040	0.040	-0.3	2425.8	2421.8	0.2	0.741
9	2	56.0	0.03394	0.056	0.056	-0.7	2002.4	1995.1	0.4	0.610
10	6	76.0	0.04312	0.068	0.068	-0.3	2306.4	2299.3	0.3	0.703
11	2	96.0	0.10787	0.102	0.101	0.7	1167.1	1174.8	-0.7	0.359
12	2	116.0	0.15303	0.120	0.119	0.9	969.4	981.5	-1.3	0.300
13	2	136.0	0.12403	0.109	0.109	0.2	1343.4	1346.1	-0.2	0.333
14	2	156.0	0.09850	0.097	0.098	-0.1	1824.0	1820.5	0.2	0.373
15	2	176.0	0.07613	0.087	0.088	-0.8	2506.6	2484.0	0.9	0.427

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	8	4.0	2.0	0.00545	54.79	39.29
2	5	5.0	6.5	5.85994	163.80	37.92
3	5	5.0	11.5	2.59192	230.45	38.60
4	5	5.0	16.5	1.58649	290.91	38.58
5	5	5.0	21.5	1.06366	323.21	38.53
6	5	5.0	26.5	0.95644	401.80	37.58
7	5	7.0	32.5	0.82689	490.36	37.54
8	2	10.0	41.0	0.02516	609.34	37.43
9	2	20.0	56.0	0.04849	967.39	37.42
10	6	20.0	76.0	0.06160	1416.32	37.40
11	2	20.0	96.0	0.15410	1810.28	37.41
12	2	20.0	116.0	0.21861	2145.69	37.40
13	2	20.0	136.0	0.17719	2385.16	37.36

```
    14     2           20.0          156.0        0.14072        2561.80          37.36
    15     2           20.0          176.0        0.10876        2701.54          37.34

  PERIOD = 1.34 FROM AVERAGE SHEAR VELOCITY =    554.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =   5.18
 FOR FREQUENCY         =   0.54 C/SEC.
     PERIOD            =   1.87 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -chy029.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', CHY029.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED           ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN            0.0        0.21560          38.33           0.69               0.350
     0
     WITHIN            4.0        0.21548          38.33           0.69               0.350
     0
     WITHIN            9.0        0.19275          38.00           1.05               0.253
     0
     WITHIN           14.0        0.22735          37.93           1.14               0.185
     0
     WITHIN           19.0        0.22141          37.51           1.20               0.190
     0
     WITHIN           19.0        0.22141          37.51           1.20               0.190
     0
     WITHIN           24.0        0.21016          37.48           1.26               0.172
     0
     WITHIN           29.0        0.20195          37.45           1.36               0.170
     0
     WITHIN           36.0        0.19202          37.40           1.51               0.184
     0
     WITHIN           46.0        0.18961          37.40           1.45               0.179
     0
     WITHIN           66.0        0.18016          37.38           1.14               0.158
     0
     WITHIN           86.0        0.17167          37.33           1.07               0.162
     0
     WITHIN          106.0        0.16579          37.31           1.69               0.181
     0
     WITHIN          126.0        0.15483          37.88           2.22               0.240
     0
```



```
     WITHIN          146.0        0.13505          37.84           2.43               0.298
     0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -chy029.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', CHY029.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED           ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN          166.0        0.15608          38.00           7.80               0.265
     0
     WITHIN          186.0        0.25294          37.98          48.27               0.239
     0
     OUTCR.          186.0        0.29000          37.17          50.00               0.245
     0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
  ******************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ---------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ---------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ---------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ---------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ******************************************************
  MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
  NECESSARY LENGTH OF BLANK COMMON X        =    204819
     Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 5
 **********************

 CURVE NO.  9:      #5 modulus for Young Bay Mud, Sun et al., EERC-88/15)
 CURVE NO. 10:        damping for Young Bay Mud


      CURVE NO. 9              CURVE NO.10
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.56
    0.0010     1.000         0.0010      1.56
```



```
    0.0030     0.991         0.0030      1.56
    0.0100     0.942         0.0100      1.87
    0.0300     0.840         0.0300      2.64
    0.1000     0.647         0.1000      5.44
    0.3000     0.451         0.3000     10.30
    1.0000     0.304         1.0000     17.73
    3.0000     0.135         3.0000     24.00
   10.0000     0.085        10.0000     27.00

 **********************
  MATERIAL TYPE NO. 2
 **********************

 CURVE NO.  3:      #2 modulus for sand (seed & idriss 1970) - upper Range
 CURVE NO.  4:        damping for sand (Idriss 1990) - (about LRng from SI


      CURVE NO. 3              CURVE NO. 4
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      0.24
    0.0003     1.000         0.0003      0.42
    0.0010     0.990         0.0010      0.80
    0.0030     0.960         0.0030      1.40
    0.0100     0.850         0.0100      2.80
    0.0300     0.640         0.0300      5.10
    0.1000     0.370         0.1000      9.80
    0.3000     0.180         0.3000     15.50
    1.0000     0.080         1.0000     21.00
    3.0000     0.050         3.0000     25.00
   10.0000     0.035        10.0000     28.00

 **********************
  MATERIAL TYPE NO. 6
 **********************

 CURVE NO. 11:      #6 modulus for Old Bay Mud (Clay PI=20-40, Sun et al.,
 CURVE NO. 12:        damping for clay (Dobry & Vucetic Curve, 4/9/91)


      CURVE NO.11              CURVE NO.12
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.55
    0.0010     0.999         0.0010      1.55
    0.0030     0.980         0.0030      2.20
    0.0100     0.920         0.0100      3.70
```

```
    0.0300     0.780         0.0300      6.00
    0.1000     0.532         0.1000      8.70
    0.3000     0.293         0.3000     12.50
    1.0000     0.137         1.0000     17.00
    3.0000     0.075         3.0000     21.00
   10.0000     0.025        10.0000     22.75

 **********************
  MATERIAL TYPE NO. 3
 **********************

 CURVE NO.  5:       #3 ATTENUATION OF  ROCK  AVERAGE
 CURVE NO.  6:       DAMPING IN ROCK


      CURVE NO. 5              CURVE NO. 6
  ===================       ==================
    STRAIN    G/Gmax          STRAIN    DAMPING
  --------   -------         --------  --------
    0.0001     1.000          0.0001      0.40
    0.0003     1.000          0.0010      0.80
    0.0010     0.988          0.0100      1.50
    0.0030     0.952          0.1000      3.00
    0.0100     0.900          1.0000      4.60
    0.0300     0.810          0.0000      0.00
    0.1000     0.725          0.0000      0.00
    1.0000     0.550          0.0000      0.00
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION   HPS, Parcel E-2, A-A', TCU076.acc
 NUMBER OF LAYERS                 16          DEPTH TO BEDROCK        186.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)              (kcf)    (fps)
   1    8      4.00      2.00      0.26       1453.   0.050    0.130     600.0
   2    5      5.00      6.50      0.77         23.   0.050    0.100      86.0
   3    5      5.00     11.50      1.27         41.   0.050    0.100     115.0
   4    5      5.00     16.50      1.77         64.   0.050    0.100     143.0
   5    5      5.00     21.50      2.27         90.   0.050    0.100     170.0
   6    5      5.00     26.50      2.77        119.   0.050    0.100     196.0
   7    5      7.00     32.50      3.37        160.   0.050    0.100     227.0
   8    2     10.00     41.00      4.37       3270.   0.050    0.130     900.0
   9    2     20.00     56.00      6.32       3270.   0.050    0.130     900.0
  10    6     20.00     76.00      8.92       3270.   0.050    0.130     900.0
  11    2     20.00     96.00     11.52       3270.   0.050    0.130     900.0
  12    2     20.00    116.00     14.12       3270.   0.050    0.130     900.0
  13    2     20.00    136.00     16.72       4037.   0.050    0.130    1000.0
```



```
  14    2     20.00    156.00     19.32       4885.   0.050    0.130    1100.0
  15    2     20.00    176.00     21.92       5814.   0.050    0.130    1200.0
  16   BASE                                   55163.   0.010    0.145    3500.0

  PERIOD = 0.90 FROM AVERAGE SHEAR VELOCITY =    831.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  21.28
 FOR FREQUENCY         =   1.01 C/SEC.
     PERIOD            =   0.99 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = TCU076.acc
    NO. OF INPUT ACC. POINTS = 14500
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY =  (1F9.6)


  READING INPUT MOTION FROM ----> TCU076.acc
  FORMAT OF INPUT MOTION USED -->  (1F9.6)

 ***** H E A D E R
NGA1511 TCU076 1999 Chi-Chi- Taiwan  EQ
No. of Time Steps = 14500, Step Interval = 0.005 Sec
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000014
     2 -0.000014
     3  0.000026
     4  0.000045
     5  0.000003
   ........ INPUT MOTION READ NOT ECHOED...........
 14496 -0.000068
 14497 -0.000067
 14498 -0.000066
 14499 -0.000065
 14500 -0.000064

 MAXIMUM ACCELERATION =  0.45736
 AT TIME              = 34.17 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  0.634
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.29000
```

```
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.29000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  16 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.70


+              ITERATION NUMBER  1
     EARTHQUAKE   - TCU076.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU076.acc

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00629	0.045	0.050	-10.2	900.3	1453.4	-61.4	1.000
2	5	6.5	1.12494	0.184	0.050	72.8	6.6	23.0	-250.2	1.000
3	5	11.5	0.84372	0.167	0.050	70.0	13.3	41.1	-208.2	1.000
4	5	16.5	0.67078	0.153	0.050	67.2	22.4	63.5	-183.6	1.000
5	5	21.5	0.55824	0.141	0.050	64.6	33.7	89.8	-166.6	1.000
6	5	26.5	0.46855	0.131	0.050	61.7	47.3	119.3	-152.2	1.000
7	5	32.5	0.37715	0.117	0.050	57.3	67.7	160.0	-136.3	1.000
8	2	41.0	0.01965	0.042	0.050	-18.7	2357.5	3270.2	-38.7	1.000
9	2	56.0	0.02246	0.045	0.050	-11.3	2273.8	3270.2	-43.8	1.000
10	6	76.0	0.03270	0.062	0.050	19.3	2492.7	3270.2	-31.2	1.000
11	2	96.0	0.04037	0.063	0.050	20.1	1875.2	3270.2	-74.4	1.000
12	2	116.0	0.04764	0.069	0.050	27.6	1753.8	3270.2	-86.5	1.000
13	2	136.0	0.04416	0.066	0.050	24.3	2233.9	4037.3	-80.7	1.000
14	2	156.0	0.04023	0.062	0.050	19.9	2804.9	4885.1	-74.2	1.000
15	2	176.0	0.03646	0.059	0.050	14.7	3466.5	5813.7	-67.7	1.000

```
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - TCU076.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU076.acc

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```


NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00529	0.042	0.045	-8.5	937.6	900.3	4.0	0.619
2	5	6.5	2.11063	0.220	0.184	16.3	4.3	6.6	-51.1	0.286
3	5	11.5	1.39173	0.196	0.167	15.0	10.4	13.3	-28.3	0.324
4	5	16.5	0.89100	0.170	0.153	10.3	20.2	22.4	-11.0	0.353
5	5	21.5	0.60939	0.147	0.141	3.7	32.7	33.7	-3.0	0.375
6	5	26.5	0.47314	0.131	0.131	0.5	47.2	47.3	-0.3	0.397
7	5	32.5	0.38420	0.118	0.117	1.0	67.4	67.7	-0.5	0.423
8	2	41.0	0.01420	0.035	0.042	-19.2	2560.3	2357.5	7.9	0.721
9	2	56.0	0.02143	0.044	0.045	-2.2	2303.1	2273.8	1.3	0.695
10	6	76.0	0.02726	0.058	0.062	-6.8	2590.6	2492.7	3.8	0.762
11	2	96.0	0.04673	0.068	0.063	8.4	1767.9	1875.2	-6.1	0.573
12	2	116.0	0.05881	0.077	0.069	10.6	1599.3	1753.8	-9.7	0.536
13	2	136.0	0.05304	0.073	0.066	9.8	2067.9	2233.9	-8.0	0.553
14	2	156.0	0.04688	0.068	0.062	8.7	2637.5	2804.9	-6.3	0.574
15	2	176.0	0.04162	0.064	0.059	8.1	3293.9	3466.5	-5.2	0.596

```
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - TCU076.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU076.acc

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00495	0.040	0.042	-3.4	952.2	937.6	1.5	0.645
2	5	6.5	3.06262	0.241	0.220	8.6	3.1	4.3	-40.9	0.189
3	5	11.5	1.56666	0.203	0.196	3.3	9.6	10.4	-7.7	0.253
4	5	16.5	0.85235	0.167	0.170	-1.6	20.5	20.2	1.7	0.318
5	5	21.5	0.59660	0.145	0.147	-0.9	32.9	32.7	0.7	0.364
6	5	26.5	0.48745	0.133	0.131	1.4	46.7	47.2	-0.9	0.395
7	5	32.5	0.40478	0.121	0.118	2.7	66.3	67.4	-1.5	0.421
8	2	41.0	0.01329	0.034	0.035	-4.1	2602.0	2560.3	1.6	0.783
9	2	56.0	0.02147	0.044	0.044	0.1	2301.9	2303.1	0.0	0.704
10	6	76.0	0.02688	0.058	0.058	-0.5	2596.5	2590.6	0.2	0.792
11	2	96.0	0.05040	0.071	0.068	4.1	1712.4	1767.9	-3.2	0.541
12	2	116.0	0.06696	0.082	0.077	6.2	1504.1	1599.3	-6.3	0.489
13	2	136.0	0.05951	0.078	0.073	5.8	1963.7	2067.9	-5.3	0.512
14	2	156.0	0.05166	0.072	0.068	5.2	2531.2	2637.5	-4.2	0.540
15	2	176.0	0.04492	0.067	0.064	4.5	3194.3	3293.9	-3.1	0.567

```
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - TCU076.acc
```

SOIL PROFILE - HPS, Parcel E-2, A-A', TCU076.acc

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00462	0.039	0.040	-3.7	967.2	952.2	1.6	0.655
2	5	6.5	3.98624	0.247	0.241	2.7	2.8	3.1	-8.9	0.134
3	5	11.5	1.44123	0.198	0.203	-2.4	10.2	9.6	5.2	0.235
4	5	16.5	0.75791	0.160	0.167	-4.5	21.4	20.5	4.3	0.323
5	5	21.5	0.58354	0.144	0.145	-0.9	33.2	32.9	0.7	0.367
6	5	26.5	0.49899	0.134	0.133	1.1	46.4	46.7	-0.7	0.392
7	5	32.5	0.41689	0.123	0.121	1.5	65.7	66.3	-0.9	0.414
8	2	41.0	0.01321	0.034	0.034	-0.4	2605.8	2602.0	0.1	0.796
9	2	56.0	0.02174	0.044	0.044	0.6	2294.3	2301.9	-0.3	0.704
10	6	76.0	0.02739	0.058	0.058	0.7	2588.7	2596.5	-0.3	0.794
11	2	96.0	0.05334	0.073	0.071	3.0	1670.9	1712.4	-2.5	0.524
12	2	116.0	0.07273	0.086	0.082	3.8	1443.5	1504.1	-4.2	0.460
13	2	136.0	0.06355	0.080	0.078	3.2	1904.2	1963.7	-3.1	0.486
14	2	156.0	0.05408	0.074	0.072	2.4	2480.8	2531.2	-2.0	0.518
15	2	176.0	0.04610	0.068	0.067	1.5	3160.6	3194.3	-1.1	0.549

+ ITERATION NUMBER 5
1

EARTHQUAKE - TCU076.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', TCU076.acc

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00450	0.038	0.039	-1.4	973.0	967.2	0.6	0.665
2	5	6.5	4.26672	0.249	0.247	0.7	2.8	2.8	-2.3	0.123
3	5	11.5	1.32537	0.193	0.198	-2.5	10.7	10.2	4.9	0.248
4	5	16.5	0.72818	0.158	0.160	-1.6	21.8	21.4	1.4	0.338
5	5	21.5	0.58931	0.145	0.144	0.4	33.1	33.2	-0.3	0.370
6	5	26.5	0.51177	0.136	0.134	1.1	46.0	46.4	-0.8	0.389
7	5	32.5	0.42684	0.125	0.123	1.2	65.3	65.7	-0.7	0.411
8	2	41.0	0.01335	0.034	0.034	0.7	2599.2	2605.8	-0.3	0.797
9	2	56.0	0.02194	0.044	0.044	0.4	2288.5	2294.3	-0.3	0.702
10	6	76.0	0.02763	0.058	0.058	0.3	2585.1	2588.7	-0.1	0.792
11	2	96.0	0.05491	0.075	0.073	1.5	1649.6	1670.9	-1.3	0.511
12	2	116.0	0.07580	0.087	0.086	1.8	1413.2	1443.5	-2.1	0.441
13	2	136.0	0.06521	0.081	0.080	1.2	1880.9	1904.2	-1.2	0.472

14	2	156.0	0.05472	0.074	0.074	0.6	2468.0	2480.8	-0.5	0.508
15	2	176.0	0.04598	0.068	0.068	-0.2	3164.1	3160.6	0.1	0.544

+ ITERATION NUMBER 6
1

EARTHQUAKE - TCU076.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', TCU076.acc

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00447	0.038	0.038	-0.3	974.3	973.0	0.1	0.669
2	5	6.5	4.35967	0.249	0.249	0.2	2.7	2.8	-0.7	0.120
3	5	11.5	1.25613	0.190	0.193	-1.6	11.0	10.7	3.1	0.260
4	5	16.5	0.72396	0.157	0.158	-0.2	21.8	21.8	0.2	0.342
5	5	21.5	0.59637	0.145	0.145	0.5	32.9	33.1	-0.4	0.368
6	5	26.5	0.51942	0.137	0.136	0.7	45.8	46.0	-0.5	0.386
7	5	32.5	0.43197	0.125	0.125	0.6	65.1	65.3	-0.4	0.408
8	2	41.0	0.01343	0.034	0.034	0.4	2595.5	2599.2	-0.1	0.795
9	2	56.0	0.02200	0.045	0.044	0.1	2286.7	2288.5	-0.1	0.700
10	6	76.0	0.02768	0.058	0.058	0.1	2584.2	2585.1	0.0	0.791
11	2	96.0	0.05563	0.075	0.075	0.7	1640.1	1649.6	-0.6	0.504
12	2	116.0	0.07730	0.088	0.087	0.9	1398.8	1413.2	-1.0	0.432
13	2	136.0	0.06581	0.082	0.081	0.4	1872.5	1880.9	-0.4	0.466
14	2	156.0	0.05475	0.074	0.074	0.0	2467.3	2468.0	0.0	0.505
15	2	176.0	0.04566	0.067	0.068	-0.4	3173.2	3164.1	0.3	0.544

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	8	4.0	2.0	0.00639	62.14	18.22
2	5	5.0	6.5	6.22810	172.20	18.26
3	5	5.0	11.5	1.79448	191.90	18.15
4	5	5.0	16.5	1.03423	224.95	18.05
5	5	5.0	21.5	0.85196	281.72	17.98
6	5	5.0	26.5	0.74203	341.47	17.93
7	5	7.0	32.5	0.61710	402.88	17.90
8	2	10.0	41.0	0.01918	498.49	17.84
9	2	20.0	56.0	0.03144	719.42	17.79
10	6	20.0	76.0	0.03955	1022.36	17.78
11	2	20.0	96.0	0.07947	1310.90	17.77
12	2	20.0	116.0	0.11043	1560.58	17.75
13	2	20.0	136.0	0.09402	1768.41	17.73
14	2	20.0	156.0	0.07822	1930.46	17.70

```
    15     2           20.0          176.0        0.06522        2063.73          17.67

  PERIOD = 1.20 FROM AVERAGE SHEAR VELOCITY =    622.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =   5.56
 FOR FREQUENCY         =   1.04 C/SEC.
     PERIOD            =   0.96 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -TCU076.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', TCU076.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED
                        ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN            0.0        0.23758          18.20           0.86               0.752
     0
     WITHIN            4.0        0.23732          18.20           0.86               0.752
     0
     WITHIN            9.0        0.18699          55.11           1.28               0.764
     0
     WITHIN           14.0        0.19446          17.85           1.25               0.825
     0
     WITHIN           19.0        0.18373          30.87           1.26               0.833
     0
     WITHIN           19.0        0.18373          30.87           1.26               0.833
     0
     WITHIN           24.0        0.17173          16.21           1.31               0.822
     0
     WITHIN           29.0        0.17145          16.17           1.39               0.758
     0
     WITHIN           36.0        0.16837          16.13           1.53               0.700
     0
     WITHIN           46.0        0.16444          16.12           1.46               0.710
     0
     WITHIN           66.0        0.14217          30.70           1.30               0.781
     0
     WITHIN           86.0        0.13779          34.43           1.26               0.728
     0
     WITHIN          106.0        0.11909          17.68           1.48               0.716
     0
     WITHIN          126.0        0.12326          27.72           2.08               0.595
     0
     WITHIN          146.0        0.11989          27.57           3.60               0.547
```



```
     0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -TCU076.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', TCU076.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED
                        ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN          166.0        0.12191          34.19          14.68               0.569
     0
     WITHIN          186.0        0.24332          34.17          48.10               0.412
     0
     OUTCR.          186.0        0.29000          34.17          50.00               0.434
     0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
  ******************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ---------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ---------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ---------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ---------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ******************************************************
  MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
  NECESSARY LENGTH OF BLANK COMMON X        =    204819
     Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 5
 **********************

 CURVE NO.  9:      #5 modulus for Young Bay Mud, Sun et al., EERC-88/15)
 CURVE NO. 10:        damping for Young Bay Mud


      CURVE NO. 9              CURVE NO.10
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.56
    0.0010     1.000         0.0010      1.56
```



```
    0.0030     0.991         0.0030      1.56
    0.0100     0.942         0.0100      1.87
    0.0300     0.840         0.0300      2.64
    0.1000     0.647         0.1000      5.44
    0.3000     0.451         0.3000     10.30
    1.0000     0.304         1.0000     17.73
    3.0000     0.135         3.0000     24.00
   10.0000     0.085        10.0000     27.00

 **********************
  MATERIAL TYPE NO. 2
 **********************

 CURVE NO.  3:      #2 modulus for sand (seed & idriss 1970) - upper Range
 CURVE NO.  4:        damping for sand (Idriss 1990) - (about LRng from SI


      CURVE NO. 3              CURVE NO. 4
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      0.24
    0.0003     1.000         0.0003      0.42
    0.0010     0.990         0.0010      0.80
    0.0030     0.960         0.0030      1.40
    0.0100     0.850         0.0100      2.80
    0.0300     0.640         0.0300      5.10
    0.1000     0.370         0.1000      9.80
    0.3000     0.180         0.3000     15.50
    1.0000     0.080         1.0000     21.00
    3.0000     0.050         3.0000     25.00
   10.0000     0.035        10.0000     28.00

 **********************
  MATERIAL TYPE NO. 6
 **********************

 CURVE NO. 11:      #6 modulus for Old Bay Mud (Clay PI=20-40, Sun et al.,
 CURVE NO. 12:        damping for clay (Dobry & Vucetic Curve, 4/9/91)


      CURVE NO.11              CURVE NO.12
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.55
    0.0010     0.999         0.0010      1.55
    0.0030     0.980         0.0030      2.20
    0.0100     0.920         0.0100      3.70
```

```
    0.0300     0.780         0.0300      6.00
    0.1000     0.532         0.1000      8.70
    0.3000     0.293         0.3000     12.50
    1.0000     0.137         1.0000     17.00
    3.0000     0.075         3.0000     21.00
   10.0000     0.025        10.0000     22.75

 **********************
  MATERIAL TYPE NO. 3
 **********************

 CURVE NO.  5:       #3 ATTENUATION OF  ROCK  AVERAGE
 CURVE NO.  6:       DAMPING IN ROCK


      CURVE NO. 5              CURVE NO. 6
  ===================       ==================
    STRAIN    G/Gmax          STRAIN    DAMPING
  --------   -------         --------  --------
    0.0001     1.000          0.0001      0.40
    0.0003     1.000          0.0010      0.80
    0.0010     0.988          0.0100      1.50
    0.0030     0.952          0.1000      3.00
    0.0100     0.900          1.0000      4.60
    0.0300     0.810          0.0000      0.00
    0.1000     0.725          0.0000      0.00
    1.0000     0.550          0.0000      0.00
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION   HPS, Parcel E-2, A-A', TCU059.acc
 NUMBER OF LAYERS                  16          DEPTH TO BEDROCK        186.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)              (kcf)    (fps)
   1    8      4.00      2.00      0.26       1453.   0.050    0.130     600.0
   2    5      5.00      6.50      0.77         23.   0.050    0.100      86.0
   3    5      5.00     11.50      1.27         41.   0.050    0.100     115.0
   4    5      5.00     16.50      1.77         64.   0.050    0.100     143.0
   5    5      5.00     21.50      2.27         90.   0.050    0.100     170.0
   6    5      5.00     26.50      2.77        119.   0.050    0.100     196.0
   7    5      7.00     32.50      3.37        160.   0.050    0.100     227.0
   8    2     10.00     41.00      4.37       3270.   0.050    0.130     900.0
   9    2     20.00     56.00      6.32       3270.   0.050    0.130     900.0
  10    6     20.00     76.00      8.92       3270.   0.050    0.130     900.0
  11    2     20.00     96.00     11.52       3270.   0.050    0.130     900.0
  12    2     20.00    116.00     14.12       3270.   0.050    0.130     900.0
  13    2     20.00    136.00     16.72       4037.   0.050    0.130    1000.0
```



```
  14    2     20.00    156.00     19.32       4885.   0.050    0.130    1100.0
  15    2     20.00    176.00     21.92       5814.   0.050    0.130    1200.0
  16   BASE                                   55163.   0.010    0.145    3500.0

  PERIOD = 0.90 FROM AVERAGE SHEAR VELOCITY =    831.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  21.28
 FOR FREQUENCY         =   1.01 C/SEC.
     PERIOD            =   0.99 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = TCU051.acc
    NO. OF INPUT ACC. POINTS = 14500
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY =  (1F9.6)


  READING INPUT MOTION FROM ----> TCU051.acc
  FORMAT OF INPUT MOTION USED -->  (1F9.6)

 ***** H E A D E R
NGA1491  TCU051 1999 Chi-Chi- Taiwan  EQ
No. of Time Steps = 14500, Step Interval = 0.005 sec
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000231
     2 -0.000553
     3 -0.000920
     4 -0.000512
     5  0.000033
   ........ INPUT MOTION READ NOT ECHOED...........
 14496 -0.000003
 14497 -0.000003
 14498 -0.000003
 14499 -0.000003
 14500 -0.000003

 MAXIMUM ACCELERATION =  0.43415
 AT TIME              = 38.98 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  0.668
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.29000
```

```
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.29000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  16 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.70



+              ITERATION NUMBER  1
     EARTHQUAKE   - TCU051.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU059.acc

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00669 0.047  0.050     -7.1     886.6    1453.4    -63.9   1.000
  2  5    6.5 1.21216 0.188  0.050     73.4       6.3      23.0   -264.9   1.000
  3  5   11.5 0.96099 0.175  0.050     71.4      12.7      41.1   -224.2   1.000
  4  5   16.5 0.73414 0.158  0.050     68.4      21.7      63.5   -192.8   1.000
  5  5   21.5 0.56384 0.142  0.050     64.8      33.6      89.8   -167.5   1.000
  6  5   26.5 0.44397 0.127  0.050     60.7      48.1     119.3   -148.0   1.000
  7  5   32.5 0.35873 0.114  0.050     56.2      68.7     160.0   -132.9   1.000
  8  2   41.0 0.01982 0.042  0.050    -18.2    2352.1    3270.2    -39.0   1.000
  9  2   56.0 0.02500 0.047  0.050     -6.0    2206.8    3270.2    -48.2   1.000
 10  6   76.0 0.03379 0.063  0.050     20.2    2470.6    3270.2    -32.4   1.000
 11  2   96.0 0.04155 0.064  0.050     21.5    1854.0    3270.2    -76.4   1.000
 12  2  116.0 0.04759 0.069  0.050     27.6    1754.5    3270.2    -86.4   1.000
 13  2  136.0 0.04163 0.064  0.050     21.6    2287.3    4037.3    -76.5   1.000
 14  2  156.0 0.03558 0.058  0.050     13.3    2939.7    4885.1    -66.2   1.000
 15  2  176.0 0.02998 0.051  0.050      1.9    3721.5    5813.7    -56.2   1.000
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - TCU051.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU059.acc

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```



```
 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00655 0.046  0.047     -1.0     891.3     886.6      0.5   0.610
  2  5    6.5 2.51815 0.230  0.188     18.1       3.7       6.3    -69.3   0.274
  3  5   11.5 1.77853 0.210  0.175     16.8       8.8      12.7    -43.3   0.308
  4  5   16.5 1.22120 0.189  0.158     16.2      17.3      21.7    -25.1   0.341
  5  5   21.5 0.85841 0.168  0.142     15.5      28.9      33.6    -16.0   0.374
  6  5   26.5 0.63122 0.149  0.127     14.6      43.0      48.1    -12.0   0.403
  7  5   32.5 0.46095 0.130  0.114     11.9      63.8      68.7     -7.7   0.429
  8  2   41.0 0.01650 0.038  0.042    -10.0    2466.5    2352.1      4.6   0.719
  9  2   56.0 0.02599 0.048  0.047      1.7    2182.5    2206.8     -1.1   0.675
 10  6   76.0 0.03368 0.063  0.063     -0.1    2472.9    2470.6      0.1   0.755
 11  2   96.0 0.05759 0.076  0.064     16.7    1614.7    1854.0    -14.8   0.567
 12  2  116.0 0.07140 0.085  0.069     18.7    1457.0    1754.5    -20.4   0.537
 13  2  136.0 0.06019 0.078  0.064     18.4    1953.4    2287.3    -17.1   0.567
 14  2  156.0 0.05077 0.072  0.058     19.4    2550.2    2939.7    -15.3   0.602
 15  2  176.0 0.04390 0.066  0.051     22.6    3224.5    3721.5    -15.4   0.640
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - TCU051.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', TCU059.acc

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------   ------   -----
  1  8    2.0 0.00502 0.041  0.046    -13.6     949.3     891.3      6.1   0.613
  2  5    6.5 3.55766 0.244  0.230      5.8       2.9       3.7    -26.5   0.162
  3  5   11.5 1.96043 0.216  0.210      2.6       8.2       8.8     -7.5   0.215
  4  5   16.5 1.06368 0.181  0.189     -4.4      18.7      17.3      7.2   0.273
  5  5   21.5 0.72941 0.158  0.168     -6.4      30.7      28.9      5.8   0.322
  6  5   26.5 0.58386 0.144  0.149     -3.3      44.1      43.0      2.6   0.360
  7  5   32.5 0.46363 0.130  0.130      0.3      63.7      63.8     -0.2   0.399
  8  2   41.0 0.01481 0.036  0.038     -6.3    2534.2    2466.5      2.7   0.754
  9  2   56.0 0.02493 0.047  0.048     -1.9    2208.7    2182.5      1.2   0.667
 10  6   76.0 0.03322 0.062  0.063     -0.5    2482.1    2472.9      0.4   0.756
 11  2   96.0 0.06403 0.081  0.076      5.1    1536.9    1614.7     -5.1   0.494
 12  2  116.0 0.08038 0.089  0.085      5.2    1370.1    1457.0     -6.3   0.446
 13  2  136.0 0.06845 0.083  0.078      6.0    1837.0    1953.4     -6.3   0.484
 14  2  156.0 0.05874 0.077  0.072      7.4    2390.3    2550.2     -6.7   0.522
 15  2  176.0 0.05069 0.071  0.066      7.9    3036.8    3224.5     -6.2   0.555
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - TCU051.acc
```

SOIL PROFILE - HPS, Parcel E-2, A-A', TCU059.acc

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00443	0.038	0.041	-6.8	976.4	949.3	2.8	0.653
2	5	6.5	4.23825	0.249	0.244	1.8	2.8	2.9	-6.0	0.128
3	5	11.5	1.85280	0.212	0.216	-1.5	8.6	8.2	4.1	0.200
4	5	16.5	0.90928	0.171	0.181	-5.5	20.0	18.7	6.7	0.294
5	5	21.5	0.70114	0.155	0.158	-1.6	31.2	30.7	1.4	0.342
6	5	26.5	0.58447	0.144	0.144	0.0	44.1	44.1	0.0	0.370
7	5	32.5	0.47745	0.132	0.130	1.4	63.1	63.7	-0.9	0.398
8	2	41.0	0.01472	0.036	0.036	-0.4	2538.0	2534.2	0.1	0.775
9	2	56.0	0.02503	0.047	0.047	0.2	2206.1	2208.7	-0.1	0.675
10	6	76.0	0.03238	0.062	0.062	-0.9	2499.3	2482.1	0.7	0.759
11	2	96.0	0.06508	0.081	0.081	0.8	1525.0	1536.9	-0.8	0.470
12	2	116.0	0.08614	0.092	0.089	2.9	1319.4	1370.1	-3.8	0.419
13	2	136.0	0.07296	0.086	0.083	2.9	1779.2	1837.0	-3.2	0.455
14	2	156.0	0.06254	0.080	0.077	3.1	2321.7	2390.3	-3.0	0.489
15	2	176.0	0.05350	0.074	0.071	2.9	2966.5	3036.8	-2.4	0.522

+ ITERATION NUMBER 5
1

EARTHQUAKE - TCU051.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', TCU059.acc

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00430	0.037	0.038	-1.6	982.8	976.4	0.7	0.672
2	5	6.5	4.49589	0.250	0.249	0.6	2.7	2.8	-2.1	0.121
3	5	11.5	1.75503	0.209	0.212	-1.5	8.9	8.6	3.8	0.209
4	5	16.5	0.85209	0.167	0.171	-2.4	20.5	20.0	2.5	0.315
5	5	21.5	0.69844	0.155	0.155	-0.2	31.2	31.2	0.1	0.347
6	5	26.5	0.59037	0.145	0.144	0.4	43.9	44.1	-0.3	0.369
7	5	32.5	0.48510	0.133	0.132	0.7	62.8	63.1	-0.5	0.394
8	2	41.0	0.01474	0.036	0.036	0.1	2537.3	2538.0	0.0	0.776
9	2	56.0	0.02508	0.047	0.047	0.1	2204.8	2206.1	-0.1	0.675
10	6	76.0	0.03156	0.061	0.062	-0.9	2516.6	2499.3	0.7	0.764
11	2	96.0	0.06557	0.082	0.081	0.4	1519.5	1525.0	-0.4	0.466
12	2	116.0	0.08932	0.094	0.092	1.5	1292.8	1319.4	-2.1	0.403
13	2	136.0	0.07504	0.087	0.086	1.3	1753.8	1779.2	-1.4	0.441

14	2	156.0	0.06404	0.081	0.080	1.1	2295.7	2321.7	-1.1	0.475
15	2	176.0	0.05435	0.074	0.074	0.8	2946.0	2966.5	-0.7	0.510

+ ITERATION NUMBER 6
1

EARTHQUAKE - TCU051.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', TCU059.acc

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00429	0.037	0.037	-0.1	983.4	982.8	0.1	0.676
2	5	6.5	4.61108	0.251	0.250	0.3	2.7	2.7	-0.9	0.118
3	5	11.5	1.69059	0.207	0.209	-1.0	9.2	8.9	2.6	0.217
4	5	16.5	0.83279	0.166	0.167	-0.9	20.7	20.5	0.9	0.323
5	5	21.5	0.70010	0.155	0.155	0.1	31.2	31.2	-0.1	0.348
6	5	26.5	0.59421	0.145	0.145	0.3	43.8	43.9	-0.2	0.368
7	5	32.5	0.48807	0.133	0.133	0.3	62.7	62.8	-0.2	0.392
8	2	41.0	0.01473	0.036	0.036	0.0	2537.7	2537.3	0.0	0.776
9	2	56.0	0.02507	0.047	0.047	0.0	2205.3	2204.8	0.0	0.674
10	6	76.0	0.03123	0.061	0.061	-0.4	2523.6	2516.6	0.3	0.770
11	2	96.0	0.06577	0.082	0.082	0.1	1517.2	1519.5	-0.1	0.465
12	2	116.0	0.09106	0.094	0.094	0.8	1278.7	1292.8	-1.1	0.395
13	2	136.0	0.07595	0.087	0.087	0.5	1742.9	1753.8	-0.6	0.434
14	2	156.0	0.06458	0.081	0.081	0.4	2286.5	2295.7	-0.4	0.470
15	2	176.0	0.05452	0.074	0.074	0.2	2942.0	2946.0	-0.1	0.507

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	8	4.0	2.0	0.00613	60.20	57.18
2	5	5.0	6.5	6.58725	178.84	57.26
3	5	5.0	11.5	2.41512	215.52	57.17
4	5	5.0	16.5	1.18970	244.21	69.06
5	5	5.0	21.5	1.00015	312.02	69.01
6	5	5.0	26.5	0.84888	372.90	68.97
7	5	7.0	32.5	0.69725	437.71	68.93
8	2	10.0	41.0	0.02104	533.78	68.86
9	2	20.0	56.0	0.03581	789.50	68.83
10	6	20.0	76.0	0.04462	1122.88	68.82
11	2	20.0	96.0	0.09396	1427.68	68.81
12	2	20.0	116.0	0.13008	1681.74	68.78
13	2	20.0	136.0	0.10849	1902.76	68.75
14	2	20.0	156.0	0.09226	2118.05	68.73

```
    15     2           20.0          176.0        0.07788        2294.39          68.71

  PERIOD = 1.23 FROM AVERAGE SHEAR VELOCITY =    604.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =   5.28
 FOR FREQUENCY         =   1.01 C/SEC.
     PERIOD            =   0.99 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -TCU051.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', TCU059.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED
                        ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN            0.0        0.23014          57.16           0.82               0.773
     0
     WITHIN            4.0        0.23001          57.16           0.82               0.773
     0
     WITHIN            9.0        0.19766          49.49           1.25               0.836
     0
     WITHIN           14.0        0.21139          49.43           1.26               0.779
     0
     WITHIN           19.0        0.19415          38.49           1.25               0.814
     0
     WITHIN           19.0        0.19415          38.49           1.25               0.814
     0
     WITHIN           24.0        0.19610          38.45           1.31               0.772
     0
     WITHIN           29.0        0.19389          38.42           1.41               0.747
     0
     WITHIN           36.0        0.17807          38.37           1.52               0.770
     0
     WITHIN           46.0        0.17386          38.36           1.48               0.780
     0
     WITHIN           66.0        0.15308          38.34           1.27               0.837
     0
     WITHIN           86.0        0.13536          38.31           1.17               0.923
     0
     WITHIN          106.0        0.12552          68.71           1.49               1.000
     0
     WITHIN          126.0        0.14719          38.23           2.08               0.834
     0
     WITHIN          146.0        0.14885          38.22           2.92               0.776
```



```
     0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -TCU051.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', TCU059.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED
                        ,
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                      RECORD
     WITHIN          166.0        0.14001          39.00          11.93               0.857
     0
     WITHIN          186.0        0.22911          38.98          48.31               0.695
     0
     OUTCR.          186.0        0.29000          38.98          50.00               0.663
     0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
  ******************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ---------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ---------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ---------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ---------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ******************************************************
  MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
  NECESSARY LENGTH OF BLANK COMMON X        =    204819
     Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 5
 **********************

 CURVE NO.  9:      #5 modulus for Young Bay Mud, Sun et al., EERC-88/15)
 CURVE NO. 10:        damping for Young Bay Mud


      CURVE NO. 9              CURVE NO.10
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.56
    0.0010     1.000         0.0010      1.56
```



```
    0.0030     0.991         0.0030      1.56
    0.0100     0.942         0.0100      1.87
    0.0300     0.840         0.0300      2.64
    0.1000     0.647         0.1000      5.44
    0.3000     0.451         0.3000     10.30
    1.0000     0.304         1.0000     17.73
    3.0000     0.135         3.0000     24.00
   10.0000     0.085        10.0000     27.00

 **********************
  MATERIAL TYPE NO. 2
 **********************

 CURVE NO.  3:      #2 modulus for sand (seed & idriss 1970) - upper Range
 CURVE NO.  4:        damping for sand (Idriss 1990) - (about LRng from SI


      CURVE NO. 3              CURVE NO. 4
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      0.24
    0.0003     1.000         0.0003      0.42
    0.0010     0.990         0.0010      0.80
    0.0030     0.960         0.0030      1.40
    0.0100     0.850         0.0100      2.80
    0.0300     0.640         0.0300      5.10
    0.1000     0.370         0.1000      9.80
    0.3000     0.180         0.3000     15.50
    1.0000     0.080         1.0000     21.00
    3.0000     0.050         3.0000     25.00
   10.0000     0.035        10.0000     28.00

 **********************
  MATERIAL TYPE NO. 6
 **********************

 CURVE NO. 11:      #6 modulus for Old Bay Mud (Clay PI=20-40, Sun et al.,
 CURVE NO. 12:        damping for clay (Dobry & Vucetic Curve, 4/9/91)


      CURVE NO.11              CURVE NO.12
  ===================       ==================
    STRAIN    G/Gmax         STRAIN    DAMPING
  --------   -------        --------  --------
    0.0001     1.000         0.0001      1.55
    0.0010     0.999         0.0010      1.55
    0.0030     0.980         0.0030      2.20
    0.0100     0.920         0.0100      3.70
```

```
    0.0300     0.780         0.0300      6.00
    0.1000     0.532         0.1000      8.70
    0.3000     0.293         0.3000     12.50
    1.0000     0.137         1.0000     17.00
    3.0000     0.075         3.0000     21.00
   10.0000     0.025        10.0000     22.75

 **********************
  MATERIAL TYPE NO. 3
 **********************

 CURVE NO.  5:       #3 ATTENUATION OF  ROCK  AVERAGE
 CURVE NO.  6:       DAMPING IN ROCK


      CURVE NO. 5              CURVE NO. 6
  ===================       ==================
    STRAIN    G/Gmax          STRAIN    DAMPING
  --------   -------         --------  --------
    0.0001     1.000          0.0001      0.40
    0.0003     1.000          0.0010      0.80
    0.0010     0.988          0.0100      1.50
    0.0030     0.952          0.1000      3.00
    0.0100     0.900          1.0000      4.60
    0.0300     0.810          0.0000      0.00
    0.1000     0.725          0.0000      0.00
    1.0000     0.550          0.0000      0.00
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.  16      IDENTIFICATION   HPS, Parcel E-2, A-A', IZMIT.acc
 NUMBER OF LAYERS                  16          DEPTH TO BEDROCK        186.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)              (kcf)     (fps)
   1    8      4.00      2.00      0.26       1453.   0.050    0.130     600.0
   2    5      5.00      6.50      0.61         23.   0.050    0.100      86.0
   3    5      5.00     11.50      0.80         41.   0.050    0.100     115.0
   4    5      5.00     16.50      0.99         64.   0.050    0.100     143.0
   5    5      5.00     21.50      1.18         90.   0.050    0.100     170.0
   6    5      5.00     26.50      1.37        119.   0.050    0.100     196.0
   7    5      7.00     32.50      1.59        160.   0.050    0.100     227.0
   8    2     10.00     41.00      2.06       3270.   0.050    0.130     900.0
   9    2     20.00     56.00      3.08       3270.   0.050    0.130     900.0
  10    6     20.00     76.00      4.43       3270.   0.050    0.130     900.0
  11    2     20.00     96.00      5.78       3270.   0.050    0.130     900.0
  12    2     20.00    116.00      7.13       3270.   0.050    0.130     900.0
  13    2     20.00    136.00      8.48       4037.   0.050    0.130    1000.0
```



```
  14    2     20.00    156.00      9.84       4885.   0.050    0.130    1100.0
  15    2     20.00    176.00     11.19       5814.   0.050    0.130    1200.0
  16   BASE                                  55163.   0.010    0.145    3500.0

  PERIOD = 0.90 FROM AVERAGE SHEAR VELOCITY =    831.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  21.28
 FOR FREQUENCY         =   1.01 C/SEC.
     PERIOD            =   0.99 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = IZMIT.acc
    NO. OF INPUT ACC. POINTS = 13360
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY = (1F9.6)


  READING INPUT MOTION FROM ----> IZMIT.acc
  FORMAT OF INPUT MOTION USED --> (1F9.6)

 ***** H E A D E R
NGA1165 Izmit 1999 Kocaeli EQ
No. of Time Steps = 13525, Step Interval = 0.005 sec
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1  0.000297
     2  0.000298
     3  0.000298
     4  0.000298
     5  0.000299
   ........ INPUT MOTION READ NOT ECHOED...........
 13356  0.000010
 13357  0.000010
 13358  0.000010
 13359  0.000010
 13360  0.000010

 MAXIMUM ACCELERATION =  0.45693
 AT TIME              = 27.26 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  0.635
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.29000
```

```
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.29000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  16 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     9
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.70



+              ITERATION NUMBER  1
     EARTHQUAKE   - IZMIT.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', IZMIT.acc

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00683	0.047	0.050	-6.2	882.2	1453.4	-64.7	1.000
2	5	6.5	1.24313	0.190	0.050	73.6	6.2	23.0	-270.1	1.000
3	5	11.5	1.01339	0.178	0.050	71.9	12.4	41.1	-231.6	1.000
4	5	16.5	0.76254	0.161	0.050	68.9	21.4	63.5	-196.9	1.000
5	5	21.5	0.64123	0.150	0.050	66.6	32.1	89.8	-179.3	1.000
6	5	26.5	0.55616	0.141	0.050	64.6	44.8	119.3	-166.3	1.000
7	5	32.5	0.45212	0.128	0.050	61.0	64.2	160.0	-149.4	1.000
8	2	41.0	0.02314	0.046	0.050	-9.7	2255.1	3270.2	-45.0	1.000
9	2	56.0	0.02771	0.049	0.050	-1.3	2142.7	3270.2	-52.6	1.000
10	6	76.0	0.03478	0.063	0.050	21.0	2451.1	3270.2	-33.4	1.000
11	2	96.0	0.04060	0.063	0.050	20.4	1871.0	3270.2	-74.8	1.000
12	2	116.0	0.04616	0.068	0.050	26.3	1777.0	3270.2	-84.0	1.000
13	2	136.0	0.04118	0.063	0.050	21.1	2297.1	4037.3	-75.8	1.000
14	2	156.0	0.03697	0.059	0.050	15.5	2897.5	4885.1	-68.6	1.000
15	2	176.0	0.03307	0.055	0.050	8.8	3593.8	5813.7	-61.8	1.000

```
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - IZMIT.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', IZMIT.acc

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```


NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00803	0.050	0.047	6.7	847.1	882.2	-4.2	0.607
2	5	6.5	3.06297	0.241	0.190	21.1	3.1	6.2	-101.4	0.270
3	5	11.5	1.77860	0.210	0.178	15.3	8.8	12.4	-40.1	0.302
4	5	16.5	1.15912	0.186	0.161	13.5	17.8	21.4	-19.9	0.337
5	5	21.5	0.88013	0.169	0.150	11.5	28.7	32.1	-12.2	0.358
6	5	26.5	0.70946	0.156	0.141	9.6	41.2	44.8	-8.6	0.376
7	5	32.5	0.55534	0.141	0.128	9.0	60.1	64.2	-6.7	0.401
8	2	41.0	0.01853	0.041	0.046	-11.4	2394.2	2255.1	5.8	0.690
9	2	56.0	0.03093	0.052	0.049	5.5	2070.4	2142.7	-3.5	0.655
10	6	76.0	0.04106	0.067	0.063	5.5	2339.4	2451.1	-4.8	0.750
11	2	96.0	0.06862	0.083	0.063	24.6	1486.1	1871.0	-25.9	0.572
12	2	116.0	0.08224	0.090	0.068	25.0	1353.4	1777.0	-31.3	0.543
13	2	136.0	0.06653	0.082	0.063	22.8	1862.7	2297.1	-23.3	0.569
14	2	156.0	0.05481	0.075	0.059	20.6	2466.3	2897.5	-17.5	0.593
15	2	176.0	0.04812	0.069	0.055	21.1	3104.8	3593.8	-15.8	0.618

```
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - IZMIT.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', IZMIT.acc

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00624	0.045	0.050	-11.6	901.8	847.1	6.1	0.583
2	5	6.5	4.04598	0.247	0.241	2.8	2.8	3.1	-9.4	0.134
3	5	11.5	1.77853	0.210	0.210	0.0	8.8	8.8	0.0	0.215
4	5	16.5	1.05704	0.180	0.186	-2.9	18.7	17.8	4.8	0.281
5	5	21.5	0.77492	0.162	0.169	-4.9	30.1	28.7	4.7	0.319
6	5	26.5	0.63256	0.149	0.156	-4.8	42.9	41.2	3.9	0.346
7	5	32.5	0.53800	0.139	0.141	-1.4	60.7	60.1	1.0	0.376
8	2	41.0	0.01657	0.039	0.041	-6.1	2464.2	2394.2	2.8	0.732
9	2	56.0	0.02976	0.051	0.052	-2.7	2098.0	2070.4	1.3	0.633
10	6	76.0	0.03939	0.066	0.067	-1.4	2367.2	2339.4	1.2	0.715
11	2	96.0	0.07893	0.089	0.083	6.2	1383.5	1486.1	-7.4	0.454
12	2	116.0	0.09935	0.098	0.090	7.5	1214.7	1353.4	-11.4	0.414
13	2	136.0	0.07696	0.088	0.082	6.5	1730.8	1862.7	-7.6	0.461
14	2	156.0	0.05834	0.077	0.075	3.2	2397.9	2466.3	-2.9	0.505
15	2	176.0	0.05039	0.071	0.069	2.5	3044.7	3104.8	-2.0	0.534

```
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - IZMIT.acc
```

SOIL PROFILE - HPS, Parcel E-2, A-A', IZMIT.acc

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00579	0.044	0.045	-3.6	918.3	901.8	1.8	0.620
2	5	6.5	4.36628	0.249	0.247	0.8	2.7	2.8	-2.6	0.123
3	5	11.5	1.74583	0.209	0.210	-0.5	9.0	8.8	1.3	0.215
4	5	16.5	0.99842	0.177	0.180	-1.8	19.3	18.7	2.9	0.295
5	5	21.5	0.73873	0.159	0.162	-1.9	30.6	30.1	1.7	0.335
6	5	26.5	0.60446	0.146	0.149	-1.9	43.6	42.9	1.5	0.360
7	5	32.5	0.52346	0.137	0.139	-1.2	61.3	60.7	0.9	0.380
8	2	41.0	0.01571	0.037	0.039	-3.0	2497.5	2464.2	1.3	0.754
9	2	56.0	0.02878	0.050	0.051	-1.4	2118.8	2098.0	1.0	0.642
10	6	76.0	0.03812	0.065	0.066	-1.1	2389.3	2367.2	0.9	0.724
11	2	96.0	0.08352	0.091	0.089	2.4	1342.1	1383.5	-3.1	0.423
12	2	116.0	0.10845	0.102	0.098	4.4	1164.1	1214.7	-4.3	0.371
13	2	136.0	0.07996	0.089	0.088	1.7	1696.3	1730.8	-2.0	0.429
14	2	156.0	0.05816	0.077	0.077	-0.2	2401.2	2397.9	0.1	0.491
15	2	176.0	0.05034	0.071	0.071	0.0	3045.8	3044.7	0.0	0.524

+ ITERATION NUMBER 5
1

EARTHQUAKE - IZMIT.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', IZMIT.acc

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00568	0.043	0.044	-0.9	922.2	918.3	0.4	0.632
2	5	6.5	4.48481	0.250	0.249	0.3	2.7	2.7	-0.9	0.119
3	5	11.5	1.72025	0.208	0.209	-0.4	9.1	9.0	1.0	0.218
4	5	16.5	0.97258	0.176	0.177	-0.9	19.5	19.3	1.0	0.304
5	5	21.5	0.72975	0.158	0.159	-0.5	30.7	30.6	0.4	0.341
6	5	26.5	0.59236	0.145	0.146	-0.9	43.9	43.6	0.7	0.365
7	5	32.5	0.51495	0.136	0.137	-0.7	61.6	61.3	0.5	0.383
8	2	41.0	0.01535	0.037	0.037	-1.3	2511.9	2497.5	0.6	0.764
9	2	56.0	0.02832	0.050	0.050	-0.7	2128.9	2118.8	0.5	0.648
10	6	76.0	0.03751	0.065	0.065	-0.6	2400.3	2389.3	0.5	0.731
11	2	96.0	0.08551	0.092	0.091	1.0	1324.7	1342.1	-1.3	0.410
12	2	116.0	0.11192	0.104	0.102	1.6	1146.3	1164.1	-1.6	0.356
13	2	136.0	0.08032	0.089	0.089	0.2	1692.2	1696.3	-0.2	0.420

14	2	156.0	0.05763	0.076	0.077	-0.5	2411.3	2401.2	0.4	0.492
15	2	176.0	0.05000	0.071	0.071	-0.4	3054.8	3045.8	0.3	0.524

+ ITERATION NUMBER 6
1

EARTHQUAKE - IZMIT.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', IZMIT.acc

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00567	0.043	0.043	-0.1	922.8	922.2	0.1	0.634
2	5	6.5	4.53193	0.250	0.250	0.1	2.7	2.7	-0.4	0.118
3	5	11.5	1.70353	0.208	0.208	-0.3	9.1	9.1	0.7	0.220
4	5	16.5	0.96481	0.175	0.176	-0.3	19.6	19.5	0.3	0.307
5	5	21.5	0.72877	0.158	0.158	-0.1	30.7	30.7	0.0	0.342
6	5	26.5	0.58766	0.144	0.145	-0.3	44.0	43.9	0.3	0.368
7	5	32.5	0.51135	0.136	0.136	-0.3	61.7	61.6	0.2	0.385
8	2	41.0	0.01522	0.037	0.037	-0.5	2517.2	2511.9	0.2	0.768
9	2	56.0	0.02814	0.050	0.050	-0.3	2132.9	2128.9	0.2	0.651
10	6	76.0	0.03726	0.065	0.065	-0.2	2404.7	2400.3	0.2	0.734
11	2	96.0	0.08643	0.092	0.092	0.5	1316.9	1324.7	-0.6	0.405
12	2	116.0	0.11318	0.104	0.104	0.6	1139.9	1146.3	-0.6	0.351
13	2	136.0	0.08009	0.089	0.089	-0.1	1694.9	1692.2	0.2	0.419
14	2	156.0	0.05725	0.076	0.076	-0.3	2418.4	2411.3	0.3	0.494
15	2	176.0	0.04978	0.071	0.071	-0.2	3060.5	3054.8	0.2	0.525

+ ITERATION NUMBER 7
1

EARTHQUAKE - IZMIT.acc
SOIL PROFILE - HPS, Parcel E-2, A-A', IZMIT.acc

ITERATION NUMBER 7

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	8	2.0	0.00567	0.043	0.043	0.0	922.7	922.8	0.0	0.635
2	5	6.5	4.55131	0.250	0.250	0.0	2.7	2.7	-0.2	0.118
3	5	11.5	1.69281	0.207	0.208	-0.2	9.2	9.1	0.4	0.222
4	5	16.5	0.96308	0.175	0.175	-0.1	19.6	19.6	0.1	0.308
5	5	21.5	0.72949	0.158	0.158	0.0	30.7	30.7	0.0	0.342
6	5	26.5	0.58598	0.144	0.144	-0.1	44.0	44.0	0.1	0.369
7	5	32.5	0.51000	0.136	0.136	-0.1	61.8	61.7	0.1	0.386
8	2	41.0	0.01517	0.037	0.037	-0.2	2519.1	2517.2	0.1	0.770

```
  9  2   56.0 0.02808 0.050  0.050     -0.1    2134.3    2132.9      0.1   0.652
 10  6   76.0 0.03718 0.065  0.065     -0.1    2406.2    2404.7      0.1   0.735
 11  2   96.0 0.08689 0.093  0.092      0.2    1313.1    1316.9     -0.3   0.403
 12  2  116.0 0.11365 0.105  0.104      0.2    1137.6    1139.9     -0.2   0.349
 13  2  136.0 0.07982 0.089  0.089     -0.1    1697.9    1694.9      0.2   0.420
 14  2  156.0 0.05706 0.076  0.076     -0.2    2422.2    2418.4      0.2   0.495
 15  2  176.0 0.04968 0.071  0.071     -0.1    3063.0    3060.5      0.1   0.526
+              ITERATION NUMBER  8
1
     EARTHQUAKE   - IZMIT.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', IZMIT.acc

  ITERATION NUMBER  8

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  8    2.0 0.00567 0.043  0.043      0.0     922.6     922.7      0.0   0.635
  2  5    6.5 4.55972 0.250  0.250      0.0       2.7       2.7     -0.1   0.118
  3  5   11.5 1.68603 0.207  0.207     -0.1       9.2       9.2      0.3   0.223
  4  5   16.5 0.96318 0.175  0.175      0.0      19.6      19.6      0.0   0.308
  5  5   21.5 0.73028 0.158  0.158      0.0      30.7      30.7      0.0   0.342
  6  5   26.5 0.58538 0.144  0.144      0.0      44.1      44.0      0.0   0.369
  7  5   32.5 0.50953 0.136  0.136      0.0      61.8      61.8      0.0   0.386
  8  2   41.0 0.01516 0.037  0.037     -0.1    2519.8    2519.1      0.0   0.770
  9  2   56.0 0.02806 0.050  0.050      0.0    2134.7    2134.3      0.0   0.653
 10  6   76.0 0.03715 0.065  0.065      0.0    2406.8    2406.2      0.0   0.736
 11  2   96.0 0.08712 0.093  0.093      0.1    1311.1    1313.1     -0.2   0.402
 12  2  116.0 0.11382 0.105  0.105      0.1    1136.8    1137.6     -0.1   0.348
 13  2  136.0 0.07963 0.089  0.089     -0.1    1700.1    1697.9      0.1   0.421
 14  2  156.0 0.05697 0.076  0.076     -0.1    2424.0    2422.2      0.1   0.496
 15  2  176.0 0.04965 0.071  0.071      0.0    3063.9    3063.0      0.0   0.527
+              ITERATION NUMBER  9
1
     EARTHQUAKE   - IZMIT.acc
     SOIL PROFILE -  HPS, Parcel E-2, A-A', IZMIT.acc

  ITERATION NUMBER  9

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  8    2.0 0.00568 0.043  0.043      0.0     922.5     922.6      0.0   0.635
  2  5    6.5 4.56366 0.250  0.250      0.0       2.7       2.7      0.0   0.118
  3  5   11.5 1.68178 0.207  0.207     -0.1       9.2       9.2      0.2   0.223
```



```
  4  5   16.5 0.96370 0.175  0.175      0.0      19.6      19.6      0.0   0.308
  5  5   21.5 0.73086 0.158  0.158      0.0      30.7      30.7      0.0   0.342
  6  5   26.5 0.58517 0.144  0.144      0.0      44.1      44.1      0.0   0.369
  7  5   32.5 0.50935 0.136  0.136      0.0      61.8      61.8      0.0   0.386
  8  2   41.0 0.01515 0.037  0.037      0.0    2520.0    2519.8      0.0   0.771
  9  2   56.0 0.02805 0.050  0.050      0.0    2134.8    2134.7      0.0   0.653
 10  6   76.0 0.03714 0.065  0.065      0.0    2406.9    2406.8      0.0   0.736
 11  2   96.0 0.08725 0.093  0.093      0.1    1310.0    1311.1     -0.1   0.401
 12  2  116.0 0.11388 0.105  0.105      0.0    1136.5    1136.8      0.0   0.348
 13  2  136.0 0.07951 0.089  0.089     -0.1    1701.4    1700.1      0.1   0.421
 14  2  156.0 0.05693 0.076  0.076      0.0    2424.7    2424.0      0.0   0.496
 15  2  176.0 0.04964 0.071  0.071      0.0    3064.1    3063.9      0.0   0.527

  VALUES IN TIME DOMAIN

  LAYER  TYPE      THICKNESS          DEPTH     MAX STRAIN     MAX STRESS          TIME
                       FT               FT        PRCNT           PSF              SEC

     1     8           4.0             2.0       0.00811         74.80           18.45
     2     5           5.0             6.5       6.51951        176.12           17.98
     3     5           5.0            11.5       2.40255        220.47           17.85
     4     5           5.0            16.5       1.37671        269.46           17.76
     5     5           5.0            21.5       1.04409        320.61           17.70
     6     5           5.0            26.5       0.83596        368.26           18.91
     7     5           7.0            32.5       0.72765        449.78           18.88
     8     2          10.0            41.0       0.02164        545.34           18.83
     9     2          20.0            56.0       0.04008        855.54           27.51
    10     6          20.0            76.0       0.05306       1277.02           27.49
    11     2          20.0            96.0       0.12464       1634.09           17.94
    12     2          20.0           116.0       0.16268       1849.33           17.93
    13     2          20.0           136.0       0.11358       1930.92           17.91
    14     2          20.0           156.0       0.08133       1971.29           27.40
    15     2          20.0           176.0       0.07092       2172.85           27.38

  PERIOD = 1.25 FROM AVERAGE SHEAR VELOCITY =    595.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =   5.18
 FOR FREQUENCY         =   0.99 C/SEC.
     PERIOD            =   1.01 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -IZMIT.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', IZMIT.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
```

```
        SAVED
                          ,
                         FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                         RECORD
     WITHIN               0.0        0.29224          18.44           0.83               0.170
     0
     WITHIN               4.0        0.29172          18.44           0.83               0.170
     0
     WITHIN               9.0        0.22114          18.19           1.22               0.185
     0
     WITHIN              14.0        0.24970          18.11           1.20               0.187
     0
     WITHIN              19.0        0.25189          18.07           1.22               0.170
     0
     WITHIN              19.0        0.25189          18.07           1.22               0.170
     0
     WITHIN              24.0        0.23741          18.02           1.28               0.161
     0
     WITHIN              29.0        0.23035          17.99           1.36               0.160
     0
     WITHIN              36.0        0.21812          17.94           1.50               0.157
     0
     WITHIN              46.0        0.21487          17.94           1.45               0.157
     0
     WITHIN              66.0        0.20269          17.91           1.22               0.151
     0
     WITHIN              86.0        0.18238          17.90           1.20               0.140
     0
     WITHIN             106.0        0.15360          17.87           1.62               0.170
     0
     WITHIN             126.0        0.16200          27.34           2.20               0.156
     0
     WITHIN             146.0        0.15934          17.78           3.36               0.148
     0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -IZMIT.acc
  SOIL DEPOSIT -  HPS, Parcel E-2, A-A', IZMIT.acc
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH
        SAVED
                          ,
                         FT            G                SEC          C/SEC             QUIET ZONE       ACC.
                         RECORD
     WITHIN             166.0        0.16806          17.78          13.27               0.132
     0
     WITHIN             186.0        0.23702          27.26          48.35               0.167
     0
     OUTCR.             186.0        0.29000          27.26          50.00               0.173
```



```
     0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    8
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

ATTACHMENT E8

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Hunter's Point, Parcel E-2, Cross Section A-A', Time History=Chy029.acc

YIELD ACCELERATION = 0.0770

DT = 0.0050 ACCN DUE GRAVITY = 32.200 NLINES = 2048

A max = 0.13719 Acc Factor = 1.00000 Static F.S.= 1.540

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.42163 Ft/S Dfinal = 0.22227 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.11353 Ft/S Dfinal = 0.04707 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.42163	0.26758	0.22227	0.13467
2	0.11353		0.04707	

*** PROGRAM TERMINATED ***

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Hunter's Point, Parcel E-2, Cross Section A-A', Time History=TCU076.acc

YIELD ACCELERATION = 0.0770

DT = 0.0050 ACCN DUE GRAVITY = 32.200 NLINES = 2048

A max = 0.11834 Acc Factor = 1.00000 Static F.S.= 1.540

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.09747 Ft/S Dfinal = 0.05513 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.22754 Ft/S Dfinal = 0.11057 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.09747	0.16251	0.05513	0.08285
2	0.22754		0.11057	

*** PROGRAM TERMINATED ***

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Hunter's Point, Parcel E-2, Cross Section A-A', Time History=TCU051.acc

YIELD ACCELERATION = 0.0770

DT = 0.0050 ACCN DUE GRAVITY = 32.200 NLINES = 2048

A max = 0.12385 Acc Factor = 1.00000 Static F.S.= 1.540

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.16470 Ft/S Dfinal = 0.14907 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.29305 Ft/S Dfinal = 0.10536 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.16470	0.22888	0.14907	0.12722
2	0.29305		0.10536	

*** PROGRAM TERMINATED ***

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Hunter's Point, Parcel E-2, Cross Section A-A', Time History=Izmit.acc

YIELD ACCELERATION = 0.0770

DT = 0.0050 ACCN DUE GRAVITY = 32.200 NLINES = 1804

A max = 0.12826 Acc Factor = 1.00000 Static F.S.= 1.540

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.25544 Ft/S Dfinal = 0.15365 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.23771 Ft/S Dfinal = 0.08374 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.25544	0.24657	0.15365	0.11870
2	0.23771		0.08374	

*** PROGRAM TERMINATED ***

Appendix F. Groundwater Containment System Modeling

Table of Contents

SECTION F1. INTRODUCTION AND MODELING OBJECTIVES F-1

SECTION F2. MODEL SETUP F-3

F2.1. Model Domain and Boundary Conditions F-3

F2.2. Model Layers F-7

F2.3. Hydrogeologic Parameters F-8

F2.4. Model Calibration F-9

F2.5. Proposed Conditions Simulation Components F-10

F2.5.1 Upgradient and Nearshore Slurry Walls F-10

F2.5.2. French Drain F-11

F2.5.3. Freshwater Wetland F-12

SECTION F3. PREDICTIVE SIMULATION RESULTS F-13

SECTION F4. MODELING CONCLUSIONS F-18

SECTION F5. MODEL LIMITATIONS F-19

SECTION F6. REFERENCES F-20

List of Figures

Figure F-1. Study Area Features F-2
Figure F-2. Modeled Area F-4
Figure F-3. Model Domain and Boundary Conditions F-6
Figure F-4. Recharge Distribution F-7
Figure F-5. Model Layer Configuration (Cross-Section View) F-8
Figure F-6. Hydraulic Conductivity Zones in Layer 1 ..... F-9
Figure F-7. Model Calibration Results F-10
Figure F-8. Slurry Walls, Drain, and Wetland F-11
Figure F-9. Slurry Walls, French Drain, and Unlined Wetland F-15
Figure F-10. Nearshore Slurry Wall F-16
Figure F-11. Nearshore Slurry Wall and Extraction Wells F-17

List of Tables

Table F-1. Calibrated Hydrogeologic Aquifer Parameters F-8

Acronyms and Abbreviations

FS	Feasibility Study
GES	groundwater extraction system
gpm	gallons per minute
msl	mean sea level
PCBs	polychlorinated biphenyls
RI	Remedial Investigation
USGS	U.S. Geological Survey

Section F1. Introduction and Modeling Objectives

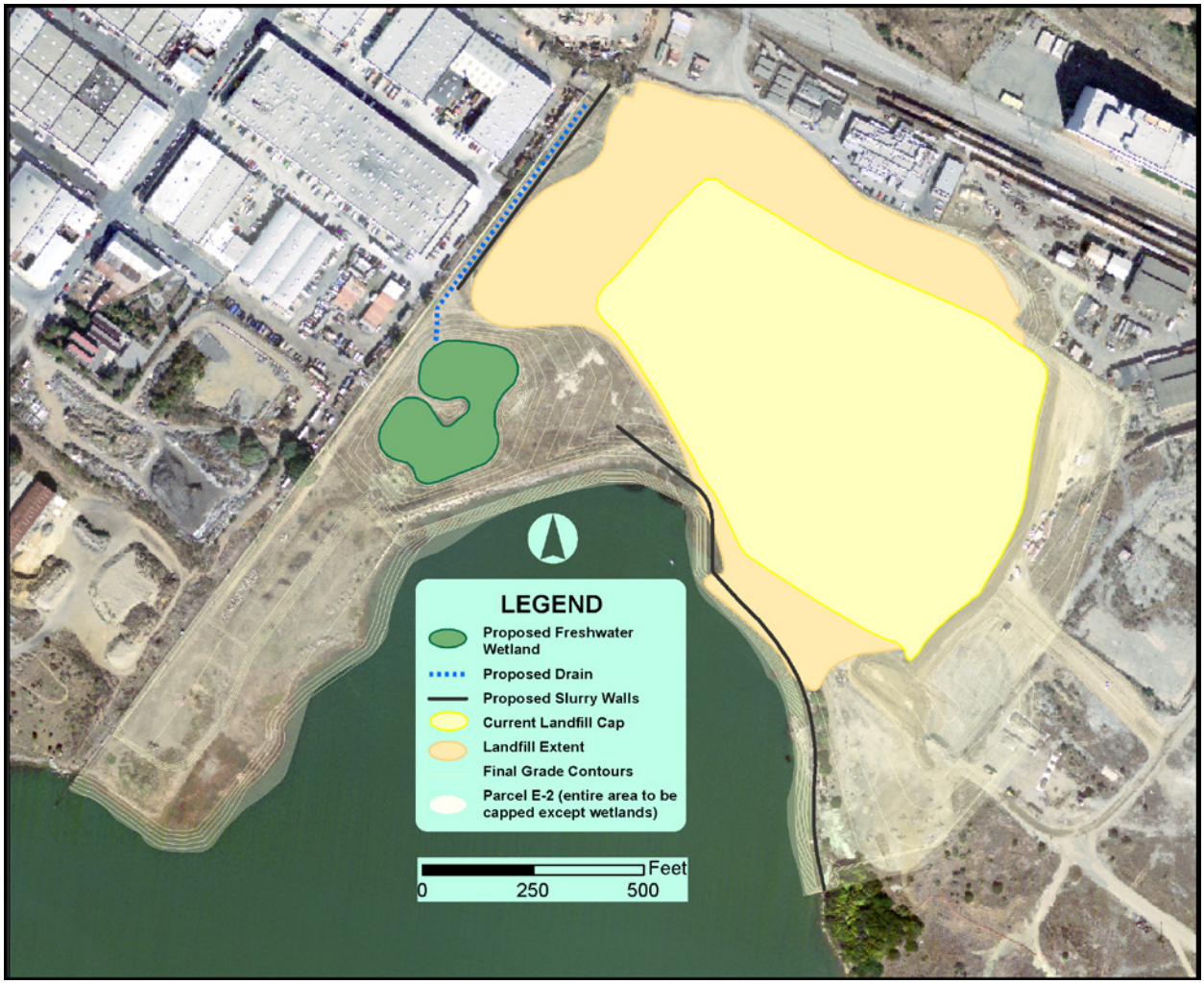
This appendix summarizes the numerical groundwater modeling performed to evaluate changes in groundwater elevations and flow that could occur following construction of the proposed groundwater containment alternative at Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California. The proposed groundwater containment actions to be implemented at Parcel E-2 include the following components (Figure F-1):

1. A slurry wall located upgradient of the landfill to divert a portion of the groundwater away from the landfill waste (herein referred to as the "upgradient slurry wall").
2. A French drain located upgradient of the upgradient slurry wall to intercept groundwater from behind the proposed slurry wall and convey it to a new 2.38-acre freshwater wetland located in the Panhandle Area.
3. A shoreline slurry wall to limit discharge of contaminated groundwater to San Francisco Bay (the Bay) (herein referred to as the "nearshore slurry wall").
4. A network of extraction wells located upgradient of the nearshore slurry wall that could be used to manage landfill leachate in the future, as needed.

The objectives of the hydrogeologic modeling were to:

1. Evaluate the hydrologic effects of constructing a slurry wall upgradient of the landfill to reduce leachate generation by diverting upgradient groundwater, to the extent practicable.
2. Evaluate the hydrologic effects of constructing a French drain on the upgradient side of the proposed upgradient slurry wall to reduce hydraulic head buildup behind the slurry wall, and to provide an additional source of water to the proposed freshwater wetlands, in order to prolong the presence of aquatic habitat in the freshwater wetlands, to the extent practicable
3. Estimate the approximate volume of water that the French drain will divert to the freshwater wetlands.
4. Evaluate the hydrologic effects of constructing a slurry wall downgradient of the landfill along the shoreline to divert groundwater flow around the wall and maximize the groundwater travel time between areas upgradient of the wall and the Bay.
5. Evaluate the feasibility of installing a series of extraction wells upgradient of the proposed shoreline slurry wall, and the required pumping rate to create measurable drawdown behind the wall to inhibit the potential flow of contaminated groundwater towards the Bay.

Figure F-1. Study Area Features



This report documents groundwater modeling work conducted to date to support the Navy's 60% Remedial Design submittal. Further modeling simulation evaluations and refinements, including sensitivity analyses, will be performed to support future design submittals. The groundwater modeling methodology and results may be revised in future design submittals to reflect the results of additional evaluations. The modeling results presented herein represent average anticipated groundwater conditions at the site, which are defined by the most recent eight consecutive quarterly groundwater monitoring results available for the site from 2010 and 2011. The modeling results presented in this report are design basis elements that were used to develop designs for the slurry wall, French drain, and extraction well network presented in the Design Basis Report (to which this document is appended).

Section F2. Model Setup

A groundwater model was previously constructed by IT Corporation (2001) to evaluate groundwater conditions at Parcel E-2, with a specific focus on the southeast portion of the site that is known to include elevated concentrations of polychlorinated biphenyls (PCBs) in soil and groundwater (referred to as the "PCB Hot Spot Area"). At this area, a sheet-pile wall and groundwater extraction system (GES) were constructed in 1998 as part of an interim removal action to control discharge of PCB-contaminated groundwater to the Bay. The GES was decommissioned in 2005 prior to source removal activities that were performed as part of a separate removal action (Tetra Tech EC, Inc., 2007). The previously constructed model was adapted for the purposes of this evaluation because it includes the subject area of interest, and because the flow regime generated by the model calibrated well to field measurements collected across Parcel E-2.

The U.S. Geological Survey's (USGS) MODFLOW 2000 numerical groundwater flow code, which simulates groundwater flow through porous media, was used (Harbaugh et al, 2001). The graphical user interface used to construct the model and run numerical simulations was Groundwater Vistas, V. 6.29 (Environmental Science Simulations, Inc., 2012).

The following subsections summarize the groundwater flow model setup, including the model domain, boundary conditions, layer structure, hydrogeologic parameters, model calibration, upgradient and shoreline slurry walls, French drain, and freshwater wetlands.

F2.1. MODEL DOMAIN AND BOUNDARY CONDITIONS

The model domain is a 3,500-foot by 6,700-foot rectangular area, covering approximately 538 acres oriented northwest-southeast along the direction of regional groundwater flow (left to right across the model domain) in the southwestern portion of Hunters Point Naval Shipyard in San Francisco, California (Figure F-2). The southwestern and southeastern model boundaries represent San Francisco Bay, and the northwestern and northeastern boundaries represent steady-state regional groundwater elevations along the site periphery determined by past site groundwater mapping. The northwestern upgradient border of the model domain lies between Griffith and Hawes Streets northwest of the South Basin embayment adjoining the central portion of San Francisco Bay. For this evaluation, the northwestern upgradient border of the model was moved approximately 500 feet further upgradient from its original position in the original 2001 model. The boundary was moved out onto non-Navy property to improve the accuracy of model simulations in the vicinity of the proposed upgradient slurry wall and associated French drain,

which had previously been located relatively close to the model boundary. The South Basin forms the south and southwestern borders of the model. The northeastern boundary lies approximately between Kiska Road and Hawes Street, near the crest of the Hunters Point ridge.

Figure F-2. Modeled Area

In plan view, the model domain is covered by a grid that includes 70 by 134 grid cells. Vertically, the model is discretized into five model layers representing the various stratigraphic units underlying the land surface. With 9,380 grid cells in each of the five model layers, the model contains a total of 46,900 cells. Grid cells are spaced evenly across the model domain and consist of 50-foot squares. Cell thicknesses

vary according to the thickness of the model stratigraphic layers in different locations. Model layer elevations are spatially variable and were informed by the numerous subsurface geologic borings located throughout the model domain. The upper surface of model layer 1 was updated as part of the current modeling effort to reflect topographic changes to the site that have occurred since 2001, as well as proposed topographic changes expected as part of the proposed Remedial Design for Parcel E2.

The slight northwestward expansion of the model grid by 500 linear feet onto non-Navy property required interpolation and/or extension of numerous model boundary conditions and properties including hydraulic conductivity values, recharge values, and constant head cells. With limited hydrogeologic information available in the expanded model domain area (i.e., non-Navy property), model layer elevations were held constant over the expanded area. Given that the expanded domain area is relatively limited in extent compared to the size of the model, this simplifying assumption is reasonable and should not affect model accuracy for its stated objectives (Section F1).

Constant Head boundary conditions border the northwestern and northeastern boundaries to represent the regional groundwater flow from upgradient areas. The hydraulic heads specified at these boundaries were adjusted for the expanded northwestern boundary condition during this modeling effort, as described above. The constant head boundary condition cells that had occupied the former northwestern boundary location were moved outward to the new boundary location, and their hydraulic head values extrapolated upwards during calibration until the simulated hydraulic heads at the former boundary location approximated the values previously specified by the original 2001 model's constant head cells. Constant head values along the upgradient, northeastern boundary were also adjusted upward from those in the original 2001 model in order to calibrate to the more current groundwater elevation data used for this modeling effort. The Bay shoreline constant head boundary condition was maintained at a value of 0 feet above mean sea level (msl) for the top layer (consistent with the original 2001 model), reflective of average tidal conditions. Bay shoreline constant head cells formerly included for layers two through five in the original 2001 model were removed from this current model to more accurately reflect the three-dimensional position of the Bay, and to improve numerical model stability. Similarly, layer 1 cells seaward of the shoreline constant head boundary were set to inactive in the current model to improve numerical stability.

Sources of inflow to the model domain include regional groundwater flow from the northwest and northeast and recharge due to precipitation. Sources of outflow from the model domain include regional groundwater flow to the south and southeast, with ultimate discharge to the Bay, and drainage to existing buried sanitary sewer lines. These features are represented by model boundary conditions, which act as areas for groundwater to enter and exit the model. It should be noted that many sewer lines at the site have been already been removed. However, current groundwater flow conditions indicate that the locations, or former locations, of the sewer lines continue to act as high conductivity pathways for groundwater flow; either because the sewer lines are still present or because the sewer trenches were

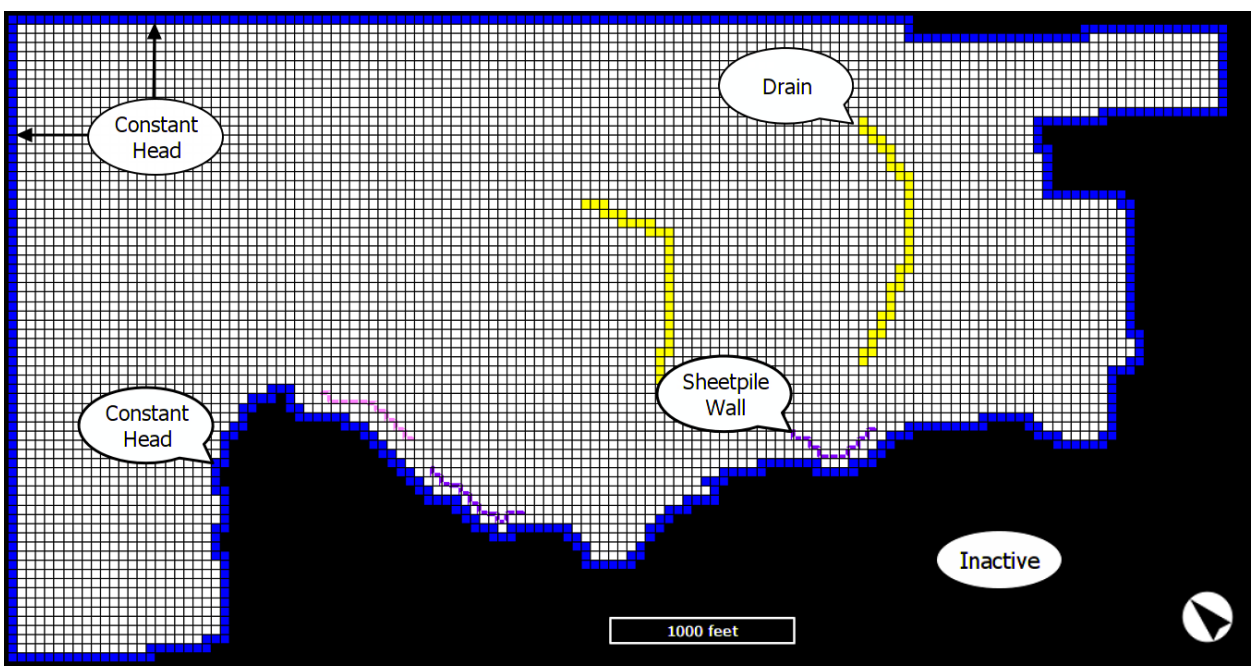
backfilled with coarse granular fill below the water table (e.g., drain rock). Further evaluation of this condition is being performed and will be further explained in future submissions of this report.

In the original 2001 model, drain cells were assigned, using the Drain Package in MODFLOW, to various elevations in the southeastern portion of the model to represent damaged subsurface sanitary sewer lines. The drain cells were retained in the revised model to represent damaged sanitary sewer lines or sanitary sewer trenches containing granular fill, given that current groundwater conditions continue to depict the effects of these features. As stated above, additional investigations are currently underway to confirm the source of the hydrologic effects observed in this area of the model.

The Drain Package is a head-dependent flux boundary package, where the flux out of the groundwater aquifer to the drain varies linearly with the difference between the head in the cell and the drain's reference head elevation. In addition to specifying the reference head, the user also specifies a conductance, which reflects the ability of groundwater to flow into the drain. Water can only leave the groundwater system through the drain cell and never re-enters the system. When the head in the cell drops below the drain reference head, the boundary condition is ineffective, and no drainage occurs.

The configuration of the boundary conditions is shown in Figure F-3.

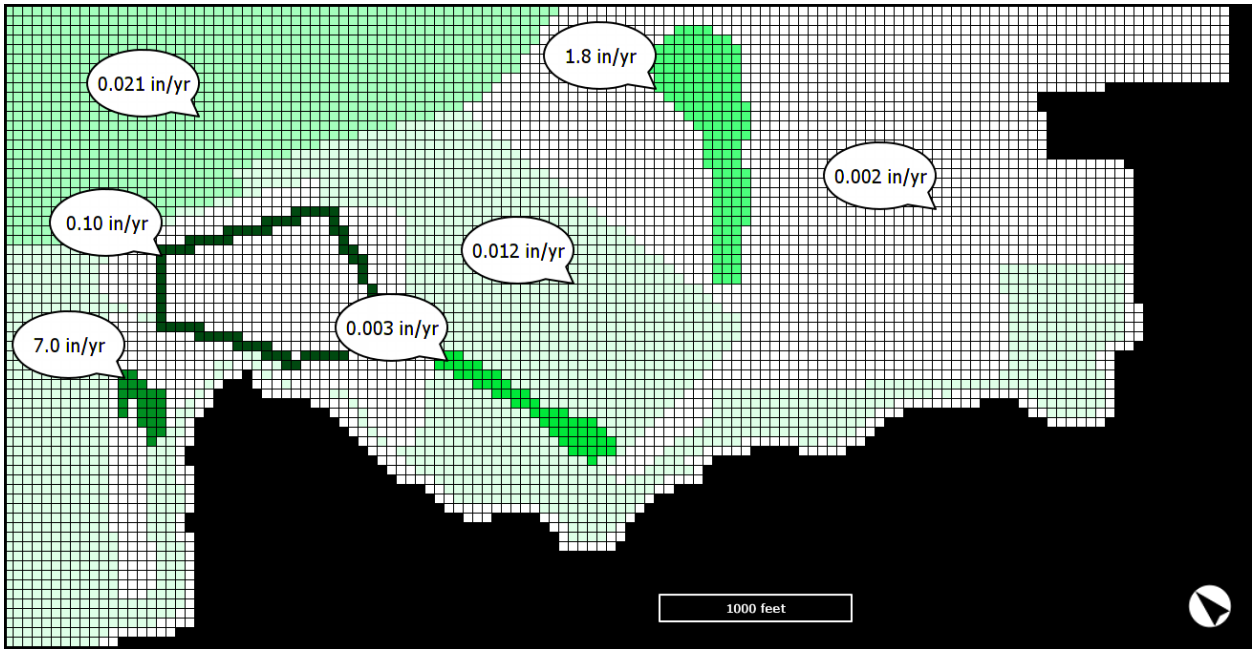
Figure F-3. Model Domain and Boundary Conditions



Recharge is applied to the top of the model at varying rates to represent recharge to the aquifer due to precipitation. Recharge rates in some areas were adjusted slightly from those in the original 2001 model in order to calibrate to the current groundwater elevation data used during this modeling effort. Lower

recharge rates of 0.002 inches per year were applied to the model in capped areas of the landfill and paved areas. Higher recharge rates of up to 1.8 inches per year were applied to unpaved and uncapped areas, representing up to approximately 10 percent of the average annual rainfall. A natural depression was simulated with a recharge rate of 7.0 inches per year to account for additional recharge of runoff from surrounding areas; with the amount determined during model calibration to match nearby observed groundwater elevations. Figure F-4 shows the distribution of recharge applied to the model.

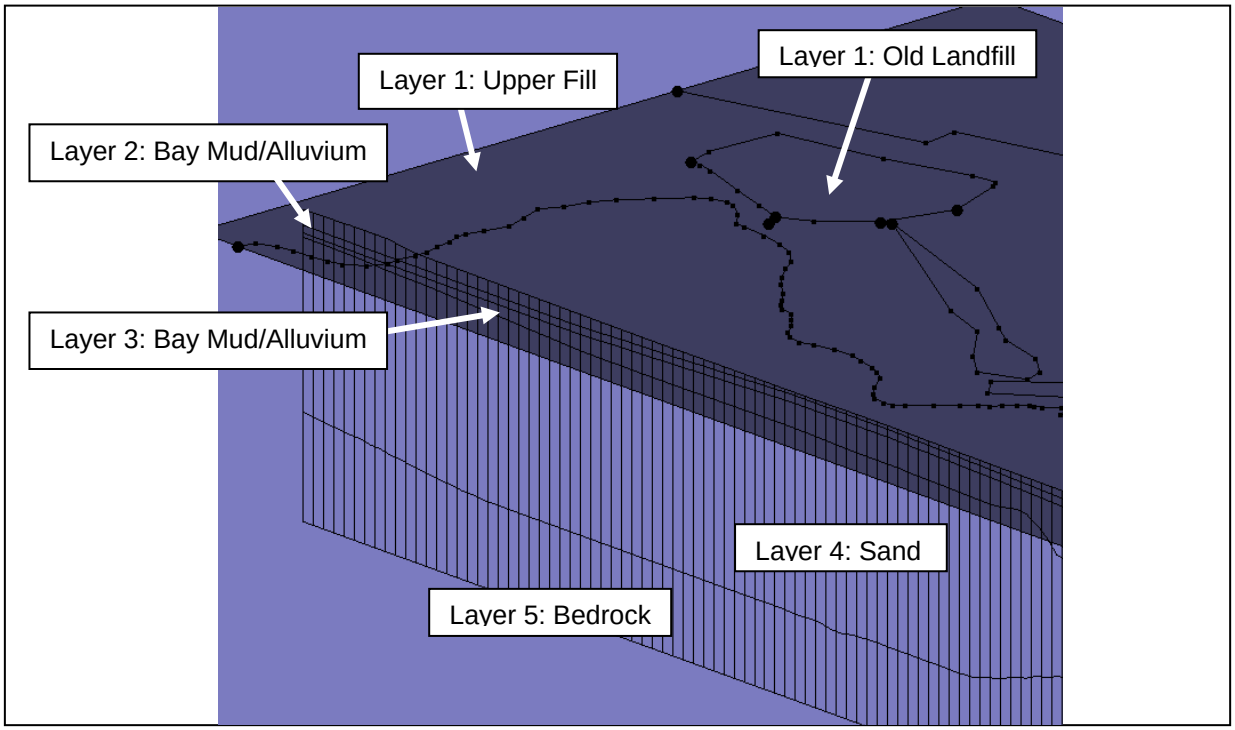
Figure F-4. Recharge Distribution



F2.2. MODEL LAYERS

Consistent with the original 2001 model, the current model structure consists of five vertical layers representing the four hydrostratigraphic units underlying the site: (1) artificial fill (the A-Aquifer), (2) Bay Mud/alluvium (the Bay Mud Aquitard), (3) sand (B-Aquifer), and (4) bedrock (the bedrock water-bearing zone). The Bay Mud/Alluvium is represented as two model layers to allow for a more gradual transition between layers of higher and lower hydraulic conductivity, thereby improving the numerical stability of the model. The ground surface in the model domain ranges from sea level to approximately 100 feet above msl. The base of the model is assigned to 350 feet below msl reflecting competent bedrock with little water bearing capacity. Figure F-5 shows the model layer configuration.

Figure F-5. Model Layer Configuration (Cross-Section View)



F2.3. HYDROGEOLOGIC PARAMETERS

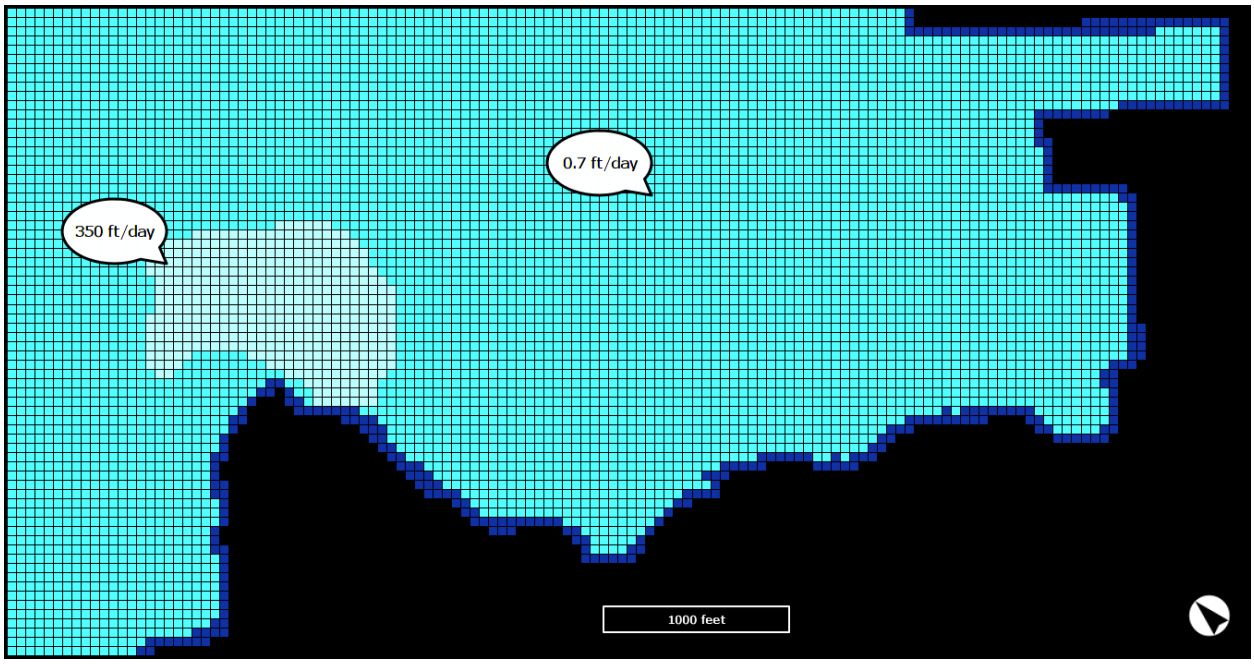
Horizontal hydraulic conductivity values (K_h) were assigned previously in the original 2001 model to the different aquifer materials represented in the model, and then refined during this current modeling effort during the model calibration process in order to calibrate the model to current groundwater elevation data. A vertical anisotropy (the ratio of vertical hydraulic conductivity [K_v] to K_h) of 10 percent was applied to all aquifer materials, as assigned in the original 2001 model. These values are summarized in Table F-1.

Table F-1. Calibrated Hydrogeologic Aquifer Parameters

Material	Model Layer	K_h (feet per day)	K_v/K_h
Fill	1	0.7	0.1
Old Landfill	1	350	0.1
Bay Mud	2-3	0.003	0.1
Alluvium	2-3	120	0.1
Sand	4	280	0.1
Bedrock	5	1.2	0.1

Two zones are present in Layer 1 to represent the old landfill area and artificial fill. The old landfill area has a K_h of 350 feet per day representative of poorly compacted debris with void spaces, and the remaining area representing low-permeability fill materials has a K_h of 0.7 feet per day. These zones are shown on Figure F-6.

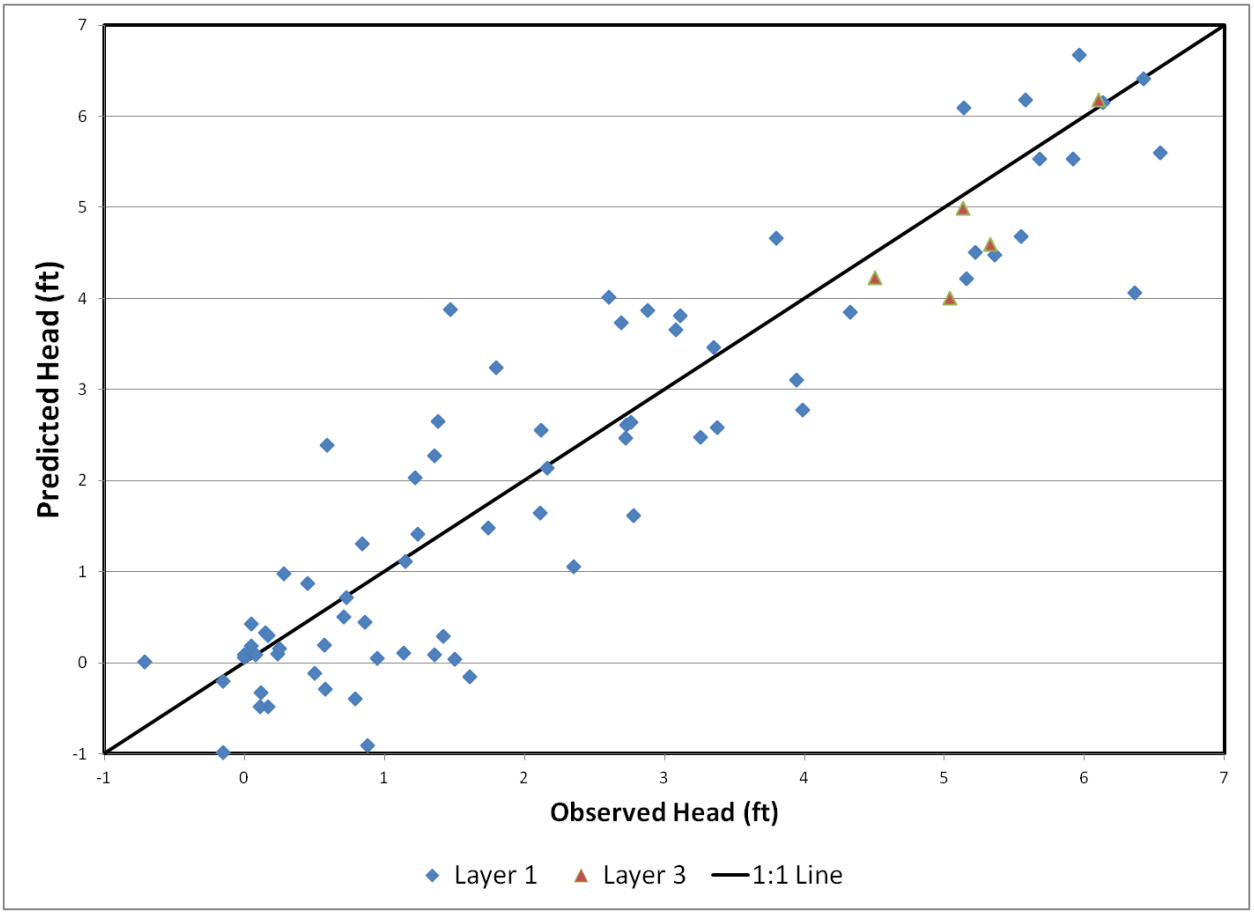
Figure F-6. Hydraulic Conductivity Zones in Layer 1



F2.4. MODEL CALIBRATION

The model was calibrated to match average groundwater elevations based on data collected in 2010 and 2011. These were the most recent consecutive eight quarters of groundwater elevation data available at the time of model calibration. The model was calibrated to the average groundwater elevation at each monitoring well across those eight quarters. Because the model is a steady state groundwater model simulating long-term average hydrologic conditions, calibrating to average water levels is a better approach than calibrating to specific time periods. The most recent eight quarters were selected to best reflect recent site alterations that may have potentially affected site hydrology. Figure F-7 illustrates modeled versus observed hydraulic heads for all calibration wells. Calibration results are well distributed around the 1:1 ratio line with no significant bias to either higher or lower heads. Calibration results are within acceptable tolerances for groundwater modeling, as described in Anderson and Woessner (1992). For example, it is generally considered that root mean squared (RMS) error should be within 10% of the total head variation across the model domain. The RMS error for the current calibrated model is 0.85 feet; less than 10% of the 9 feet of total head change across the model domain.

Figure F-7. Model Calibration Results



F2.5. PROPOSED CONDITIONS SIMULATION COMPONENTS

Following calibration of the existing conditions model, a variety of simulations were performed to evaluate the modeling objectives discussed in Section F1. The proposed remedy components included in the predictive modeling simulations include the previously mentioned upgradient slurry wall, nearshore slurry wall, French drain, and constructed wetland. Those remedy components are more fully discussed in the following subsections. The predictive simulation results are discussed in Section F3.

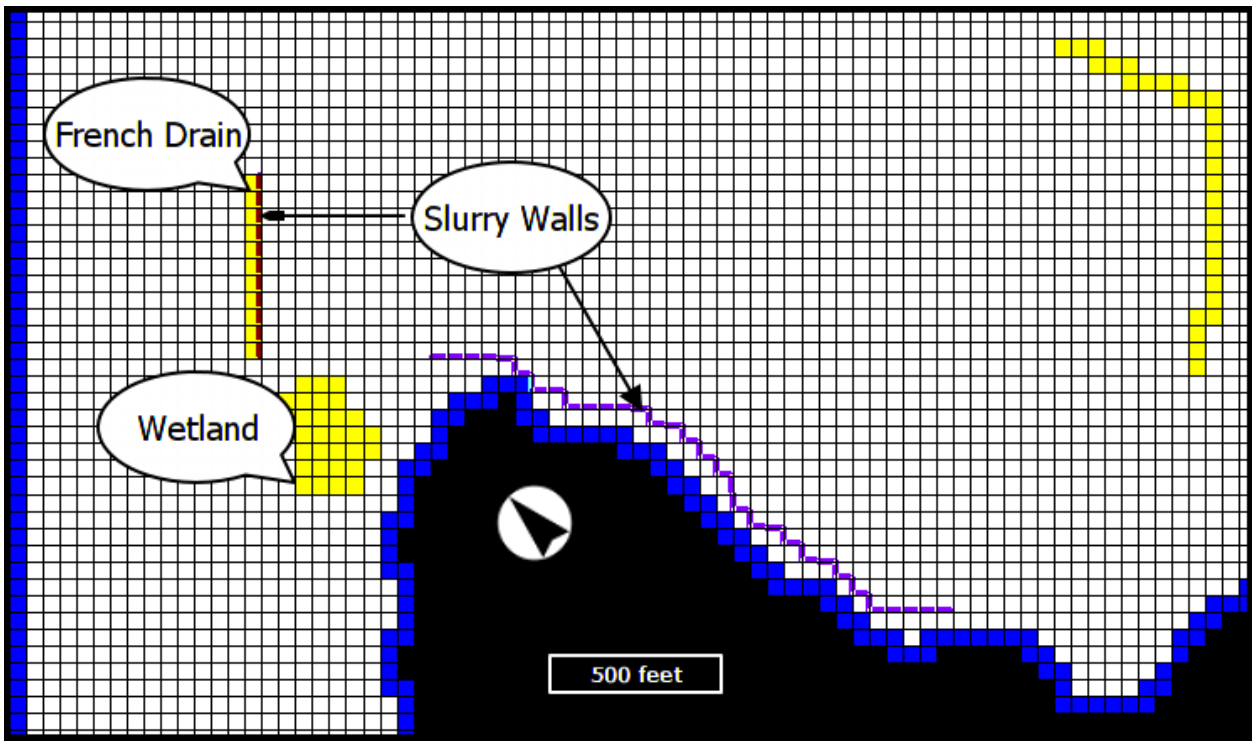
F2.5.1 Upgradient and Nearshore Slurry Walls

The upgradient and nearshore slurry walls are represented using the MODFLOW Horizontal Flow Barrier package (Hsieh and Freckleton, 1993), which simulates a thin, vertical low-permeability geologic feature that impedes the horizontal flow of groundwater. Consistent with the Design Basis Report, the slurry walls have been modeled with a conductance value of 10^{-5} feet per day. The key assumption underlying this package is that the width of the barrier is negligibly small compared to the width of the cells in the

grid. The barrier is assumed to have zero storage capacity. Its sole function is to lower the horizontal conductance between the two cells that it separates.

The locations of the slurry walls in the model domain are shown on Figure F-8. The slurry walls in the model extend through the first two model layers (i.e., the upper fill and the Bay Mud/Alluvium), corresponding to an approximate depth of 25 feet below ground surface. The nearshore slurry wall is keyed into the Bay Mud aquitard, while the upgradient shoreline slurry wall is not. This is because the aquitard is present in the shoreline area of the site, but absent in the northern area.

Figure F-8. Slurry Walls, Drain, and Wetland



F2.5.2. French Drain

The proposed remedial design includes a French drain upgradient of the upgradient slurry wall to divert groundwater to the proposed freshwater wetlands. The French drain diversion will provide a supplemental water source to the freshwater wetland, thereby prolonging the amount of time that the area would provide aquatic habitat during drier time periods. The French drain was represented in the model using Drain cells assigned with the MODLOW Drain Package. Water can only leave the groundwater system through a drain cell and can never reenter the system. When the head in the cell drops below the drain reference head, the boundary condition is rendered ineffective, and no drainage occurs. The French drain's Drain cells were assigned a reference head elevation that corresponds to the proposed drain elevation from the Design Basis Report (6 feet above msl). The drain elevation was assigned based upon

practical engineering factors related to the topography of the site in the vicinity of the upgradient slurry wall and the proposed freshwater wetland configuration. The drain represented in the model is 550 feet long. The proposed drain is shown on Figure F-8.

F2.5.3. Freshwater Wetland

In the proposed remedial design for Parcel E-2, the freshwater wetland area is proposed to occupy a total of approximately 2.38 acres (Figure F-8). The proposed constructed wetlands will be unlined to allow for hydraulic communication between the wetland and the subsurface beneath it. Unlined wetlands will allow for recharge to the aquifer from precipitation, diverted water from the French drain, and runoff directed from the capped landfill area.

In the model, the unlined wetland receiving recharge was assigned a recharge value equivalent to the direct precipitation recharge plus the outflow volume from the drain cells associated with the modeled French drain. The proposed wetland is also planned to receive surface runoff from a portion of the capped landfill. The quantity of estimated stormwater runoff to be directed to the wetland was not available at the time the modeling evaluation was performed for the 60 percent Remedial Design Package, thus it is not included in the current modeling results. Future submittals will incorporate the design runoff volume from the proposed landfill cap into the modeled wetland recharge, increasing the average flow to the wetland.

The wetland soil in the first layer of the model was assigned a K_H of 0.01 feet per day and a Kv of 0.001 feet per day. These values are representative of hydric soil, which tends to be comprised of poorly conductive soil that contains fine sediment and decaying organic material that can support hydrophytic vegetation. As wetlands become established, hydric soil density tends to increase as decomposition of organic materials progresses, resulting in material that is very poorly drained (Khadlec and Knight, 1996).

The freshwater wetland is proposed to be constructed with an overflow structure to divert large surges of water to a higher capacity conveyance structure. Therefore, the cells within the modeled wetland were assigned using Drain cells, and the reference elevations of the cells were assigned the proposed overflow elevation of the wetland (6 feet above msl). This elevation also corresponds to the drain elevation of the upgradient French drain, which contributes flow to the wetland; therefore, water in the wetland cannot buildup to an elevation higher than the incoming French drain invert.

Section F3. Predictive Simulation Results

Predictive simulations were performed to simulate the anticipated combined effects of the presence of the proposed slurry walls, French drain, unlined freshwater wetland, and wetland overflow structure. All predictive simulations also included an expanded landfill cap covering all of Parcel E2, with the exception of the area underlying the proposed freshwater wetland and shoreline revetment structure. Recharge to the newly capped area was reduced to 0.002 inches per year, and a narrow band of increased recharge (4.38 inches per year) was added around the perimeter of the cap to account for increased runoff draining from the cap. The primary questions to be answered by the hydrogeologic modeling were:

1. What hydraulic gradient will be created across the proposed upgradient slurry wall?
2. What will be the average flow conveyed by the French drain on the upgradient side of the proposed upgradient slurry wall?
3. What proportions of upgradient groundwater flow approaching the proposed upgradient slurry wall will go into the French drain, as opposed to under or around the wall?
4. What hydraulic gradient will be created across the proposed nearshore slurry wall?
5. What will be the travel time for groundwater to migrate around the proposed nearshore slurry wall and reach the Bay?
6. What will be the required pumping rate from a series of extraction wells (spaced 50 feet apart) installed behind the proposed nearshore slurry wall to create measurable drawdown behind the wall and inhibit the potential flow of contaminated groundwater towards the Bay? It should be noted that the need to operate extraction wells would only occur if the results of the future groundwater monitoring program, described in detail in the Remedial Action Monitoring Plan included in this Remedial Design Package, determines that contaminant migration to San Francisco Bay poses a potential risk to aquatic wildlife.

The results of the predictive simulations developed to respond to these questions are described below.

Simulation 1: Upgradient Slurry Wall and French Drain Hydraulic Gradient and Flow Estimation

A predictive model simulation was performed to estimate the anticipated flow to the French drain. ZONEBUDGET, a feature in MODFLOW that allows for calculating subregional water budgets, was used to estimate the average outflow around and under the slurry wall, and through the French drain with the upgradient slurry wall in place. Those ZONEBUDGET results were compared to the ZONEBUDGET results for the same areas in the existing conditions model to estimate the changes in

groundwater flow patterns resulting from the upgradient slurry wall and French drain. The key results from Simulation 1 are:

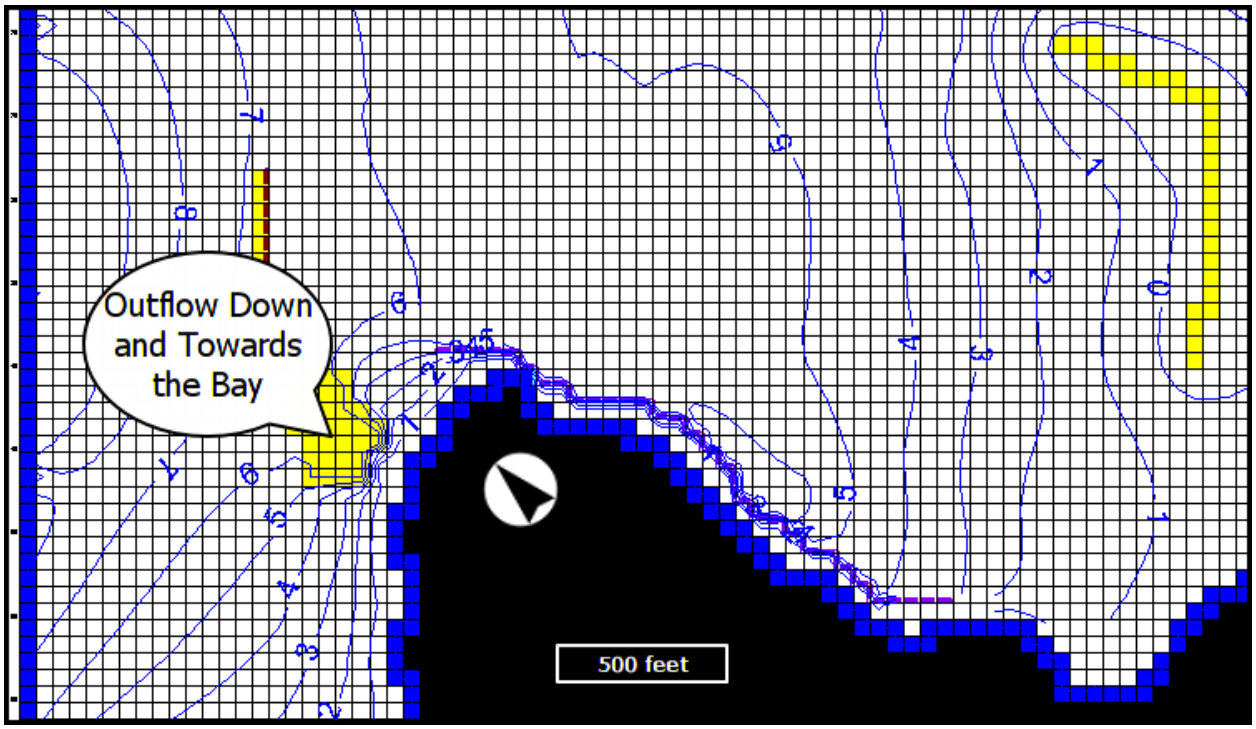
- The maximum hydraulic gradient created across the proposed upgradient slurry wall (head difference from one side of the wall to the other under proposed conditions) is estimated to be approximately 1 foot.
- The maximum groundwater mound built up behind the proposed upgradient slurry wall (proposed conditions head minus existing conditions head) is estimated to be approximately 0.2 feet.
- The calculated flow to the French drain was determined to be approximately 3.6 gallons per minute (gpm) for a French drain invert elevation set to 6 feet above msl.
- The preliminary ZONEBUDGET assessment of the area around the proposed upgradient slurry wall indicates that the wall is estimated to create an approximately 900 cubic feet per day (cfd) reduction in flow through the area downgradient of the wall. Most of that reduction (approximately 700 cfd) is diverted into the proposed French drain and the remainder goes under or around the wall.

Simulation 2: Slurry Walls, French Drain, and Unlined Wetlands

For Simulation 2, the model including the slurry walls and the French drain was used as the base model (i.e., Simulation 1). To simulate the unlined wetland receiving water from the French drain, the total anticipated flow from the French drain was divided over the modeled area of the wetlands (2.38 acres) and added to the modeled recharge rate for the soils in that area of the base model. A total constructed wetlands area recharge rate of 39.6 inches per year was used for this simulation, including both the existing recharge and French drain inputs. This rate allowed for simulation of the effect of higher hydraulic heads in the wetland cells, which influences the infiltration rate through the hydric wetland soil into the underlying shallow aquifer. Figure F-9 shows the model output for this simulation. The proposed wetland is also planned to receive surface runoff from a portion of the capped landfill. The quantity of estimated stormwater runoff to be directed to the wetland was not available at the time the modeling evaluation was performed for the 60 percent Remedial Design Package, thus it is not included in the current modeling results. Future submittals will incorporate the design runoff volume from the proposed landfill cap into the modeled wetland recharge, increasing the average flow to the wetland.

This simulation shows the influence of surface water infiltration from the freshwater wetlands to the underlying aquifer. The influx of groundwater diverted from behind the upgradient slurry wall via the French drain locally raises the groundwater elevation beneath the wetland. The head contours (in feet) depicted on Figure F-9 show that the influx of groundwater to the wetland would create a downward and outward flow gradient in the aquifer, thus limiting the possibility of potentially contaminated groundwater upwelling into the wetlands.

Figure F-9. Slurry Walls, French Drain, and Unlined Wetland

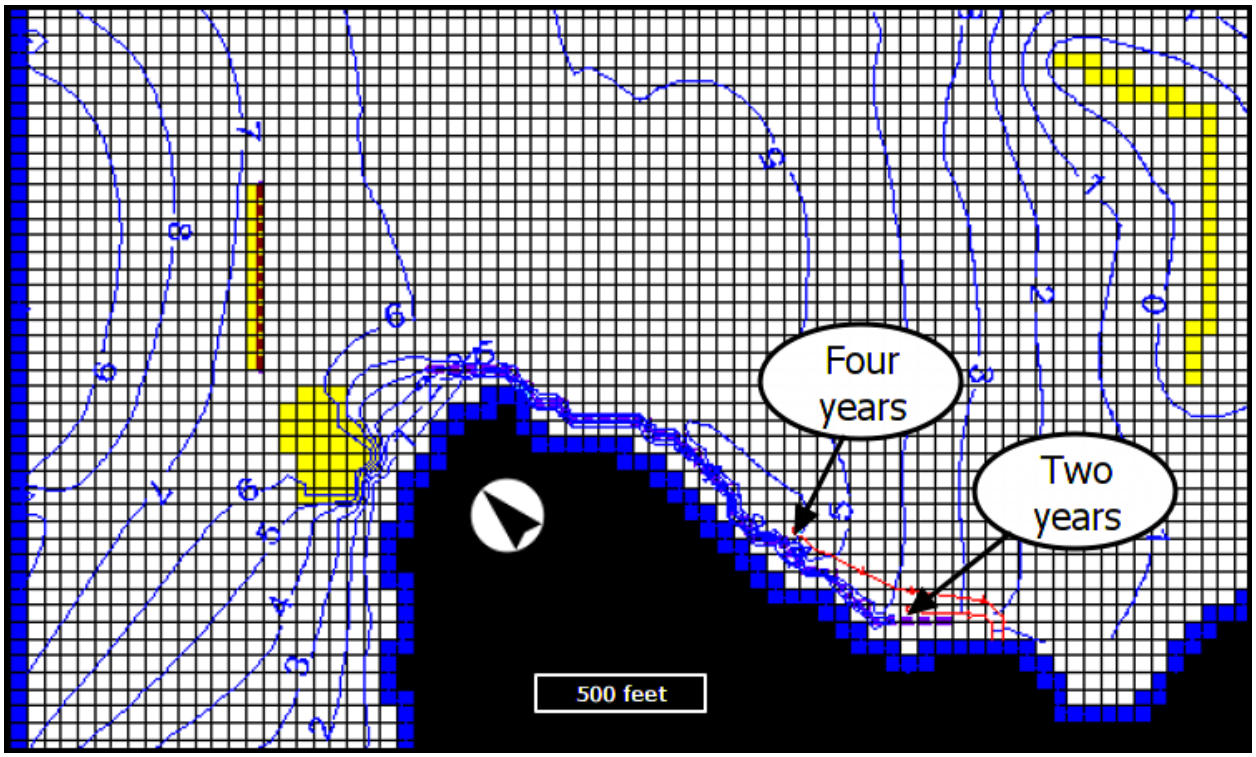


Simulation 3: Nearshore Slurry Wall

For Simulation 3, the model including the slurry walls, the French drain, and the unlined wetlands was used as the base model (i.e., Simulation 2). To evaluate the expected travel time around the proposed nearshore slurry wall, particle tracking was conducted within the hydrogeologic model using the ModPath module. Figure F-10 shows the model output for this simulation with particle traces and flow arrows each representing one year of travel time. The key results from Simulation 3 are:

- The estimated groundwater flow time around the shoreline slurry wall and to the Bay is approximately 4 years from an origination point located near the center of the nearshore slurry wall, and decreases to approximately 2 years near the eastern edge of the wall.
- The maximum hydraulic gradient built up across the proposed shoreline slurry wall (head difference from one side of the wall to the other under proposed conditions) is approximately 6 feet.
- The maximum groundwater mound built up behind the proposed shoreline slurry wall (proposed conditions head minus existing conditions head) is estimated to be approximately 3 feet.

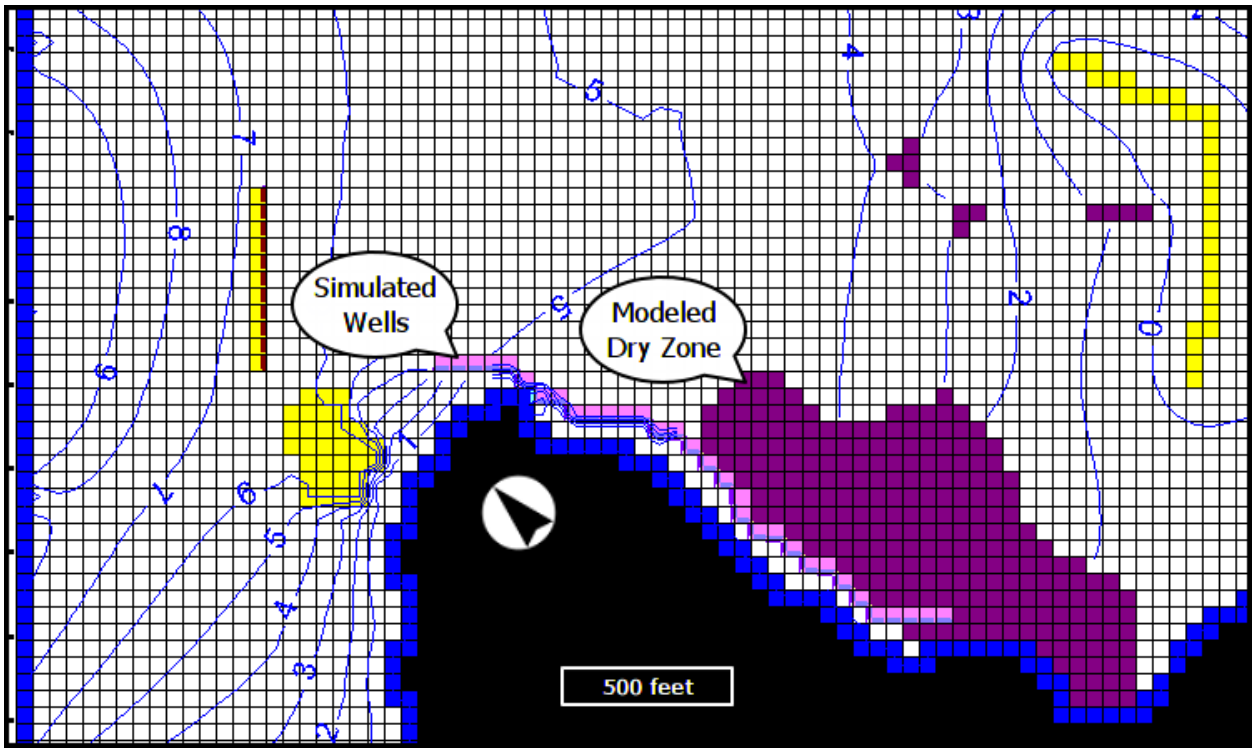
Figure F-10. Nearshore Slurry Wall



Simulation 4: Nearshore Slurry Wall and Extraction Wells

For Simulation 4, the Simulation 3 model was used as the base model and a series of 32 extraction wells, spaced 50 feet apart, were simulated behind the proposed nearshore slurry wall. The wells are all screened in layer 1 (the A-aquifer), above the Bay Mud aquitard and were simulated at a variety of pumping rates until an optimal simulation was reached where measurable drawdown was observed along the length of the slurry wall. Figure F-11 shows the model output for this simulation. Approximately 1 foot of drawdown is simulated to occur behind the wall at a total pumping rate of 42 gpm (1.3 gpm per well). However, pumping near the slurry wall at lower elevations causes the upper model layer to dry out in these areas (purple cells). This model scenario suggests pumping rates will need to be balanced to prevent extraction pumps from running dry, but that hydraulic containment can be achieved by pumping at relatively low flow rates from upgradient wells behind the nearshore slurry wall.

Figure F-11. Nearshore Slurry Wall and Extraction Wells



Section F4. Modeling Conclusions

A variety of general conclusions can be drawn from this modeling work. The following conclusions address the modeling objectives (Section F1):

The modeling demonstrates that the use of an upgradient slurry wall would reduce leachate generation, to some degree, by retarding water entering the landfill waste and allowing it to be diverted to a French drain. The basic modeling performed to assess the slurry wall and French drain technologies estimates that the diverted flow would be approximately 3.6 gpm, on average. This value is meant to represent a long-term average, rather than a typical value, because it would vary seasonally with the rise and fall of the water table.

The modeling suggests that the shoreline slurry wall produces approximately 3 feet of groundwater mounding behind it with 6 feet of hydraulic drop from behind the wall to the Bay. The model simulates that the presence of the slurry wall along the shoreline would act to discourage the migration of potentially contaminated groundwater in the direction of San Francisco Bay by lengthening the groundwater travel time to up to approximately 4 years. In addition, the model also suggests that, if necessary, a line of extraction wells spaced approximately every 50 feet along the upgradient edge of the shoreline slurry wall would create measurable drawdown to hydraulically contain potentially contaminated groundwater and minimize the potential for migration of that groundwater to the Bay. Groundwater extraction would only be required if the results of the future groundwater monitoring program, described in detail in the Remedial Action Monitoring Plan included in this Remedial Design Package, determines that contaminant migration to San Francisco Bay poses a potential risk to aquatic wildlife.

Section F5. Model Limitations

The work presented in this document provides an estimate of the relative hydrologic effects of the proposed slurry walls and French drain. The results of the groundwater simulations represent the best information available at this time. Although model simulation results are approximate by nature, they provide adequate information to support the development of the designs for the remedy components described in this report. The designs of every remedy component using these data as a basis for design should incorporate a factor of safety to account for model uncertainty.

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Draft

Remedial Action Monitoring Plan for Parcel E-2

Hunters Point Naval Shipyard
San Francisco, California

June 2013

Prepared for:
Department of the Navy
Base Realignment and Closure
Program Management Office West
San Diego, California

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Prepared under:
Naval Facilities Engineering Command Southwest
Contract Number N68711-05-C-6011
DCN: ERRG-6011-0000-0034

Draft
Remedial Action Monitoring Plan for
Parcel E-2
Hunters Point Naval Shipyard
San Francisco, California

Submitted by:
Engineering/Remediation Resources Group, Inc.

Signature	June 25, 2013 Date
Doug Bielskis, PE Name	Project Manager / Engineer of Record Title

Table of Contents

SECTION 1. INTRODUCTION 1-1
1.1. Document Organization 1-2
1.2. Background Information 1-2
1.2.1. Site Description 1-2
1.2.2. History 1-3
1.2.3. Geology and Surface Soil 1-4
1.2.4. Hydrogeology 1-4
1.2.5. Nature and Extent of Contamination 1-5
1.3. Purpose and Objectives 1-7
1.3.1. Groundwater RAOs 1-8
1.3.2. LFG RAOs 1-9
1.3.3. Surface Water RAOs 1-10

SECTION 2. GROUNDWATER MONITORING 2-1
2.1. Technical Basis of Groundwater Monitoring 2-1
2.1.1. Evaluation of Potential Impact to Aquatic Wildlife 2-1
2.1.2. Wells Proposed for Future Monitoring 2-3
2.2. Groundwater Monitoring Activities 2-4
2.2.1. Groundwater Elevation Monitoring 2-4
2.2.2. Groundwater Sampling and Analysis 2-5

SECTION 3. LANDFILL GAS MONITORING 3-1
3.1. Technical Basis of Landfill Gas Monitoring 3-1
3.1.1. Technical Basis of Perimeter LFG Monitoring 3-1
3.1.2. Technical Basis of GCCS Performance Monitoring 3-2
3.2. Landfill Gas Monitoring Activities 3-6
3.2.1. LFG Compliance Monitoring 3-6
3.2.2. GCCS Performance Monitoring 3-7

SECTION 4. WETLAND MONITORING 4-1
4.1. Technical Basis of Wetlands Monitoring 4-1
4.2. Wetland Monitoring Activities 4-1
4.2.1. Baseline Survey 4-2
4.2.2. Semiannual Surveys 4-2
4.2.3. Surface Water Sampling in Freshwater Wetlands 4-3

Table of Contents *(continued)*

SECTION 5. STORMWATER MONITORING 5-1
5.1. Technical Basis of Stormwater Monitoring 5-1
5.2. Stormwater Monitoring Activities 5-1
5.2.1. Stormwater Sampling and Analysis 5-1
5.2.2. Non-Stormwater Discharge Visual Observations 5-3
5.2.3. Stormwater Discharge Visual Observations 5-3
SECTION 6. REPORTING 6-1
6.1. Groundwater 6-1
6.1.1. Semiannual Reports 6-1
6.1.2. Annual Reports 6-1
6.2. Wetlands Monitoring 6-2
6.3. Landfill Gas 6-2
6.3.1. Semiannual Operation, Monitoring, and Maintenance Reports 6-2
6.3.2. Annual Compliance Reports 6-3
6.3.3. Miscellaneous LFG Reporting Requirements 6-3
6.4. Stormwater 6-4
SECTION 7. CHANGES TO THIS REMEDIAL ACTION MONITORING PLAN 7-1
SECTION 8. REFERENCES 8-1

List of Figures

Figure 1. Site Vicinity Map
Figure 2. Parcel E-2 Areas
Figure 3. Groundwater Monitoring Wells
Figure 4. Groundwater Monitoring Approach for Impacts to San Francisco Bay
Figure 5. Landfill Gas Monitoring and Control System
Figure 6. Stormwater Monitoring Locations

List of Tables

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a]
Table 2. Remediation Goals for Groundwater
Table 3. Surface Water Screening Criteria
Table 4. Hunters Point Groundwater Ambient Levels[1]
Table 5. Groundwater Evaluation Results and Proposed Monitoring Locations
Table 6. Analysis and Evaluation Criteria by Well
Table 7. Monitoring Wells for Groundwater Elevations
Table 8. Preliminary Acceptable Operating Ranges for LFG Extraction Wells and Vents
Table 9. Routine LFG Monitoring Locations and Frequencies
Table 10. Methane Concentrations at Landfill Gas Monitoring Locations
Table 11. Wetland Performance Standards

List of Appendices

Appendix A. Soil Gas Action Levels
Appendix B. Groundwater Monitoring Well Information

Acronyms and Abbreviations

ARARs	applicable or relevant and appropriate requirements
BAAQMD	Bay Area Air Quality Management District
BRAC	Base Realignment and Closure
Cal. Code Regs.	California Code of Regulations
CalRecycle	California Department of Resources Recycling and Recovery
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	chemicals of concern
COPECs	chemicals of potential ecological concern
^{137}Cs	Cesium-137
DBR	Design Basis Report
DTSC	Department of Toxic Substances and Control
EPA	Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group, Inc.
FFA	Federal Facility Agreement
GAC	granular activated carbon
GMPs	gas monitoring probes
GCCS	gas collection and control system
HGAL	Hunters Point groundwater ambient level
HPNS	Hunters Point Naval Shipyard
HRA	Historical Radiological Assessment
ITSI	Innovative Technical Solutions, Inc.
LEA	Local Enforcement Agency
LFG	landfill gas
LUC RD	Land Use Control Remedial Design
MMBtu	million British thermal units
MRPP	monitoring and reporting program plan
msl	mean sea level
MSW	municipal solid waste

Acronyms and Abbreviations *(continued)*

Navy	Department of the Navy
NMOCs	nonmethane organic compounds
OM&M	Operations, Monitoring, and Maintenance
OMP	Operation and Maintenance Plan
PCBs	polychlorinated biphenyls
POC	point of compliance
ppmv	parts per million by volume
^{226}Ra	Radium-226
RAMP	Remedial Action Monitoring Plan
RAOs	remedial action objectives
RI/FS	Remedial Investigation/Feasibility Study
RD	Remedial Design
ROD	Record of Decision
RSRS	Radiological Survey and Remedial Services, LLC
^{90}Sr	Strontium-90
scfm	standard cubic feet per minute
SFPUC	San Francisco Public Utilities Commission
SGALs	soil gas action levels
Shaw	Shaw Environmental, Inc.
Successor Agency	Successor Agency to the San Francisco Redevelopment Agency
SVOCs	semivolatile organic compounds
TCRA	time-critical removal action
THC	total hydrocarbon
TIZ	tidal influence zone
TMZ	tidal mixing zone
TPH	total petroleum hydrocarbons
TtEMI	Tetra Tech EM Inc.
UCSF	University of California, San Francisco
VOCs	volatile organic compounds
Water Board	San Francisco Bay Regional Water Quality Control Board
§	Section

Section 1. Introduction

This Remedial Action Monitoring Plan (RAMP) presents the approach for monitoring groundwater, landfill gas (LFG), constructed wetlands, and stormwater for the contiguous area consisting of the closed industrial landfill (hereafter referred to as the "Parcel E-2 Landfill") and the surrounding adjacent areas that contain isolated or noncontiguous pockets of buried solid waste at Parcel E-2, Hunters Point Naval Shipyard (HPNS) in San Francisco, California.

The final remedy for Parcel E-2 includes hot spot excavation, a soil cover and protective liner, constructed tidal and freshwater wetlands, shoreline revetment, and LFG and groundwater control features, as documented in the Final Record of Decision (ROD) for Parcel E-2 (Department of the Navy [Navy], 2012). The Final ROD requires long-term monitoring to ensure the objectives of the remedy have been met and comply with the substantive provisions of pertinent applicable or relevant and appropriate requirements (ARARs). Components of this RAMP include groundwater monitoring, LFG monitoring, wetlands monitoring, and stormwater monitoring.

The RAMP is one component of the overall Remedial Design (RD) for Parcel E-2, which is a primary document under the Federal Facility Agreement (FFA) for HPNS. Monitoring of groundwater, LFG, wetlands, and stormwater of the final remedy at Parcel E-2 are the responsibility of the owner. The Navy is the current owner; however, the Navy plans to transfer Parcel E-2 to the Successor Agency to the San Francisco Redevelopment Agency (Successor Agency) in the future. This RAMP discusses the monitoring required of the Navy. The Navy will conduct monitoring described in this plan until ownership of the sites and the monitoring obligations are transferred. Thereafter, monitoring of groundwater, LFG, wetlands, and stormwater will be the responsibility of the Successor Agency.

This RAMP will be submitted for the review and approval of the FFA signatories, which include the Navy, the U.S. Environmental Protection Agency (EPA), and the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) and San Francisco Bay Regional Water Quality Control Board (Water Board). The RAMP and other documents associated with site operations, maintenance, and monitoring, will be maintained in the HPNS information repositories located at the City of San Francisco Public Library at 100 Larkin Street and at the HPNS office trailer at 690 Hudson Street.

The Final ROD also requires inspection, maintenance, and repair of the final remedy to ensure the integrity of the remedy components and to comply with the substantive provisions of pertinent ARARs. The inspection, maintenance, and repair requirements for Parcel E-2 are described in a separate document, the Operation and Maintenance Plan (OMP), which is also a component of the RD. In

addition, the ROD requires implementation of institutional controls to limit the exposure of future landowner(s) or user(s) of the property to hazardous substances present on the property and in groundwater, and to ensure the integrity of the remedy. The implementation requirements for institutional controls at Parcel E-2 are described in a separate document, the Land Use Control Remedial Design (LUC RD), which is also a component of the RD.

1.1. DOCUMENT ORGANIZATION

The remainder of Section 1 describes the project background, and the purpose and objectives of the RAMP. Sections 2, 3, 4, and 5 describe the proposed monitoring of groundwater, LFG, constructed wetlands, and stormwater monitoring, respectively. Section 6 outlines reporting requirements, and Section 7 specifies procedures for future changes made to this document. Section 8 lists the documents and guidance used to prepare this RAMP.

Figures and tables are provided after Section 8. Additionally, the following supplemental information is appended to this document:

- Appendix A. Soil Gas Action Levels
- Appendix B. Groundwater Monitoring Well Information

1.2. BACKGROUND INFORMATION

The following subsections briefly describe HPNS and Parcel E-2, including the location, history, geology and surface soil, hydrogeology, and nature and extent of contamination.

1.2.1. Site Description

HPNS is located in southeastern San Francisco on a peninsula that extends east into San Francisco Bay (see Figure 1). HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay (see Figure 1). Parcel E-2 includes about 47 acres of shoreline and lowland coast along the southwestern portion of the shipyard (see Figure 2), and consists of four distinct study areas that were designated to organize the information presented in the Remedial Investigation/Feasibility Study (RI/FS) Report (Navy, 2012):

- The Parcel E-2 Landfill, located in the north-central part of Parcel E-2
- The Panhandle Area, located west and southwest of the Parcel E-2 Landfill
- The East Adjacent Area, located to the east of the Parcel E-2 Landfill
- The Shoreline Area, located at the edge of San Francisco Bay

A small portion of the Parcel E-2 Landfill extends north onto property owned by the University of California, San Francisco (UCSF) (see Figure 2).

1.2.2. History

In 1940, the Navy obtained ownership of HPNS for shipbuilding, repair, and maintenance activities. After World War II, activities at HPNS shifted to submarine maintenance and repair. HPNS was also the site of the Naval Radiological Defense Laboratory. A history of Navy radiological operations at HPNS is provided in Volume II of the Historical Radiological Assessment (HRA) (Naval Sea Systems Command, 2004), and radiological operations at Parcel E-2 are summarized in the ROD (Navy, 2012).

HPNS was deactivated in 1974 and remained relatively unused until 1976. Between 1976 and 1986, the Navy leased most of HPNS to Triple A Machine Shop, Inc., a private ship repair company. In 1987, the Navy resumed occupancy of HPNS. Because past shipyard operations left hazardous substances on site, HPNS property was placed on the National Priorities List in 1989 pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPNS involve conducting environmental remediation and making the property available for nondefense use (Navy, 2012).

Parcel E-2 was created by filling in the bay margin with various materials, including native soil, rock, and sediment, as well as construction and industrial debris. The ground surface elevation at Parcel E-2 varies from approximately 30 feet above mean sea level (msl) in the northern portion of the parcel to a few feet above msl along the southwestern portion of the parcel (Navy, 2012).

The Parcel E-2 Landfill is a 22-acre area where the Navy disposed of various shipyard wastes from the mid-1950s to the early-1970s. These wastes include:

- Construction debris (including wood, steel, concrete, and soil)
- Municipal-type trash (including paper, plastic, and metal)
- Industrial waste [including sandblast waste, paint sludge, solvents, and polychlorinated biphenyl (PCB)-containing waste oils]

The Navy's investigations showed that the landfill waste consists of mostly construction debris and trash, with smaller amounts of industrial waste. After the 22-acre landfill closed in the early 1970s, the Navy covered it with 2 to 5 feet of soil at that time. The Navy has since performed several removal actions at Parcel E-2 to minimize potential exposure to hazardous chemicals. These actions included construction of an additional interim landfill cap over 14.5 acres of the landfill that was burned during an August 2000 brush fire at the Parcel E-2 Landfill. The interim landfill cap was constructed to inhibit oxygen migration into the waste to prevent more fires from occurring under the capped area. The total volume of existing soil cover over the 22-acre landfill at the date of signature of the ROD was estimated to be 393,500 cubic yards, and the volume of landfill waste was estimated to be 473,000 cubic yards (Navy, 2012).

Fill materials in the East Adjacent, Panhandle, and Shoreline Areas of Parcel E-2 are distinct from the Parcel E-2 Landfill. Specifically, fill materials in the East Adjacent, Panhandle, and Shoreline Areas consist primarily of soil, sediment, and rock with isolated solid waste locations that are not contiguous with solid waste in the Parcel E-2 Landfill. The characteristics of the East Adjacent, Panhandle, and Shoreline Areas are described below (Navy, 2012).

- The East Adjacent Area was created by filling in San Francisco Bay prior to the 1950s with soil and construction debris. Some industrial waste was disposed of in parts of the East Adjacent Area, including an area referred to as the "PCB Hot Spot Area." The PCB Hot Spot Area was partially addressed under an early removal action.
- The Panhandle Area was created by filling in San Francisco Bay in the 1950s with soil and construction debris. The Navy disposed of metal slag in a part of the Panhandle Area referred to as the "Metal Slag Area." Also, the Navy tested ship-shielding technologies in another part of the Panhandle Area referred to as the "Ship-Shielding Area." The Metal Slag Area and the Ship-Shielding Area were partially addressed under early removal actions.
- The Shoreline Area is adjacent to San Francisco Bay and contains contaminated sediment above msl that will be addressed by the selected remedy for Parcel E-2.

1.2.3. Geology and Surface Soil

The peninsula forming HPNS is within a northwest-trending belt of the Franciscan Complex bedrock known as the Hunters Point Shear zone. The natural geology at HPNS consists of unconsolidated Holocene sediment of estuarine and alluvial origin (Quaternary age) deposited on an uneven, eroded bedrock surface composed primarily of serpentinite (Jurassic-Cretaceous age). Artificial fill was deposited extensively over the natural sediment and bedrock during expansion of the shipyard in the early 1940s. Six individual geologic units have been identified at HPNS. Representative geologic cross sections from the RI/FS Report (Engineering/Remediation Resources Group, Inc. [ERRG] and Shaw Environmental, Inc. [Shaw], 2011) are provided for information purposes in the Design Basis Report (DBR). In general, the stratigraphic sequence of these geologic units, from youngest (shallowest) to oldest (deepest), is as follows: (1) Artificial Fill; (2) Slope Debris and Ravine Fill; (3) Undifferentiated Upper Sand Deposits; (4) Bay Mud; (5) Undifferentiated Sedimentary Deposits; and (6) Franciscan Complex Bedrock (Navy, 2012).

1.2.4. Hydrogeology

The hydrostratigraphy of Parcel E-2 consists of four distinct units: the shallow A-aquifer, several aquitard zones, the deeper B-aquifer, and underlying bedrock water-bearing zone. An aquitard zone separates the A- and B-aquifer across most of Parcel E-2, except in the northwest corner. The presence of additional aquitard zones within the B-aquifer sediment isolate the uppermost portions of the B-aquifer (that are interconnected with the A-aquifer) from the lower portions of the B-aquifer. Groundwater is not currently used for any purpose at Parcel E-2. Groundwater in the A-aquifer is not suitable as a potential

source of drinking water. Based on an evaluation of site-specific conditions relative to pertinent regulatory criteria, groundwater in the B-aquifer has a moderate potential to be used as a future source of drinking water (Navy, 2012).

Groundwater flow patterns at Parcel E-2 are complex because they are potentially affected by (1) a groundwater sink located in adjacent Parcel E, (2) leaks of groundwater into former sanitary sewers or storm drains, (3) recharge from water supply lines, and (4) tides in San Francisco Bay. Most groundwater at Parcel E-2 flows toward San Francisco Bay. In the northeastern portion of Parcel E-2, however, groundwater has historically flowed toward the groundwater sink in Parcel E, where groundwater elevations are below msl. The sink was likely caused by leaks of groundwater into sanitary sewer lines, which were then pumped to the offsite publicly owned treatment works, thereby lowering groundwater levels in the area. Flow patterns continue to change now that pumping has been discontinued and as sewer and storm drain lines are removed throughout Parcel E and other HPNS parcels (Navy, 2012). Sewer and storm drain lines remain in the northern and eastern portions of Parcel E-2, as discussed in Section 5.

1.2.5. Nature and Extent of Contamination

Potential contamination at Parcel E-2 is mostly attributed to waste disposal activities by the Navy or other tenants except for several metals (such as arsenic, manganese, and nickel), which were found at concentrations consistent with ambient levels in the local serpentinite bedrock. Contaminated media at Parcel E-2 consist of shoreline sediment, soil, soil gas (emanating from the landfill), groundwater, and radiologically impacted sites. The RI/FS Report provides specific details on the nature and extent of contamination (ERRG and Shaw, 2011).

1.2.5.1. Shoreline Sediment

Shoreline sediment was found to contain concentrations of copper, lead, and PCBs that are a potential source of contamination to Parcel F. In addition, benthic invertebrates, birds, and mammals are at risk from exposure to PCBs in surface sediment along the Parcel E-2 shoreline. Containment measures are warranted along the Parcel E-2 shoreline to control potential releases of copper, lead, and PCBs to Parcel F and to mitigate potential risk to benthic invertebrates, birds, and mammals that may inhabit the shoreline.

1.2.5.2. Soil

Metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), PCBs, pesticides, and petroleum hydrocarbons were detected at concentrations exceeding evaluation criteria in soil samples collected at the Parcel E-2 Landfill. Nearly all of the chemicals detected in Parcel E-2 Landfill soil at concentrations exceeding the evaluation criteria were of a limited extent relative to the overall waste volume. These results indicate that lesser quantities of potentially hazardous industrial wastes are present in the landfill as compared with municipal-type waste and construction debris.

Metals, SVOCs, VOCs, pesticides, PCBs, dioxins and furans, and petroleum hydrocarbons were detected at concentrations exceeding the evaluation criteria in soil samples collected in the East Adjacent and Panhandle Areas. The noncontiguous and heterogeneous nature of the fill material within the East Adjacent and Panhandle Areas results in a high degree of uncertainty that this fill and the chemicals in soil can be delineated into discrete zones for remediation activities.

1.2.5.3. Soil Gas

Elevated methane concentrations were present north of the Parcel E-2 Landfill (including property owned by UCSF). The Navy conducted a time-critical removal action (TCRA) that was successful in (1) removing landfill gas and reducing subsurface methane concentrations at the UCSF compound and (2) controlling future migration of LFG to offsite areas. Data collected as part of the LFG characterization study, the TCRA, and ongoing LFG monitoring have adequately defined the nature and extent of LFG at Parcel E-2.

Additional studies are planned, in conjunction with the RD, to more thoroughly evaluate soil gas concentrations in Parcel E-2. Specifically, the Navy will perform a survey to better estimate the gas generation rates from the Parcel E-2 Landfill and to determine the content of the LFG. The LFG survey will also more thoroughly evaluate soil gas concentrations in the Panhandle, East Adjacent, and Shoreline Areas to determine if gas collection and control (such as passive subsurface venting) is required. The Navy prepared a draft work plan for the LFG survey (ITSI Gilbane Company, 2013), and fieldwork is planned for summer 2013. The results of the LFG survey will support the design of the LFG controls and will be provided in the Draft Final RD, which will describe the extraction and treatment of LFG.

1.2.5.4. Groundwater

Groundwater contamination has been confirmed in both the A-aquifer and uppermost B-aquifer. Groundwater contaminants include metals, SVOCs, VOCs, pesticides, PCBs, petroleum hydrocarbons, and anions (such as ammonia and cyanide). Groundwater sampling results indicated that the concentrations and extent of contamination in the uppermost B-aquifer are less than observed in the A-aquifer because an aquitard is present between the A- and B-aquifers beneath most of Parcel E-2. Primary potential transport pathways for contaminated groundwater include migration and discharge of A-aquifer groundwater into San Francisco Bay and wetlands and migration of A-aquifer groundwater (including the saturated waste layer) into the uppermost B-aquifer.

As described in Section 1, the final remedy for Parcel E-2 includes groundwater control features. The groundwater control features are designed to control potential discharge of contaminated groundwater (containing nonradioactive chemicals) into San Francisco Bay, and consist primarily of two slurry walls (Figure 3): (1) an upland slurry wall along the western boundary of the landfill in the northern Panhandle Area, and (2) a nearshore slurry wall near the shoreline adjacent to the Parcel E-2 Landfill and East Adjacent Area. Groundwater monitoring will be performed to demonstrate the effectiveness of the

groundwater control features, in accordance with the corrective action monitoring requirements at Title 22 California Code of Regulations (Cal. Code Regs.) Section (§) 66264.100. The purpose and objectives of the groundwater monitoring program are described further in Section 1.3.1.

1.2.5.5. Radiologically Impacted Sites

The extent of radioactive contamination in shoreline sediment and subsurface soil has not been completely defined; however, the selected remedy conservatively assumes, consistent with the findings of the HRA (Naval Sea Systems Command, 2004) and radiological addendum to the RI/FS Report (ERRG and Radiological Survey and Remedial Services, LLC [RSRS], 2011), that potential radionuclides[1] [specifically, Cesium-137 (^{137}Cs), Radium-226 (^{226}Ra), and Strontium-90 (^{90}Sr)] may be present in shoreline sediment and subsurface soil at Parcel E-2. As a result, the selected remedy addresses the potential radionuclides in shoreline sediment and subsurface soil at Parcel E-2

The ROD identified three radionuclides as potential COCs for groundwater at Parcel E-2: ^{137}Cs, ^{226}Ra, and ^{90}Sr. In 2002 and 2008, groundwater samples were collected from 78 A-aquifer wells and one B-aquifer well. The resulting groundwater data were evaluated by simple (non-statistical) threshold comparisons with a fixed standard (such as drinking water standards) and by statistical tests comparing the site data with fixed standards (one-sample statistical tests). Through these comparisons, the radiological addendum concluded that groundwater does not appear to have been impacted by radionuclides at activity levels that warrant remedial action (ERRG and RSRS, 2011). Radionuclide data from the A-aquifer were compared with groundwater standards as a conservative measure because of a lack of alternative comparison criteria. Additionally, groundwater in the A-aquifer is not a potential source of drinking water, so the evaluation is not representative of potential site exposures to future users. However, because the final remedy involves containment of potential radiological contamination, , future monitoring will include analysis for radionuclides in groundwater to demonstrate, consistent with the findings of previous radiological investigations, that radionuclides are not present in groundwater at activity levels that are both statistically significant and pose an unacceptable risk to human health and the environment (see Section 1.3.1 for further information). .

1.3. PURPOSE AND OBJECTIVES

This RAMP serves two purposes. The first purpose is to monitor groundwater, LFG, and stormwater at Parcel E-2, and the second purpose is to evaluate groundwater data collected since 2007 from selected wells against trigger levels established for the protection of the beneficial uses of San Francisco Bay, including aquatic wildlife. Results of the updated trigger-level analysis may be used to add monitoring wells and chemicals to the RAMP.

[1] As described in Section 2.6 of the Design Basis Report, the Navy completed a removal action in the Ship-Shielding Area to address potential Cobalt-60 contamination. The removal action did not identify Cobalt-60 concentrations exceeding the remediation goal (0.252 pCi/g). Accordingly, Cobalt-60 is not considered for future monitoring in this RAMP.

The following subsections describe the remedial action objectives (RAOs), as described in the ROD (Navy, 2012), for groundwater, LFG, and stormwater at Parcel E-2 that are used as a basis for developing the monitoring program in this RAMP. In addition, the monitoring program will comply with the substantive provisions of pertinent ARARs identified in Table 1.

1.3.1. Groundwater RAOs

The following RAOs are used as the basis for developing the groundwater monitoring program in this RAMP:

1. Prevent or minimize migration of B-aquifer groundwater that may contain chemicals of concern (COCs) at concentrations greater than remediation goals (see Table 2) beyond the point of compliance (POC) (defined in the RI/FS Report at the downgradient boundary of Parcel E-2; this definition is consistent with the requirements in Title 22 Cal. Code Regs. § 66264.95).
2. Prevent or minimize migration of chemicals of potential ecological concern (COPECs) to prevent discharge that would result in concentrations greater than the corresponding water quality criteria (see Table 3) for aquatic wildlife.
3. Prevent or minimize migration of A-aquifer groundwater containing total petroleum hydrocarbons (TPH) concentrations greater than the remediation goal (see Table 2) (where commingled with CERCLA substances) into San Francisco Bay.

In addition, Title 22 Cal. Code Regs. § 66264.94 requires that A-aquifer groundwater downgradient of the POC (in adjoining Parcel E) not exceed risk-based concentrations based on the vapor intrusion pathway; however, consistent with the Final FS Report for Parcel E (ERRG, 2012), actions and decisions to address the indoor inhalation of vapors at Parcel E will be based on soil gas data and the soil gas action levels (SGALs). Soil gas data will be collected along the eastern boundary of Parcel E-2 (adjacent to Parcel E), as part of the LFG monitoring program that is described in Section 3 of this RAMP, and will be compared with risk-based SGALs. However, soil gas monitoring will not be performed until the VOC contaminant source within the East Adjacent Area (see Section 3.2 of the DBR) is excavated and disposed of off site. Appendix A provides a preliminary list of risk-based SGALs, which were developed in support of soil vapor investigations elsewhere at HPNS (ChaduxTt, 2011). The SGALs may be refined based on site-specific data, would account for vapors from both soil and groundwater, and would be calculated based on a cumulative excess cancer risk level of 10^{-6} using the accepted methodology for risk assessments at HPNS.

The following additional RAOs, while not directly related to the monitoring program, inform the activity restrictions described in the LUC RD:

1. Prevent or minimize dermal exposure to and vapor inhalation from A-aquifer groundwater containing COCs at concentrations greater than remediation goals (see Table 2) by construction workers.
2. Prevent exposure to groundwater that may contain COCs at concentrations greater than remediation goals (see Table 2) through the domestic use pathway.

As stated in Section 1.2.5.5, future monitoring will also include analysis for radionuclides in groundwater to demonstrate, consistent with the findings of previous radiological investigations, that radionuclides are not present in groundwater at activity levels that are both statistically significant and pose an unacceptable risk to human health and the environment. The determination of statistical significance will be made in accordance with the substantive provisions of Title 22 Cal. Code Regs. § 66264.98(i). The duration of groundwater monitoring for radionuclides will be determined in accordance with Title 22 Cal. Code Reg. § 66264.90(c).

1.3.2. LFG RAOs

The selected remedy expands the existing LFG controls, which focus on the northern edge of the Parcel E-2 Landfill, by actively removing and treating gas from the entire Parcel E-2 Landfill. The objective of the LFG monitoring program is to verify that the gas collection and control system (GCCS) is preventing LFG from migrating beyond the Parcel E-2 boundary and is effectively reducing emissions of methane and nonmethane organic compounds (NMOCs) in accordance with the RAOs. Title 27 Cal. Code Regs. provides standards for monitoring and controlling migration of methane and trace gases (NMOCs), which are ARARs for Parcel E-2 (see Table 1). For example, Title 27 Cal. Code Regs. § 20921 sets forth the following three performance standards for control of LFG at closed landfills:

1. Concentrations of methane gas must not exceed 1.25 percent by volume in air (25 percent of the lower explosive limit) within any onsite structure.
2. The concentration of methane gas migrating laterally from the landfill must not exceed 5 percent by volume in air at the property boundary or an alternative boundary approved in accordance with Title 27 Cal. Code Regs. § 20925.
3. Trace gases (NMOCs) must be controlled to prevent adverse acute and chronic exposure to toxic and/or carcinogenic compounds.

These requirements were incorporated into the Parcel E-2 ROD as the following RAOs (Navy, 2012):

1. Control methane concentrations to 5 percent (by volume in air) or less at subsurface POCs.
2. Control methane concentrations to 1.25 percent (by volume in air) or less in onsite structures (“onsite” for this RAMP is defined as any area within the subsurface POCs for LFG).

3. Prevent exposure to NMOCs at concentrations greater than 500 parts per million by volume (ppmv) at the subsurface POCs.
4. Prevent exposure to NMOCs at concentrations greater than 5 ppmv above background levels in the breathing zone of onsite workers and visitors.

The NMOC trigger levels identified above will be evaluated further in conjunction with the ongoing LFG study, and may be revised in the Draft Final RAMP. Also, consistent with the discussion in Section 1.3.1, the NMOC trigger levels for monitoring locations along the eastern parcel boundary (adjacent to Parcel E) may be supplemented with risk-based SGALs to satisfy the substantive requirements of Title 22 Cal. Code Regs. § 66264.94. The RAOs listed above inform the LFG monitoring program in a manner that will comply with the substantive provisions of pertinent ARARs identified in Table 1. The LFG monitoring activities, which will include operational and performance monitoring of the proposed GCCS, is discussed in more detail in Section 3.

1.3.3. Surface Water RAOs

The following RAO is used as the basis for developing the surface water monitoring program in this RAMP:

1. Prevent or minimize migration of COPECs to prevent discharge that would result in concentrations greater than the corresponding water quality criteria for aquatic wildlife (Table 3).

Section 2. Groundwater Monitoring

The Final ROD requires groundwater monitoring to ensure the objectives of the remedy have been met and comply with the substantive provisions of pertinent ARARs (see Table 1). The following subsections describe the technical basis of the proposed groundwater monitoring and summarize the specific groundwater monitoring activities.

2.1. TECHNICAL BASIS OF GROUNDWATER MONITORING

Groundwater within the A-aquifer at Parcel E-2, including groundwater in direct contact with landfill waste (referred to as "leachate"), discharges to the surface water of San Francisco Bay and to adjacent Parcel E. In addition, A-aquifer groundwater at Parcel E-2 is in hydraulic communication with the underlying B-aquifer in the northwest corner of the parcel (where the Bay Mud aquitard is absent). Therefore, the following potential migration pathways require monitoring:

- A-aquifer discharge to the surface water of the bay, where chemical concentrations could affect aquatic wildlife
- A-aquifer flow beyond the POC to adjacent Parcel E, where chemical concentrations could affect future residential and industrial users
- B-aquifer flow beyond the POC, where chemical concentrations could degrade the beneficial uses of this potential groundwater source outside of Parcel E-2

The Navy performed an aquatic evaluation as part of the RI/FS Report to assess whether the concentrations of chemicals detected in A- and B-aquifer groundwater could affect aquatic wildlife in San Francisco Bay (ERRG and Shaw, 2011). The subsections below describe the results of the evaluation, which are incorporated into the planned monitoring activities (described in Section 2.2). Results of the planned monitoring will be used to evaluate the potential impact of A- and B-aquifer groundwater discharges beyond the POC by comparing with the appropriate criteria (as described in Section 1.3.1).

2.1.1. Evaluation of Potential Impact to Aquatic Wildlife

The evaluation of the potential impact of groundwater discharges to aquatic wildlife, performed as part of the RI/FS Report, consisted of two parts:

1. A screening evaluation that directly compared groundwater data against surface water quality criteria (based on promulgated federal and state requirements) and was used primarily as a tool in identifying COPECs in groundwater that may pose a risk to aquatic wildlife in San Francisco Bay.
2. A trigger-level evaluation to identify whether chemical concentrations at the groundwater/bay interface pose a potential risk to the aquatic environment. The trigger-level evaluation is a quantitative method used to conservatively estimate attenuation of chemicals as they migrate in groundwater, prior to discharging to the San Francisco Bay. The Navy developed the trigger-level evaluation for HPNS for use in FS reports, with regulatory agency concurrence.

The screening evaluation identified several COPECs that warrant further evaluation and monitoring to assess the potential effects on San Francisco Bay (ERRG and Shaw, 2011). Based on the results of the screening evaluation, the following COPECs are present in groundwater at concentrations that exceed the aquatic evaluation criteria:

- Un-ionized ammonia
- Cyanide
- Sulfide
- Copper
- Lead
- Zinc
- Total PCBs
- TPH

The results of the screening evaluation further indicated that areas within 250 feet of the shoreline (which encompass the tidal influence zone [TIZ]) require further monitoring and evaluation, because several categories of COPECs are widespread (as shown on Figure 3). The TIZ is defined as the area where the maximum tidal fluctuation exceeds 0.10 foot in the A-aquifer based on data collected during the Phase III GDGI (Tetra Tech EM Inc. [TtEMI], 2004b). Un-ionized ammonia and sulfide are not shown on Figure 3 because these COPECs are generated during decomposition of organic matter (both naturally occurring and anthropogenic) in reducing environments, and are readily transformed to non-toxic compounds upon discharge to oxygenated surface water. Accordingly, neither source removal nor containment is needed to protect aquatic wildlife from exposure to these COPECs; however, monitoring for these COPECs will be performed to verify the protectiveness of the remedy.

Trigger levels were derived for the above COPECs for unique wells by multiplying an attenuation factor (based on the distance from each well to the bay) by the surface water quality criterion (Table 3) or the Hunters Point groundwater ambient level (HGAL) (Table 4), whichever was higher. The development of trigger levels was extremely conservative because it did not account for attenuation in the TIZ or

attenuation from discharge to the surface water body. It should be noted that the TIZ, which is defined by groundwater level (pressure) responses to tidal fluctuations in San Francisco Bay, is not the same as the tidal mixing zone (TMZ), where bay water flows in and out during a tidal cycle so that A-aquifer groundwater physically mixes with bay water. Past studies have shown that the TIZ extends farther inland than the TMZ (TtEMI, 2004b); therefore, the trigger-level evaluation presented in the RI/FS Report was adequately conservative to assess potential exposure to aquatic wildlife in the bay (ERRG and Shaw, 2011).

Only hydrodynamic dispersion in the inland contaminant transport zone was used to establish attenuation factors, which were used to calculate the trigger levels. Therefore, the resulting trigger levels likely overestimated the potential for effects from COPECs migrating in groundwater to San Francisco Bay.

Based on the results of the trigger-level evaluation, the primary inland area of concern is the northern portion of the Panhandle Area, between the Landfill Area boundary and the inland extent of the TIZ. Other areas of concern include the western edge of the East Adjacent Area (north of the extent of the PCB Hot Spot Area), and the inland area at the southern tip of the Panhandle Area. Further monitoring and evaluation of these inland areas of concern was recommended because it is possible that COPECs in groundwater are migrating to San Francisco Bay from these locations at concentrations that exceed aquatic evaluation criteria (ERRG and Shaw, 2011).

Table 5 lists the results of the groundwater evaluation. These results were the basis for the proposed monitoring program for groundwater.

2.1.2. Wells Proposed for Future Monitoring

This RAMP includes a collection of groundwater samples from monitoring wells located near the Parcel E-2 shoreline to monitor for potential changes in groundwater concentrations. The primary purpose of these monitoring wells will be to indicate whether contaminants are present in groundwater at concentrations that could be impacting San Francisco Bay, as such they will be referred to as “sentinel wells.” Sentinel wells will be installed within the TIZ because tidally influenced wells are more indicative of potential chemical migration to San Francisco Bay compared with A-aquifer wells located inland of the TIZ. Monitoring wells are also located (1) near the eastern parcel boundary to monitor groundwater conditions beyond the POC to adjacent Parcel E, and (2) near the western parcel boundary to monitor groundwater conditions upgradient of Parcel E-2 (to assist in evaluating the statistical significance of chemical detections downgradient of Parcel E-2). Figure 3 shows the proposed groundwater monitoring locations, and Tables 5 and 6 identify the well locations for future monitoring of COPECs and COCs.

Monitoring wells will also be installed in areas where COPECs were detected in temporary wells installed during the March 2008 investigation along the Parcel E-2 shoreline (CE2-Kleinfelder Joint Venture [CE2-

Kleinfelder], 2008b) at concentrations exceeding trigger levels; these locations will be biased toward the most downgradient locations. A permanent well will be installed approximately every 250 feet along the shoreline areas where COPECs were detected in the temporary wells at concentrations exceeding trigger levels. Where possible, the locations of existing monitoring wells are being preserved and used for RAMP sampling. If a particular COPEC exceeded its trigger level at a temporary well where a permanent well is not being installed, samples will be collected from the two closest permanent monitoring wells.

Four existing and two new B-aquifer monitoring well locations (four near the eastern parcel boundary [i.e., the POC with adjacent Parcel E], one in the Panhandle Area adjacent to the shoreline, and one on the western parcel boundary upgradient of the Parcel E-2 Landfill) were selected to evaluate B-aquifer flow beyond the POC, where chemical concentrations could degrade the beneficial uses of this potential groundwater source.

A nearshore slurry wall is being constructed to hydraulically control groundwater moving into San Francisco Bay. The goal of the nearshore slurry wall is to maximize the travel time of groundwater between areas upgradient of the barrier and the San Francisco Bay, thus extending the natural attenuation period for contaminants in groundwater that might be discharged to the bay. The nearshore slurry wall is positioned between the southern extent of the landfill waste (and remaining contamination in the East Adjacent Area) and the proposed crest of the shoreline revetment (as shown on Figure 3). The groundwater monitoring wells in the area of the nearshore slurry wall are predominantly located along the inland side of the slurry wall and will be paired with new piezometers located on the bay side of the slurry wall. The primary purpose of these piezometers will be for collecting depth-to-water measurements; however, the piezometers will be constructed in a manner that will allow for groundwater sampling if deemed necessary based upon monitoring results.

2.2. GROUNDWATER MONITORING ACTIVITIES

This section summarizes the approach for monitoring groundwater elevations and concentrations of COCs in groundwater at Parcel E-2. Procedures for measuring groundwater elevations and collecting groundwater samples are in place for the basewide groundwater monitoring program at HPNS (CE2-Kleinfelder Joint Venture, 2008a). The groundwater monitoring described in this RAMP will follow the procedures accepted for the basewide monitoring program. Appendix B of this report contains well construction details for the existing wells selected for monitoring. Construction details for proposed monitoring wells will be provided after they are installed in a remedial action completion report, following completion of the RA.

2.2.1. Groundwater Elevation Monitoring

Groundwater elevations will be measured quarterly at all monitoring wells and piezometers at Parcel E-2 to monitor fluctuations in the groundwater elevations and changes in the magnitude and direction of

groundwater flow (see Table 7). The wells listed in Table 7 were selected to allow preparation of representative potentiometric surface elevation contour maps, several of the wells will be constructed after completion of the remedial action. Figure 3 presents the locations of the wells to be monitored.

The remedial action will include the construction of hydraulic barriers (slurry walls) along the northeastern shoreline (nearshore slurry wall) of the site and along the northwest site boundary (upland slurry wall). As described in Section 2.1.2, groundwater elevations in monitoring wells and piezometers will be used to measure the hydraulic gradient across the nearshore slurry wall.

Groundwater elevations will be measured, to the extent possible, in conjunction with the routine monitoring conducted for other areas of HPNS and using similar measurement procedures (CE2-Kleinfelder Joint Venture, 2008a) to promote collection of data that are comparable across HPNS.

2.2.2. Groundwater Sampling and Analysis

Groundwater samples will be collected under the basewide groundwater monitoring program using similar procedures (CE2-Kleinfelder Joint Venture, 2008a). Groundwater samples will be collected from all monitoring wells shown on Figure 3. Samples will be analyzed for COPECs and COCs and radionuclides as discussed in the following subsections.

2.2.2.1. COPECs and COCs

Groundwater samples will be collected semiannually, beginning after remedy construction is complete and the RAMP is approved, and continue for at least 2 years. Samples will be collected to ensure that the remedial objectives specified in the ROD, and summarized in Section 1.3.1, are being met. Samples will be analyzed for the COCs listed in Table 2 and the COPECs listed in Table 5. Table 6 lists the analytes by well and the corresponding evaluation criteria.

Data review procedures and adjustments to the frequency of sampling (including cessation of sampling) will be evaluated consistent with the current procedures at HPNS, as discussed in Section 2.2.2.3, which provide a dynamic process based on EPA's Triad approach.

2.2.2.2. Radionuclides

As described in Section 1.2.5.5, future monitoring will also include analysis for radionuclides in groundwater to demonstrate, consistent with the findings of previous radiological investigations, that radionuclides are not present in groundwater at activity levels that are both statistically significant and pose an unacceptable risk to human health and the environment. The determination of statistical significance will be made in accordance with the substantive provisions of Title 22 Cal. Code Regs.§ 66264.98(i). Concentrations of radionuclides may also be compared with drinking water standards, or a more appropriate risk-based criterion if one becomes available. Table 6 lists the wells proposed for monitoring for radionuclides.

Samples will be collected annually, beginning after the remedy construction is complete and the RAMP is approved. The duration of the groundwater monitoring for radionuclides will be determined in accordance with Title 22 Cal. Code Regs. § 66264.90(c). Data review procedures and adjustments to the frequency of sampling (including cessation of sampling) will be evaluated consistent with the current procedures at HPNS, as discussed in Section 2.2.2.3.

2.2.2.3. Comparison to Evaluation Criteria

The Navy will notify the FFA signatories when chemical concentrations exceed evaluation criteria (that is, trigger levels, remediation goals, or drinking water standards [for radionuclides]). Consistent with current procedures at HPNS, the Navy will send the notification after validated data have been received (about 3 months after samples are collected). Data will be evaluated as follows:

- Perform statistical analyses of trends and multiple verifications of statistically significant exceedances; significant exceedances can be evaluated by order of magnitude or the contaminant's trend toward attenuating naturally. Data for a minimum of four samples from each well is necessary to perform the statistical analyses.
- Evaluate data from wells downgradient from monitoring locations with trigger-level exceedances to identify whether COPEC concentrations are diminishing as they reach the bay (either as a result of natural attenuation or diminished hydraulic connectivity) Downgradient monitoring may include a phased sampling approach of nearshore wells followed by surface water sampling if necessary.

If results of the above evaluations indicate that surface water quality may have been impacted, then further analysis, including modeling, will be performed to more accurately predict contaminant fate and transportation in the mixing zone. The additional modeling would be supported by additional studies, such tracer tests. If results of additional modeling indicate that surface water quality has been impacted, then a contingency action, including groundwater extraction and treatment if necessary, will be implemented. Figure 4 shows the approach for groundwater monitoring to evaluate surface water impacts on aquatic wildlife in the San Francisco Bay.

Section 3. Landfill Gas Monitoring

The Final ROD requires LFG monitoring to ensure the objectives of the remedy have been met and comply with the substantive provisions of pertinent ARARs (see Table 1). The following subsections describe the technical basis of the proposed LFG monitoring and summarize the specific LFG monitoring activities. The LFG monitoring program is divided into two categories: (1) monitoring to demonstrate compliance with the RAOs and the substantive provisions of pertinent ARARs (referred to as LFG compliance monitoring), and (2) monitoring to evaluate the performance of the GCCS (referred to as GCCS performance monitoring).

3.1. TECHNICAL BASIS OF LANDFILL GAS MONITORING

As described in Section 1.3.2.2, the objective of the LFG monitoring program is to verify that the GCCS is preventing LFG from migrating beyond the Parcel E-2 boundary and is effectively reducing emissions of methane and NMOCs in accordance with the RAOs. The following subsections describe the technical basis of the LFG compliance monitoring and the GCCS performance monitoring.

3.1.1. Technical Basis of Perimeter LFG Monitoring

The Navy is responsible for monitoring the migration of LFG at all gas monitoring probes (GMPs) and offsite structures for the presence of methane and NMOCs. As described in Section 1.3.2.2, LFG generated at Parcel E-2 will be controlled in such a manner as to satisfy the following requirements (Title 27 Cal. Code Regs. § 20925):

1. The concentration of methane gas must not exceed 1.25 percent by volume in air within any portion of any onsite structures, including utilities.
2. The concentration of methane gas migrating from the disposal site must not exceed 5 percent by volume in air at the permitted boundary of the disposal site or an approved alternative boundary.
3. Trace gases shall be controlled to prevent adverse acute and chronic exposure to toxic and/or carcinogenic compounds.

No buildings are located within the Parcel E-2 boundary. However, monitoring has historically shown that ambient trace gases have migrated to the crawlspace under Building 830 in the UCSF compound and two runoff discharge catch basins (DP-1 and DP-2). As a conservative measure, LFG concentrations will be monitored at the Building 830 crawlspace and the catch basins in accordance with Requirement 1 above. It should be noted that the regulatory methane standard within structures may be less stringent

than associated permissible exposure levels for other LFG constituents that could adversely affect occupants of the building and utilities.

The 5-percent limit for methane at the property boundary (Requirement 2 above) does not apply to components of the GCCS or to existing passive vents or monitoring wells located on the landfill. Passive vents are part of the LFG migration control system, and methane concentrations frequently exceed 5 percent methane by design. The 5-percent limit does apply at the GMPs, which are located for compliance monitoring along the Parcel E-2 boundary and within the UCSF compound just north of the LFG barrier wall that reduces the outward migration of LFG (Figure 5).

The monitoring criteria for Requirements 1 and 2 are explicit, but Requirement 3 does not identify specific action levels for trace gas concentrations. As a result, an action level of 5 ppmv for NMOCs in the breathing zone was established based on an evaluation of previous Navy risk assessments and health and safety criteria (TtEMI, 2004a). This action level is applied to onsite utilities that are accessible to future workers and to the Building 830 crawlspace in the UCSF compound where LFG has been historically detected.

Additionally, an action level of 500 ppmv was established for NMOCs detected in GMPs. Previous risk assessments have shown that subsurface trace gases found in the GMPs within the UCSF compound and along Crisp Avenue do not pose an unacceptable health risk at this action level (TtEMI, 2004a). An action level of 100 ppmv was also established for NMOCs for utilities.

Finally, trigger levels were established to determine whether targeted extraction of LFG should resume to ensure protection of occupants at Building 830 in the UCSF compound. These trigger levels are 0.5 percent for methane and 100 ppmv for NMOCs in subsurface GMPs. Trigger levels may be revised or added based on the results of LFG extraction testing.

As described in Section 1.2.5.3, the Navy will perform a LFG survey to determine the content of the gas within the Parcel E-2 Landfill and more thoroughly evaluate soil gas concentrations in the Panhandle, East Adjacent, and Shoreline Areas. The new data, which will be provided in the Draft Final RD, will be used to reassess the action levels and trigger levels for NMOCs. The Draft Final RAMP will be revised to reflect information from the planned LFG survey.

Section 3.2.1 describes the specific activities associated with the LFG compliance monitoring.

3.1.2. Technical Basis of GCCS Performance Monitoring

Several Bay Area Air Quality Management District (BAAQMD) requirements pertinent to solid waste disposal sites were evaluated as potential ARARs in the RI/FS Report (ERRG and Shaw, 2011). BAAQMD Regulation 8, Rule 2, addresses carbon emissions from miscellaneous operations and is an ARAR for Parcel E-2. BAAQMD Regulation 8, Rule 34, addresses control of NMOC emissions from

solid waste disposal sites. As documented in the RI/FS Report (ERRG and Shaw, 2011), BAAQMD Regulation 8, Rule 34 is not an ARAR for Parcel E-2 because the Parcel E-2 Landfill meets the exemption criteria (based on its inactive status and low waste volume). However, BAAQMD Rule 34 requirements serve as a reasonable standard of practice for GCCS operations, thus they were used as guidelines for development and implementation of the GCCS performance monitoring methods in this RAMP. The following BAAQMD requirements will be used for monitoring the operation and performance of the GCCS proposed for Parcel E-2:

1. Prevent total organic compound emissions (leaks) from the GCCS components that exceed 1,000 ppmv (BAAQMD Rule 8-34-301.2).
2. Prevent total carbon emissions from the GCCS components that exceed 6.8 kilograms (15 pounds) per day and contain a concentration of more than 300 parts per million of total carbon on a dry basis (BAAQMD Rule 8-2-301).
3. Maintain an enclosed ground flare system with a destruction efficiency of 98 percent of the inlet NMOC or emit less than 30 ppmv at the outlet at 3 percent oxygen (BAAQMD Rule 8-34-301.3).
4. Prevent total organic compound emissions (leaks) from the surface of the landfill that exceed 500 ppmv (BAAQMD Rule 8-34-303).
5. Maintain wellhead gas temperatures below 131°F (BAAQMD Rule 8-34-305.2).
6. Control oxygen concentrations at the LFG extraction wellhead to below 5 percent by volume (BAAQMD Rule 8-34-305.4).

The intent of these requirements is to maximize the efficiency of the GCCS by minimizing leakage and intrusion of air and to prevent the start of subsurface oxidation (i.e., landfill fires).

The GCCS includes five major elements that require monitoring and documentation to meet both compliance reporting and operational goals: (1) LFG extraction wells; (2) landfill surface monitoring locations (i.e., fugitive emissions from surface); (3) emissions from LFG precombustion treatment (i.e., adsorptive media); (4) emissions from LFG treatment via combustion (i.e., enclosed flare); and (5) LFG condensate collection and disposal.

Periodic monitoring and agency reporting is required for:

- Testing of source emissions from the LFG treatment facility, which quantifies the emission reduction efficiency at the discharge from the LFG treatment facility.
- Key operating parameters of the LFG treatment process, which monitor and maintain high-efficiency performance of the treatment process units.
- Monitoring of the LFG condensate system, which characterizes the LFG condensate for proper pretreatment (if necessary) and disposal.

Routine operational monitoring and documentation is required for:

- Monitoring of the LFG extraction system, which optimizes the collection flow and efficiency of the LFG extraction wells, vents, piping system, and other LFG collection system components.
- Monitoring of fugitive emissions, which includes:
  - Monitoring of surface emissions and cover integrity, which identifies potential LFG leakage through the geomembrane and soil cover.
  - Monitoring of LFG components, which identifies potential LFG leakage from components of the various environmental control systems.

The following parameters will be monitored routinely at Parcel E-2 (at the frequencies proposed in Table 9) to assess the status and performance of the various elements of the GCCS (e.g., extraction wells and treatment facility):

- Major Gas Composition: Relative concentrations of the major gases (methane, oxygen, carbon dioxide, and balance gas[2]) will be measured to evaluate the status of anaerobic productivity of a well and to detect system air leaks and/or excessive air intrusion into the waste. Major gas concentrations will be measured and reported in the percent by volume range. Higher methane concentrations in LFG extraction wells or vents (>45 percent by volume) typically correlate with higher anaerobic productivity of the waste. High oxygen concentrations in LFG extraction wells or vents can indicate either atmospheric air leakage into the piping or excessive air infiltration into the waste. Table 8 identifies preliminary target ranges for oxygen and methane at various locations within the GCCS. If excessive oxygen and nitrogen concentrations are detected during monitoring of LFG extraction wells, they will be investigated thoroughly to identify and mitigate the air source.
- Trace Gases (NMOCs): Trace gases will be monitored at locations where the potential exists for emission of or exposure to gas constituents, which are hazardous at low concentrations. In general, trace gas concentrations are localized and depend on the residual amounts of VOCs or NMOCs in the waste near the sampled location. NMOC field measurements will be reported in units of ppmv. Laboratory analytical measurements will be reported in units of parts per billion by volume.
  - Trace gas concentrations will be monitored routinely in influent and effluent of the vapor adsorption units (activated carbon and potassium permanganate canisters) to identify their remaining effectiveness and vapor capacity and to schedule for replacement of adsorbent.
  - Trace gas concentrations in influent and effluent will be monitored during performance testing of the enclosed ground flare to establish and confirm appropriate operating parameters for maximizing efficient destruction of NMOCs before discharge of the treated exhaust gas.

[2] "Balance gas" is the term for the remaining LFG component after the measured fractions of methane, oxygen, and carbon dioxide are subtracted from 100 percent. For practical purposes, balance gas is generally synonymous with nitrogen, except for minor trace concentrations of other gases such as NMOCs.

- Static Pressure: Static pressure will be measured to monitor the vacuum being applied to extract LFG from a well, vent, or other location in the GCCS. In general, higher negative static pressure values correlate to higher gas extraction flow rates. Static pressure will be measured and reported in units of inches of water column gauge. Table 8 identifies preliminary target ranges for static pressure at various locations within the GCCS.
  - Static pressure measured at LFG extraction wellheads should normally be negative, indicating that the well is operational and vacuum is being applied to the waste mass.
  - Static pressure in shallow GMPs should normally be slightly negative or zero. Slightly negative or zero static pressure indicates that the GMP is being influenced by the vacuum applied to a nearby LFG extraction well or vent, and that there is minimal potential for driving LFG migration outward from the landfill. Positive pressure indicates that a potential gradient exists that could drive LFG migration or emissions.
- Extraction Well Gas Temperature: The temperature of gas flowing from an LFG extraction well will be measured to monitor the level of biological activity occurring in the waste.
  - Low temperatures near ambient ground temperature (<65°F) indicate low rates of organic decomposition.
  - Moderately high temperatures (90 to 125°F) indicate higher rates of biochemical methane generation activity.
  - Abnormally high temperatures (131 to 170°F) indicate excessive air intrusion, aerobic composting, and/or subsurface thermal oxidation (landfill fire).

  Table 8 identifies preliminary target ranges for gas temperatures at different locations within the GCCS.
- Flare Exhaust Temperature: Gas temperatures in the exhaust from the enclosed ground flare stack will be monitored and recorded automatically and continuously to optimize control of operational fuel and air mixtures, to ensure emissions are efficiently destroyed, and for routine compliance confirmation. Exhaust temperatures for maximum combustion efficiency will range between 1,800 and 2,000°F for the flare design specified in the RD.
- Gas Flow Rate: Flow rate of LFG will be measured during initial and periodic assessments of the productivity of individual wells and subareas of the landfill. LFG flow rates will be measured and reported in units of standard cubic feet per minute (scfm).
  - The total flow rate of LFG from the landfill will be monitored and recorded continuously in the LFG treatment facility to verify compliance with permitted emission rates and for operational diagnostics.
  - LFG flow rates will also be monitored at other locations in the GCCS piping for non-routine assessment and troubleshooting of the system (i.e., to determine locations of pipe damage or flow obstruction).
  - Individual LFG extraction well flow rates are sometimes monitored during system startup or for operational troubleshooting, but are not routinely required once equilibrium operation of the GCCS is achieved. Static pressure and major gas composition will be the primary well operational monitoring parameters..

Section 3.2.2 describes the specific monitoring activities associated with each element of the GCCS.

3.2. LANDFILL GAS MONITORING ACTIVITIES

The following subsections summarize activities for the LFG compliance monitoring and GCCS performance monitoring. Table 9 provides a preliminary list of monitoring requirements (including frequency and typical instruments). Detailed monitoring procedures and the objectives, frequency, and instruments to be used for each procedure will be described in the Remedial Action Work Plan (to be prepared by the contractor performing the remedial action).

3.2.1. LFG Compliance Monitoring

The Navy is conducting ongoing LFG monitoring for Parcel E-2 under the Interim LFG Monitoring and Control Plan (Innovative Technical Solutions, Inc. [ITSI] and Tetra Tech, Inc., 2004). The long-term LFG monitoring network, which includes existing and new perimeter GMPs and various other surface and subsurface locations, was designed in accordance with Title 27 Cal. Code Regs. to detect LFG migrating beyond the Parcel E-2 boundary (see Figure 5). Monitoring is performed on a regular basis and includes notification and response procedures if action or trigger levels for methane or NMOCs are exceeded at the parcel boundary or beneath the UCSF compound.

The RAO requirements include monitoring migration of LFG to maintain compliance at the perimeter GMPs. Methane, NMOC concentrations, and static pressure at the GMPs will continue to be monitored quarterly using field instrumentation as summarized in Table 9.

The RD proposes 39 GMPs located at an on-center spacing of approximately 150 feet along the Parcel E-2 boundary and within the UCSF compound. The RAO limit of 5 percent methane in the subsurface applies at the GMPs. Additionally, an action level of 500 ppmv was established for NMOCs detected in GMPs. Finally, trigger levels were established to determine if additional remedial action is required to ensure protection of occupants of the UCSF compound. The trigger levels are 0.5 percent for methane and 100 ppmv for NMOCs in subsurface GMPs within the UCSF compound.

Monitoring has shown that methane and NMOCs have historically migrated to the crawlspace under Building 830 in the UCSF compound and into two runoff discharge catch basins (DP-1 and DP-2) (ITSI and Tetra Tech, Inc., 2004). As a conservative measure, LFG concentrations will be monitored at the Building 830 crawlspace and the catch basins. These structures will continue to be monitored quarterly using portable field instrumentation for methane and NMOCs. A sample will be collected for laboratory analysis of specified trace gases when the possibility exists that personnel may be exposed (i.e., field-screened NMOC concentration >500 ppmv in the subsurface or >5 ppmv above the ground surface).

3.2.2. GCCS Performance Monitoring

The following subsections summarize each major element of the GCCS that requires performance monitoring.

3.2.2.1. LFG Extraction Well Monitoring

Data, including gas concentrations, vacuums, and flow rates, will be collected from the LFG extraction wells that will be installed throughout the Parcel E-2 Landfill. The data will be used to evaluate whether the GCCS is operating effectively. LFG extraction wells will be monitored and adjusted individually and collectively to maximize the collection of available methane without drawing excessive air into the waste. The acceptable operating ranges for gas concentrations, vacuums, and flows are specific to both the landfill's site conditions and waste characteristics, thus specific target values will be developed after obtaining baseline data during initial startup of the GCCS. Target values for the LFG extraction wells will also vary based on localized operational objectives, well design, well location, and over time. Each LFG well will be monitored and adjusted as necessary to collect data within the acceptable operating range. Table 8 lists the preliminary acceptable operating ranges.

The combined flow of LFG into the treatment system should typically fall within the same range of monitoring values as the LFG extraction wells, assuming that no major air leaks or other unaccounted for sources are contributing to the LFG flow from the landfill.

3.2.2.2. Landfill Surface Monitoring

The purpose of monitoring the landfill surface is to confirm that the remedy (including the GCCS, soil cover, and protective liner) is inhibiting emissions of fugitive LFG and maintaining ambient concentrations of NMOCs less than site-specific action levels. The action levels are 500 ppmv for total organic compounds at the Parcel E-2 boundary and at the landfill surface and 5 ppmv for NMOCs at or above the ground surface. Any surface emission concentration exceeding 500 ppmv for total organic compounds measured as methane shall be marked, recorded, repaired, and remonitored within 30 days.

All accessible components (pipe, wellheads, valves, blowers, and other mechanical appurtenances) of the GCCS will be monitored for leakage to confirm that the exposed GCCS piping and other components are continuously maintained in good repair. Additionally, monitoring for leakage will prevent releases of LFG that could result in concentrations of NMOCs exceeding the action level of 5 ppmv at or above the ground surface. Any component leak concentration in excess of 500 ppm measured as methane shall be marked, recorded, repaired, and remonitored with 30 days. All component leaks exceeding 1,000 ppmv measured as methane shall be marked, recorded, repaired, and remonitored within 7 days.

3.2.2.3. LFG Precombustion Treatment Process Monitoring

The Navy is currently operating a LFG control system at Parcel E-2 under the Interim LFG Monitoring and Control Plan (ITSI and Tetra Tech, Inc., 2004). The current LFG control system uses two different types of adsorptive media (granular activated carbon [GAC] and a potassium permanganate-impregnated zeolite [trade name Hydrosil]) to remove NMOCs from gas extracted from the vent trench along the northern edge of the Parcel E-2 Landfill.

Based on available data, the precombustion treatment system in this RD will use the same configuration (consisting of GAC and Hydrosil) as used previously. Historically, use of GAC and Hydrosil resulted in the following average removal efficiencies for NMOCs (calculated based on results of LFG monitoring from 2008 through 2012):

- Average single pass GAC vessel NMOC effluent removal efficiency 88%
- Average single pass Hydrosil vessel NMOC effluent removal efficiency 60%
- Combined GAC and Hydrosil NMOC effluent removal efficiency 95%

The adsorption beds for the existing LFG control system were sufficiently sized to effectively remove NMOCs to less than action levels for reported extraction flow rates from perimeter trench vents of up to 50 scfm and inlet NMOC concentrations up to 120 ppmv. The maximum recorded NMOC concentration in the available quarterly LFG Monitoring Reports was 180 ppmv measured at GMP19 in July 2008 (ITSI, 2008). The influent and effluent NMOC concentrations will be measured biweekly or as needed to detect initial NMOC breakthrough of the primary adsorbent bed(s).

As described in Section 1.2.5.2, the Navy will perform a LFG survey to better estimate the gas generation rates from the Parcel E-2 Landfill and to determine the content of the LFG. The new data, which will be provided in the Draft Final RD, will be used to refine the design of the adsorptive media treatment units. The adsorptive treatment units for the treatment facility in this RD will be sufficiently sized to provide similar removal efficiencies for NMOCs, which will be confirmed through regular monitoring (see Table 9). The Draft Final RAMP will be revised to reflect any required changes to the performance monitoring of these units.

3.2.2.4. LFG Enclosed Flare Monitoring

Thermal oxidation using conventional enclosed flares readily destroys over 98 percent of the methane and NMOCs in the LFG. The primary byproducts from flare combustion are carbon dioxide and water vapor. Secondary emissions are nitrogen oxide and carbon monoxide. As in all combustion devices (e.g., burners and engines), these byproducts are minimized by controlling combustion temperatures and flame characteristics. State and federal requirements for destruction efficiency of methane and NMOC at most active landfills are 99 percent and 98 percent, respectively (Title 17 Cal. Code Regs. § 95464(b)(2)(A)1;

BAAQMD Rule 34; EPA, 1999). The destruction efficiencies of properly designed and operated conventional ground flares are typically 99 percent or better for methane and NMOCs. EPA recognizes this treatment technology as the best demonstrated available technology for LFG (EPA, 1999), and the technology has been approved by the BAAQMD, as shown by implementation of flares at many municipal landfills in the San Francisco Bay area.

As described in Section 3.1.3, BAAQMD Rule 34 requirements serve as a reasonable standard of practice for GCCS operations and include guidelines for the destruction efficiency of an enclosed ground flare. The enclosed ground flare for the treatment system in this RD will destroy the methane and NMOCs remaining following pretreatment (using adsorptive media) at an efficiency that meets or exceeds the destruction efficiency provided in the BAAQMD guidelines. Based on review of quarterly LFG monitoring reports, the methane concentrations at seven landfill monitoring locations (PV-01, PV-02, PV-04, IR01MWI-5, IR01MW16A, IR01MW18A, and IR01MW366A) averaged 22 percent by volume over the period January 2008 through March 2012 (see Table 10). The most recent average methane concentration was 10 percent by volume (reported for March 2012). After normalizing the readings to remove entrained air dilution, the 4-year average methane concentrations was 48 percent by volume and the March 2012 average methane concentration was 40 percent by volume. The operation of the enclosed ground flare, including its destruction efficiency, will be regularly monitored as discussed in the following subsections and in Table 9.

Routine LFG Enclosed Flare Monitoring

The following parameters of the enclosed flare will be routinely monitored to ensure the flare is operating within the ranges shown below.

- Inlet LFG composition:
  - Methane: 15 to 50 percent
  - Carbon dioxide: 15 to 50 percent
  - Nitrogen: 15 to 40 percent
  - Oxygen: 0 to 3 percent
- Flare inlet pressure: 10 to 80 inches water column

Continuous LFG Enclosed Flare Control Monitoring

The following parameters of the LFG enclosed flare will be continuously monitored to ensure the flare is operating within the ranges shown below.

- Inlet LFG flow rate: 50 to 150 scfm
- Burner normal operating temperature: 1,800 to 2,000°F

The enclosed flare will contain the following devices so that continuous monitoring will be automated and recorded:

- Continuous logging flow meter (i.e., thermal mass anemometer) to monitor LFG flow
- Thermocouples to monitor flare stack temperature
- Ultraviolet or thermocouple flame confirmation for pilot and main burner flames
- Digital chart recorder to continuously record LFG flow rate and flare stack temperature
- Flow summation with daily and monthly totalizing

LFG Enclosed Flare Compliance Testing

The following parameters of the LFG enclosed flare will be annually tested using standard procedures approved by local and state air quality agencies to ensure the flare is operating within the ranges shown below. This testing is commonly called source emissions testing or source test.

- LFG heat rate range: 0.16 to 1.6 million British thermal units (MMBtu) per hour
- Exhaust emissions:
  - Carbon Monoxide: 0.01 to 0.20 pounds per MMBtu
  - Nitrogen Oxides: 0.005 to 0.05 pounds per MMBtu
  - NMOC: 1 to 5 ppmv as heptane at 3% oxygen
  - NMOC destruction efficiency (total): 98% (efficiency calculation may be limited by low NMOC influent concentrations)
  - Total hydrocarbon (THC) destruction efficiency: 99.99% (efficiency calculation may be limited by low THC influent concentrations)

3.2.2.5. LFG Condensate Collection and Disposal

LFG condensate will be generated and accumulated in the LFG treatment system as a result of LFG cooling during conveyance through the GCCS. LFG condensate is typically a dilute aqueous solution of trace volatile organics and hydrocarbon compounds coextracted from the waste with the LFG. LFG condensate is generally acidic due to the reducing nature of the waste and the presence of sulfides, chlorides, and carbon dioxide in the LFG. Condensate will be removed from the GCCS continuously by pumping from low elevation sump locations in the LFG collection piping to prevent accumulation and consequent blockage of LFG flow. The LFG condensate will be pumped into an interim aboveground storage tank at the LFG treatment facility (Figure 5), from which it must be periodically sampled and tested before discharge to a permitted liquid waste disposal facility. Depending on future characterization data, the LFG condensate may be pretreated within the LFG treatment facility and discharged to a publicly owned sanitary sewer connection or transported by a licensed liquid waste transporter for offsite treatment and disposal.

The San Francisco Public Utilities Commission (SFPUC) enforces a Pretreatment Program regulating discharges from nondomestic sources into the city's sewerage system. Regulations governing these discharges are contained in the city's sewer use ordinance and are summarized in Section 3.8.7 in the DBR. The SFPUC issues Industrial User Permits to regular or continuous discharges that result from commercial or industrial operations. Established discharge pretreatment limits may be applicable to known site COCs.

Condensate compliance monitoring requirements before batch discharge typically include:

- pH: continuous
- Electro-conductivity: continuous
- Laboratory sample analysis for COCs: quarterly

Theoretical estimates of condensate generation volumes from LFG extracted from Parcel E-2 Landfill are provided in the DBR. Based on LFG generation estimates in the RI/FS Report, the condensate generation rate is not expected to exceed 20 gallons per day. As described in Section 1.2.5.3, the Navy will perform a LFG survey to better estimate the gas generation rates from the Parcel E-2 Landfill and to determine the content of the LFG. The new data, which will be provided in the Draft Final RD, will include characterization of LFG condensate. The Draft Final RAMP will be revised to describe potential pretreatment requirements and specify chemical-specific monitoring requirements to comply with discharge permit standards during long-term monitoring.

Section 4. Wetland Monitoring

The Final ROD requires restoration of tidal and seasonal freshwater wetlands to mitigate for the loss of existing wetlands at Parcel E-2 and other HPNS parcels, and thereby comply with the substantive provisions of pertinent ARARs. The following subsections describe the technical basis of the proposed wetland monitoring and summarize the specific wetland monitoring activities.

4.1. TECHNICAL BASIS OF WETLANDS MONITORING

The long-term goal of the wetlands mitigation is the successful compensatory mitigation of impacts to approximately 3.17 acres of jurisdictional tidal wetlands and approximately 1.27 acres of seasonal freshwater wetlands that will be affected within Parcels B, E, and E-2 as a result of past and anticipated future cleanup actions. This goal will be accomplished by the creation of 4.74 acres of combined tidal and seasonal freshwater wetlands, including approximately 3.19 acres of tidal and approximately 1.55 acres of seasonal freshwater wetlands, with percent coverage of plant species or species groups based on reference plots in suitable nearby wetlands. Table 11 identifies the performance standards that will be used to determine if this goal has been achieved.

The wetland monitoring plan will be implemented following completion of final grading and planting of the tidal and seasonal freshwater wetlands. Implementation of the protocols and practices recommended in this plan will allow the Navy to assess the relative success of the restoration and identify appropriate contingency measures, if needed, to increase the likelihood of successfully restoring the tidal and seasonal freshwater wetlands. Constructed wetlands at Parcel E-2 will be monitored and managed to promote reestablishment of native tidal wetland and seasonal freshwater wetland species.

4.2. WETLAND MONITORING ACTIVITIES

Twice-yearly monitoring will be performed during spring (April/May) and fall (September/October). This monitoring frequency is proposed for 5 years following completion of final grading and planting. The monitoring frequency will be reevaluated after the initial 5-year period. Mitigation monitoring will begin following acceptance of plant installation (Year Zero) and will:

- Document regular tidal inundation.
- Document development of hydric soil.
- Document attainment of target elevations resulting in proper hydrology for each of the planting zones.

- Document plant survivorship, health, and vigor.
- Record natural plant recruitment (percent cover) and invasive plant species.
- Identify disturbance (human and vehicular traffic, litter).
- Document invertebrates, bird, and mammal use (species richness and diversity).
- Document evidence of bird predation by Norway and/or Black rats and other predatory rodents.
- Record any evidence of erosion and sedimentation in the tidal wetland mitigation area or the revetment.

The following subsections describe the proposed mitigation monitoring in more detail, and also discuss the surface water sampling necessary to comply with the RAOs identified in Section 1.3.2.3.

4.2.1. Baseline Survey

A baseline survey will be conducted following completion of restoration and mitigation. During the baseline wetland survey, permanent 1-meter-square data plots will be established on a minimum of five transects (three in the tidal wetland mitigation area perpendicular to the shore and two in the freshwater wetland mitigation area along its long axis), which intersect each of the vegetative zones in each of the wetland mitigation areas. Eight additional, randomly placed plots will be established at that time throughout the wetland mitigation areas. A tide gauge will be installed in the tidal wetland to evaluate tidal elevation. A series of piezometers will be installed in the seasonal freshwater wetland down to the limit of the 4-foot-thick soil cover and will be evaluated during each monitoring event to determine the level of soil saturation above contaminated soil under the cover. Grade stakes or benchmarks will be installed to monitor sediment deposition and erosion.

4.2.2. Semiannual Surveys

The restored area will be monitored twice annually (spring and fall) for at least 5 years following the construction of the wetland mitigation areas (at which point the monitoring frequency will be reevaluated). Data to be collected in each plot will include:

- Estimate of percent cover by plant species (using the Braun-Blanquet cover class methodology or a similar method).
- Evidence of faunal activity.
- Plant viability and recruitment.
- Sedimentation and erosion (tidal wetlands).
- Establishment of hydrologic regime and hydric soil.

Reference sites are typically established in undisturbed and ideal habitat, providing a point of comparison with restored and created habitat. In a highly developed area like the San Francisco peninsula and bay shoreline, ideal sites are usually difficult to find. Nearby restored wetlands, such as the small area identified in India Basin, are not ideal and should not be relied on as a guide for wetland restoration or creation in the wetland mitigation area at Parcel E-2. Nevertheless, the India Basin site and/or other appropriate nearby reference site or sites will be used to compare monitoring data collected from the tidal wetlands mitigation area to provide approximate target goals for species richness and percent coverage. The reference site or sites will be examined to identify native wetland and invasive plant species present and the approximate percent coverage of each, which will provide an indication of species richness and coverage attainable in the wetland mitigation area at Parcel E-2.

During site reconnaissance, the presence of invasive plants and nuisance and feral animal species (such as Norway and Black rats or other predatory rodents) will be documented and corrective and adaptive management measures will implemented in accordance with the OMP.

Panoramic photographs of the ground surface will be taken at selected station points in each mitigation area to illustrate year-to-year progress. Photographs will be taken from the same point each year to allow for comparison and to assess trends.

4.2.3. Surface Water Sampling in Freshwater Wetlands

The final remedy includes a French drain system along the western boundary of the landfill to limit groundwater migration through waste. The freshwater wetlands will be fed by groundwater intercepted by the upland slurry wall and French drain. Recent groundwater sampling data from wells located upgradient of the site indicated that groundwater flowing onto the site has elevated levels of the anion un-ionized ammonia. Un-ionized ammonia is readily transformed to non-toxic anions upon discharge to oxygenated surface water. To facilitate the anion oxidation process, groundwater diverted by the slurry wall will be aerated through a concrete aeration structure prior to entering the wetland.

The RAO for surface water includes preventing or minimizing migration of COPECs to prevent discharge that would result in concentrations greater than corresponding water quality criteria for aquatic wildlife. Therefore, discharge to surface water (i.e., the freshwater wetlands) will be monitored. Surface water samples will be collected during the baseline survey and analyzed for all COPECs previously identified at Parcel E-2. As described in Section 2.2.2.1, COPECs include three anions (un-ionized ammonia, cyanide, and sulfide), three metals (copper, lead, and zinc), total PCBs, and TPH (ERRG and Shaw, 2011). The analytical suite will be reevaluated following the baseline survey to determine, in consultation with the regulatory agencies, which COPECs require periodic monitoring. Sampling and analysis will be performed twice annually (spring and fall) in conjunction with the semiannual surveys (described in Section 4.2.2), and will continue for at least 2 years. Data review procedures and adjustments to the frequency of sampling (including cessation of sampling) will be evaluated consistent with the current

procedures at HPNS, as discussed in Section 2.2.2.1, that provide a dynamic process based on EPA's Triad approach.

In addition, performance samples will be collected to verify the effectiveness of the aeration structure to oxidize un-ionized ammonia prior to discharge into the freshwater wetlands. Samples will be collected before and after aeration occurs, along with field measurements of temperature, pH, and specific conductance at each location. The samples would be analyzed for total ammonia, and the concentration of un-ionized ammonia would be calculated using the corresponding temperature, pH, and specific conductance measurements at each location.

Results of all surface water samples will be compared with surface water quality criteria (see Table 3) that are based on promulgated federal and state requirements (specifically the California Toxics Rule and the San Francisco Bay Basin Plan).

The freshwater wetlands will receive stormwater runoff from upland portions of Parcel E-2. Also, during storm events, the freshwater wetlands will discharge water to the adjoining tidal wetlands via an outflow structure. The required monitoring of stormwater discharges, both entering and exiting the freshwater wetlands, is described in Section 5.

Another factor potentially affecting the freshwater wetlands is saltwater intrusion. The final remedy includes a shoreline revetment that will withstand waves and separate the freshwater wetland from the bay. Over the next century, a rise in sea level is expected to result in significant changes along coastlines, causing shorelines to migrate inland. The potential for saltwater intrusion into the freshwater wetland will be minimized for many years by the shoreline revetment. Because the freshwater wetlands will be a part of the final CERCLA remedy for Parcel E-2, future 5-year reviews will evaluate the long-term effectiveness of the shoreline revetment to prevent saltwater intrusion.

Section 5. Stormwater Monitoring

The Final ROD requires stormwater monitoring to comply with the substantive provisions of pertinent ARARs. The following subsections describe the technical basis of the proposed stormwater monitoring and summarize the specific stormwater monitoring activities.

5.1. TECHNICAL BASIS OF STORMWATER MONITORING

Procedures for collecting stormwater samples and making observations are currently in place, as provided in the "Stormwater Discharge Management Plan Update Based on 2011/2012 Monitoring Program" (Accord MACTEC Joint Venture, 2012). The current monitoring and reporting program plan (MRPP) will be used as the basis of the program described in this RAMP and satisfies the substantive provisions of pertinent ARARs. The MRPP for stormwater has the following four components: (1) stormwater sampling and analysis, (2) non-stormwater discharge visual observations, (3) stormwater discharge visual observations, and (4) guidance for collecting and maintaining records and reporting program results to the Water Board. Section 5.2 discusses the first three components of the MRPP, and the fourth component (i.e., reporting) is discussed in Section 6.

5.2. STORMWATER MONITORING ACTIVITIES

The following sections describe the requirements and methods for stormwater monitoring.

5.2.1. Stormwater Sampling and Analysis

5.2.1.1. Locations

The General Permit, provided in the Stormwater Discharge Management Plan Update (Accord MACTEC Joint Venture, 2012), requires that samples be collected from all drainage areas that represent the quality and quantity of the site's stormwater discharges. The proposed monitoring locations, presented on Figure 6, are as follows:

- Outfall into San Francisco Bay from the perimeter channel on the east side of the landfill
- Outfall into the wetlands from the surface water channels on the west side of the landfill
- Pipe outfall into the wetlands from the landfill cap drainage layer
- Outfall into San Francisco Bay from freshwater wetlands

The proposed monitoring locations are designed to be representative of stormwater flow over these areas.

5.2.1.2. Analytical Parameters

The General Permit requires that stormwater samples be analyzed for the following parameters:

- Total suspended solids, pH, specific conductivity, and total organic carbon; oil and grease may be substituted for total organic carbon.
- Toxic pollutant parameters likely to be present in stormwater discharges in significant quantities.
- Other analytical parameters listed in Table D of the General Permit (because no industrial activities are associated with Parcel E-2, analytical parameters listed in Table D do not apply).

The annual report should certify that the above parameters and conditions have been satisfied. Benchmarks are provided in the Stormwater Discharge Management Plan Update (Accord MACTEC Joint Venture, 2012) for each stormwater analyte and will be used to evaluate the significance of the analytical results. A benchmark establishes a level below which analytical results are considered "insignificant" and can therefore be eliminated from subsequent sampling programs following two consecutive insignificant results or two consecutive results less than the benchmark.

The benchmarks for analytical comparison purposes are based on the following sources, listed in order of priority for use in establishing the most appropriate water quality goals:

- EPA, 2000a. "Numeric Criteria for Priority Toxic Pollutants for the State of California, California Toxics Rule." Title 65 *Federal Register*, Sections 31682–31719. May 18.
- State Water Resources Control Board, 2001. "Water Quality Control Plan for Ocean Waters of California (California Ocean Plan)." December 3.
- EPA, 2000b. "National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities." Title 65 *Federal Register*, Section 64746. Final Reissuance. October 30.
- EPA, Various Dates. "National Recommended Ambient Water Quality Criteria – Saltwater or Freshwater Aquatic Life Protection, Ambient Water Quality Criteria."
- EPA, 1993. "Integrated Risk Information System Reference Dose as a Drinking Water Level."
- EPA, 1991. "Drinking Water Standards, Maximum Contaminant Levels – California." Title 22 Cal. Code Reg., Division 4, Chapter 15, Domestic Water Quality and Monitoring.
- EPA, 2002c. "Drinking Water Standards, Maximum Contaminant Levels – Federal." Title 40 Code of Federal Regulations, Parts 141 and 143.

Where the above sources do not have a water quality goal for an analyte, the laboratory's method detection limit is used for analytical comparative purposes. In addition, the Water Board's "Water Quality Control Plan (Basin Plan) for the San Francisco Bay Region" is used to select applicable surface water criteria (Water Board, 2011).

5.2.1.3. Sampling Schedule

At a minimum, stormwater samples are collected biannually from the drainage locations identified on Figure 6. Samples will be collected during the first hour of discharge from (1) the first storm event of the wet season and (2) at least one other storm event during the wet season. The General Permit defines the wet season as the period from October 1 through May 31. Stormwater samples are analyzed for the parameters described above in Section 5.2.1.2 and in the General Permit.

5.2.2. Non-Stormwater Discharge Visual Observations

Non-stormwater discharges will be visually observed quarterly in accordance with the General Permit. The observations will be performed during daylight hours and on days with no stormwater discharges. An observation is required for each drainage area at the site associated with industrial activities. Visual observations of non-stormwater discharge are also required at each authorized source of non-stormwater discharge.

5.2.3. Stormwater Discharge Visual Observations

Stormwater discharge will be visually observed during the first hour of one storm event per month during the wet season (October 1 through May 31). The visual observations should be performed during daylight hours of a normal workday during the start of rain event that is preceded by at least 3 days without stormwater discharge. The observations should document the presence of any floating and suspended material, oil and grease, discolorations, turbidity, odor, and source of any pollutant observed.

Section 6. Reporting

The monitoring results for groundwater, LFG, constructed wetlands, and stormwater will be summarized in periodic reports that will be submitted for review and approval by the FFA signatories (and other regulatory agencies, as appropriate). The following sections describe the reporting requirements for the various monitoring programs described in Sections 2, 3, 4, and 5.

6.1. GROUNDWATER

The Navy will present the results of groundwater monitoring in semiannual and annual reports. Groundwater monitoring reports will be similar to reports prepared previously for Parcel E-2 and for other areas at HPNS (e.g., CE2-Kleinfelder Joint Venture, 2008b) for consistency and comparability across HPNS. The following sections discuss these reports.

6.1.1. Semiannual Reports

Semiannual reports will summarize basic monitoring data and analytical results. Each report will include the following information:

- Tabulated groundwater levels for wells and piezometers monitored; figures showing the locations of monitoring points and the groundwater potentiometric surface
- Tabulated analytical results for samples from each monitoring well; figures showing the extent of chemicals in groundwater or soil gas
- Copies of sample chain-of-custody forms, field sampling forms and notes, laboratory analytical and data validation reports, including quality assurance and quality control information, and other associated forms
- Comparison of analytical results with remediation goals and trigger levels
- Description of deviations from this RAMP
- Identification of damage to monitoring wells or piezometers and recommendations for corrective action
- Recommendations for adjustments to this RAMP

6.1.2. Annual Reports

Annual reports will summarize the evaluation and interpretation of the data collected over the previous year in addition to summarizing basic monitoring data and analytical results from the preceding 6 months.

Annual reports have the following objectives:

- Evaluate groundwater and methane data obtained during the past year to identify significant trends
- Evaluate COC concentrations in monitoring wells and methane in GMPs
- Describe deviations from this RAMP
- Discuss analytical data quality
- Recommend adjustments to this RAMP

6.2. WETLANDS MONITORING

Annual monitoring reports will be submitted for review and approval to the FFA signatories (including EPA, DTSC, and the Water Board), the California Department of Fish and Game, and other interested agencies such as the San Francisco Bay Conservation and Development Commission. These reports will discuss the progress of the constructed wetlands in achieving success criteria throughout the 5-year monitoring period and will identify any problems that may arise, which will be addressed using adaptive management techniques. Problems identified as a result of ongoing monitoring will be addressed in consultation with regulatory agencies.

6.3. LANDFILL GAS

The Navy will present the results of LFG monitoring in semiannual and annual reports. LFG monitoring reports will be similar to reports prepared previously for Parcel E-2 and for other areas at HPNS for consistency and comparability across HPNS. The following sections discuss these reports, as well as miscellaneous reporting requirements for LFG.

6.3.1. Semiannual Operation, Monitoring, and Maintenance Reports

The Semiannual Operation, Monitoring, and Maintenance (OM&M) Reports will present and summarize the evaluation of monitoring data collected in the preceding 6 months based on the monitoring program schedule proposed by the Navy and approved by FFA signatories. The reports will be prepared in accordance with the requirements of Title 27 Cal. Code Regs. § 20934. Operational records and monitoring data will also be included in Semiannual OM&M Reports. The reports will, at a minimum, include the following documentation:

- Operation log
- Maintenance activity log
- Inspection records
- Monitoring records

- Laboratory analytical results
- System performance evaluations
- Notification procedures

Specifically, the semiannual reports will include the following information:

- Concentrations of methane measured at each LFG monitoring location.
- Concentrations of oxygen, carbon dioxide, and NMOCs measured at each LFG monitoring location.
- Locations and concentrations of all measurements exceeding the site action and trigger levels, and a description of corrective actions planned or implemented and follow-up monitoring results.
- The dates and times of monitoring activities, and the barometric pressures, atmospheric temperatures, general weather conditions, and probe pressures measured and recorded during the monitoring events.
- Names of monitoring personnel, and a brief description of the sampling apparatus and methods used.
- Documentation of the dates, extraction locations, periods of operation, and any maintenance issues or fieldwork variances related to operation of the GCCS.

6.3.2. Annual Compliance Reports

The Annual Compliance Reports will present and summarize the evaluation of applicable monitoring data provided in previous semiannual reports. These reports are required to demonstrate compliance with the site cleanup levels and the pertinent ARARs. In addition to summarizing content from the Semiannual OM&M Reports, the Annual Compliance Report will include, but is not limited to, the following information:

- The initial performance test report (in the first Annual Report). The initial performance test report summarizes the effectiveness of the LFG treatment facility to control emissions as determined by the flare performance testing outlined in Section 3.2.2.4 and establishes the optimum range of the key operating parameter (flare stack temperature) for the following year.
- Summaries of the treatment system up time and down time, total throughput, and key operating parameter (inlet LFG flow and flare stack temperature) records.
- Summaries of the fugitive emissions monitoring excesses (landfill surface emission and GCCS component leak testing).

6.3.3. Miscellaneous LFG Reporting Requirements

In addition to the Annual Compliance Report, other reports that must be prepared and submitted for compliance with specific provisions of the ARARs include:

- A flare performance testing protocol (which is described in Section 3.2.2.4) will be prepared and submitted to the BAAQMD for review prior to testing and will include the following:
  - Advance notification of the scheduled test date and time and certified test laboratory to be used.
  - A complete test plan detailing all test methods to be used, the quantity and duration of samples, and the results to be obtained and reported.
- If the results of LFG monitoring indicate concentrations of methane or NMOC in excess of the limits identified in the RAOs, the operator shall comply with all applicable reporting and remediation control procedures required by Title 27 Cal. Code Regs. § 20937 and § 20939, including:
  - Immediately take all steps necessary to protect public health and safety and the environment, and notifying the California Department of Resources Recycling and Recovery (CalRecycle) or its Local Enforcement Agency (LEA) by telephone or electronic means.
  - Review and verify the monitoring data within 7 days of detecting methane or NMOC concentrations exceeding the limits identified in the RAOs (see Section 1.3.2).
  - Submit into the operating record and to the LEA a letter describing the concentrations of methane; the nature and extent of the problem based on information currently available; the steps taken to protect public health and safety and the environment; and any further corrective actions that need to be taken to adequately protect public health and safety and the environment prior to implementation of a remediation plan, as described in Title 27 Cal. Code Regs. § 20939.
  - Implement a remediation plan approved by CalRecycle or its LEA for the methane gas releases within 60 days of detection. Place a copy of the plan in the operating record and forward a copy of the plan to CalRecycle and the LEA, and notify the LEA that the plan has been implemented. The plan shall describe the nature and extent of the problem and the proposed remedy.
- All significant GMP maintenance, repair, and replacement activities (i.e., that modify the probe function or dimensions as approved in the most recent LFG monitoring plan) shall be reapproved by the regulatory agencies prior to implementation.

6.4. STORMWATER

As described in the Stormwater Discharge Management Plan Update (Accord MACTEC Joint Venture, 2012), an annual report will be submitted by July 1 of each year to the Water Board. In addition, annual monitoring reports will be available to the public and retained on site. The document and supporting materials will be made available upon request of a representative of the EPA, State Water Resources Control Board, Water Board, or local stormwater management agencies. Records will contain the names of the individuals; date, time, and place of the task; observation; inspection; and sample collection or measurement. The annual report should include the following components:

- A summary of improvements or modifications of best management practices
- Descriptions of all known releases to storm drains or San Francisco Bay
- A summary of the visual observations and sampling results
- An evaluation of the visual observation and sampling and analysis results
- Laboratory reports
- Method detection limits and analytical parameters; analytical results that are less than the detection limit of each analytical parameter will be reported as “less than the method detection limit”
- The annual comprehensive site compliance evaluation report
- Explanation of why a facility did not implement any activities required by the General Permit (if applicable and not already included in the evaluation report)
- Certification of the activity’s compliance or noncompliance with the requirements of the General Permit
- Any information on sampling and analysis exemptions and reductions
- A description of why sampling or visual observations could not be conducted (if appropriate)

Section 7. Changes to this Remedial Action Monitoring Plan

The Navy intends the monitoring strategies for groundwater, LFG, wetlands, and stormwater presented in this RAMP to be adaptable based on the data collected, in accordance with the EPA's Triad approach, to allow flexibility to optimize monitoring. The Navy will discuss the results of each monitoring program with the FFA signatories (and other interested regulatory agencies, such as CalRecycle for LFG monitoring and the California Department of Fish and Game for wetlands monitoring). The Navy may revise the list of monitoring locations to be sampled, the analytes measured, or the frequency of sampling based on the results of this RAMP, with the approval of the FFA signatories. The process for changing the RAMP, including procedures for data review and modification of plans for sampling, will follow the process described in the basewide groundwater monitoring program (CE2-Kleinfelder Joint Venture, 2008a). Sections 2, 3, 4, and 5 describe the initial monitoring periods for this RAMP. The need for monitoring beyond the initial periods will be evaluated based on the results of the initial periods. Results of groundwater, LFG, wetlands, and stormwater monitoring will support the ongoing 5-year review reports that will be prepared under CERCLA. Statutory 5-year reviews pursuant to CERCLA § 121 and the National Oil and Hazardous Substances Pollution Contingency Plan will be conducted because the selected remedy will leave contamination in place at Parcel E-2 above levels that allow for unrestricted use and unlimited exposure. Five-year reviews for Parcel E-2 will follow the ongoing schedule of 5-year reviews established for other remedies in place at HPNS.

Section 8. References

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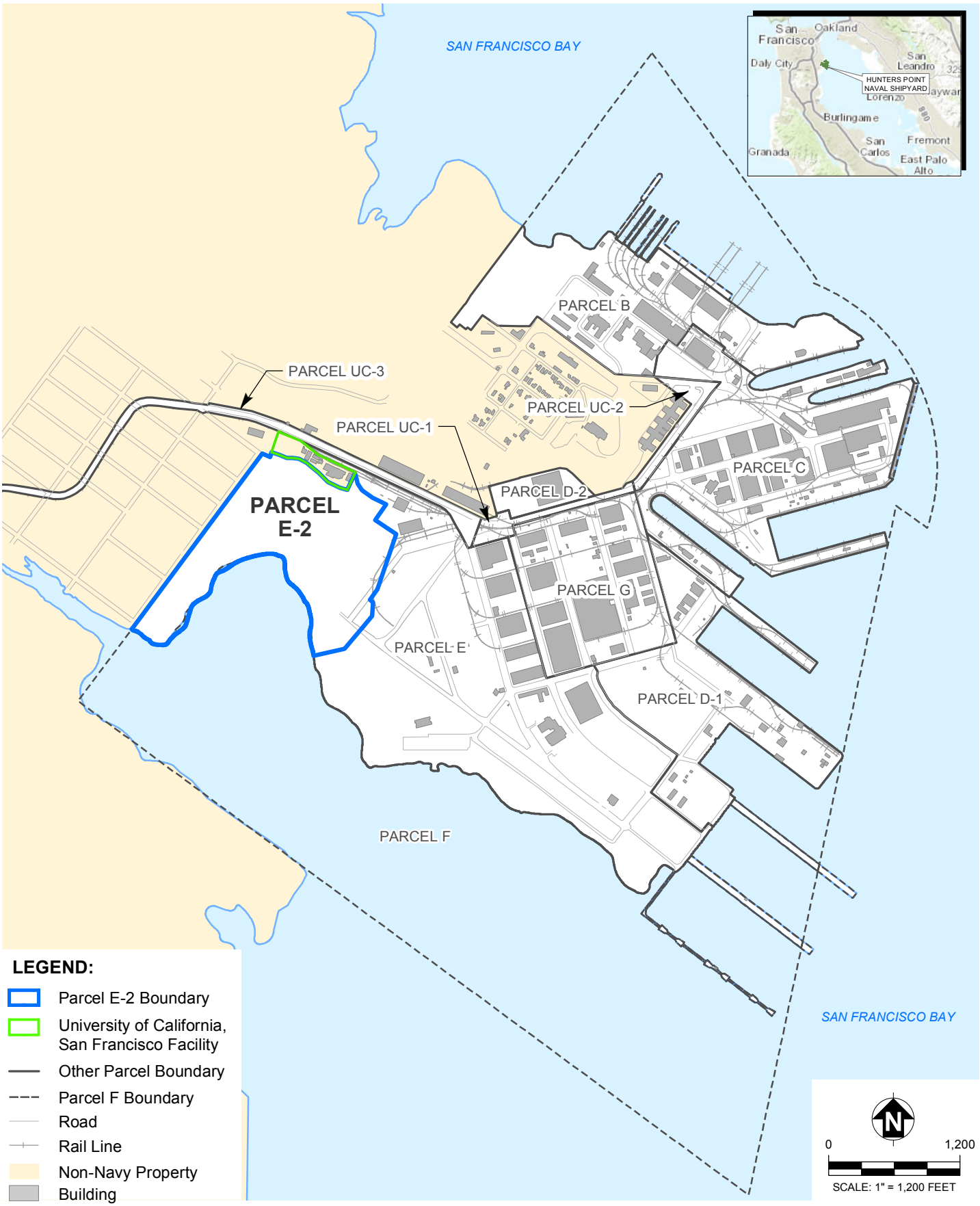
Figures



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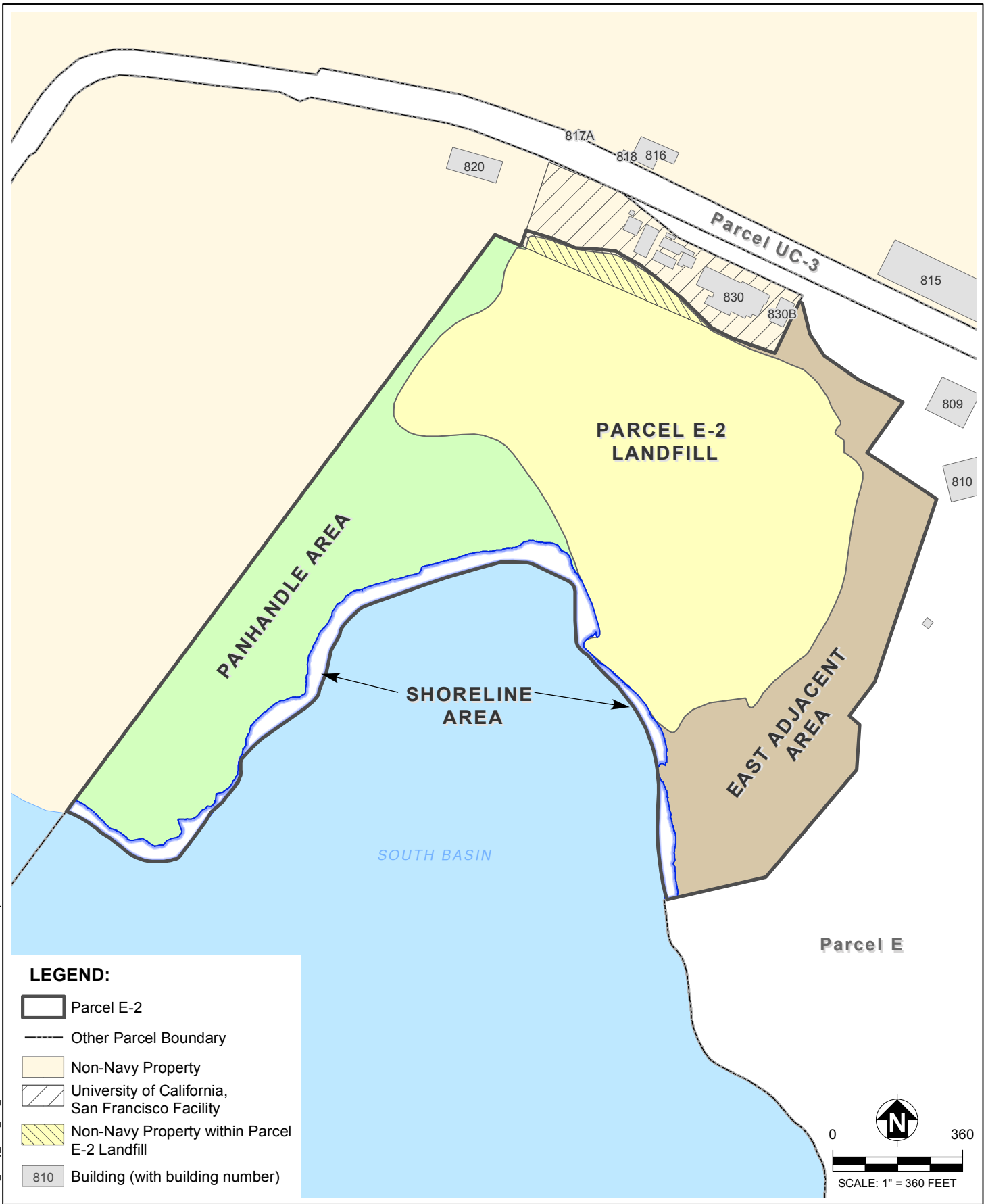
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 1



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ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PARCEL E-2 AREAS			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 2

Notes:

1. Point of compliance is the vertical surface located at the hydraulically downgradient limit of Parcel E-2 that extends through the B-aquifer.

2. In areas where the point of compliance is located in an area with tidal mixing (e.g. A-aquifer areas at Parcel E-2 shoreline), the point of monitoring was adjusted to ensure that groundwater quality is accurately monitored.

[a] Well proposed for monitoring groundwater upgradient of Parcel E-2.

[b] Well or piezometer designated for groundwater elevation only (no sampling).

[c] Well was decomissioned during previous removal action, and will be replaced for remedial action monitoring.

Well-specific analyte sampling list is provided in Table 7 of this RAMP.

Well IDs preceded by NMW indicate a proposed new monitoring well location.

Well IDs preceded by NPZ indicate a proposed new piezometer location.

Proposed monitoring well and piezometer locations will be named in accordance with site naming conventions when they are constructed.

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CLIENT:	GROUNDWATER MONITORING WELLS			
DEPARTMENT OF THE NAVY, BRAC PMO WEST				
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	EJ 02/20/13	25-049	3

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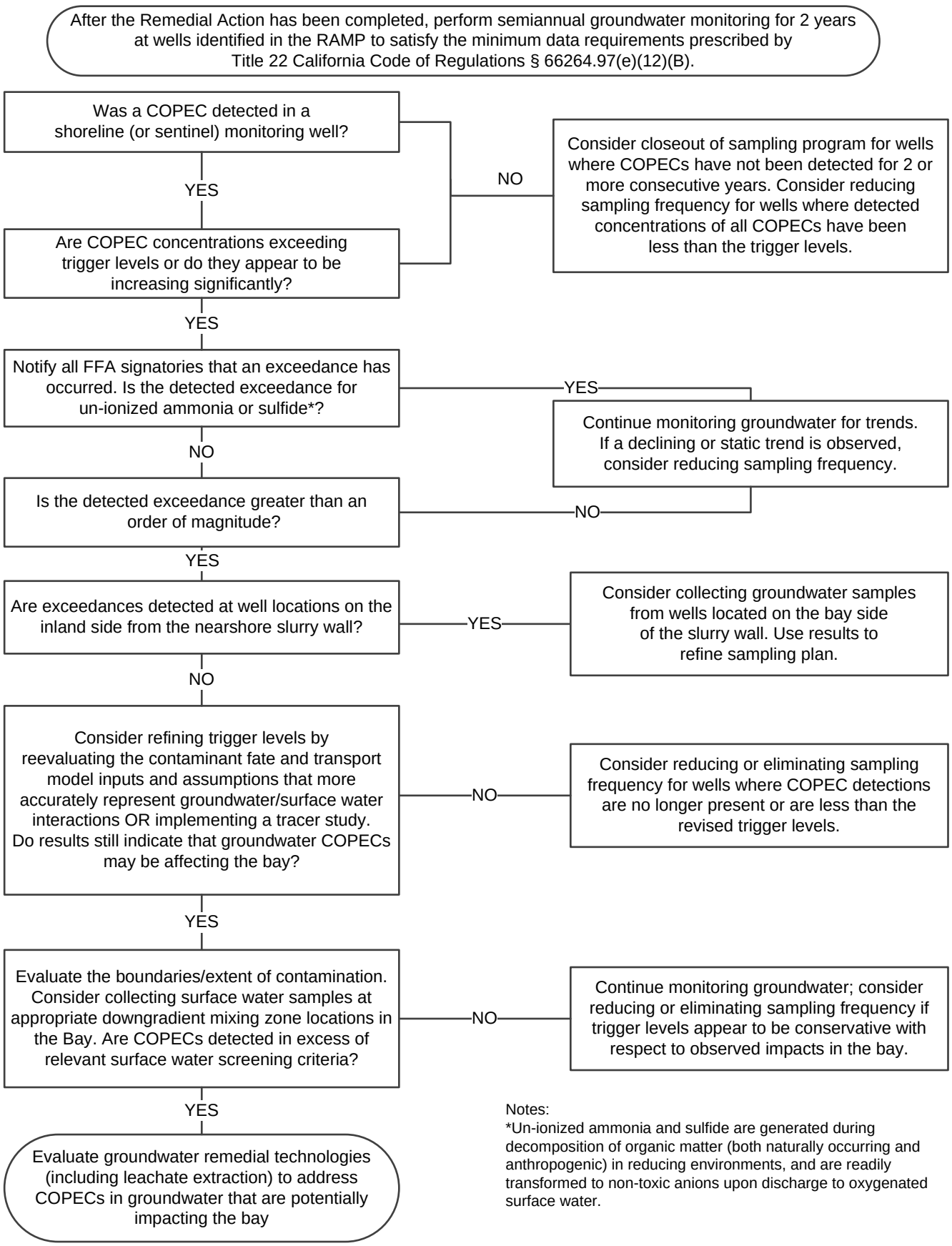

Notes:
*Un-ionized ammonia and sulfide are generated during decomposition of organic matter (both naturally occurring and anthropogenic) in reducing environments, and are readily transformed to non-toxic anions upon discharge to oxygenated surface water.

ERRG **Engineering/Remediation Resources Group, Inc.** 115 Sansome St., Suite 200 San Francisco, CA 94104	*CLIENT:* DEPARTMENT OF THE NAVY BRAC PMO WEST	*DRAWN BY:* AC 03/25/13	Groundwater Monitoring Approach for Impacts to San Francisco Bay					
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	*CHECKED BY:* JS 03/25/13						
		PE/PG: DB 03/25/13	*ERRG PROJECT NO.* 25-049	*REVISION NO.* 0	*SHEET* 1	*OF* 1	*FIG NO.* 4	

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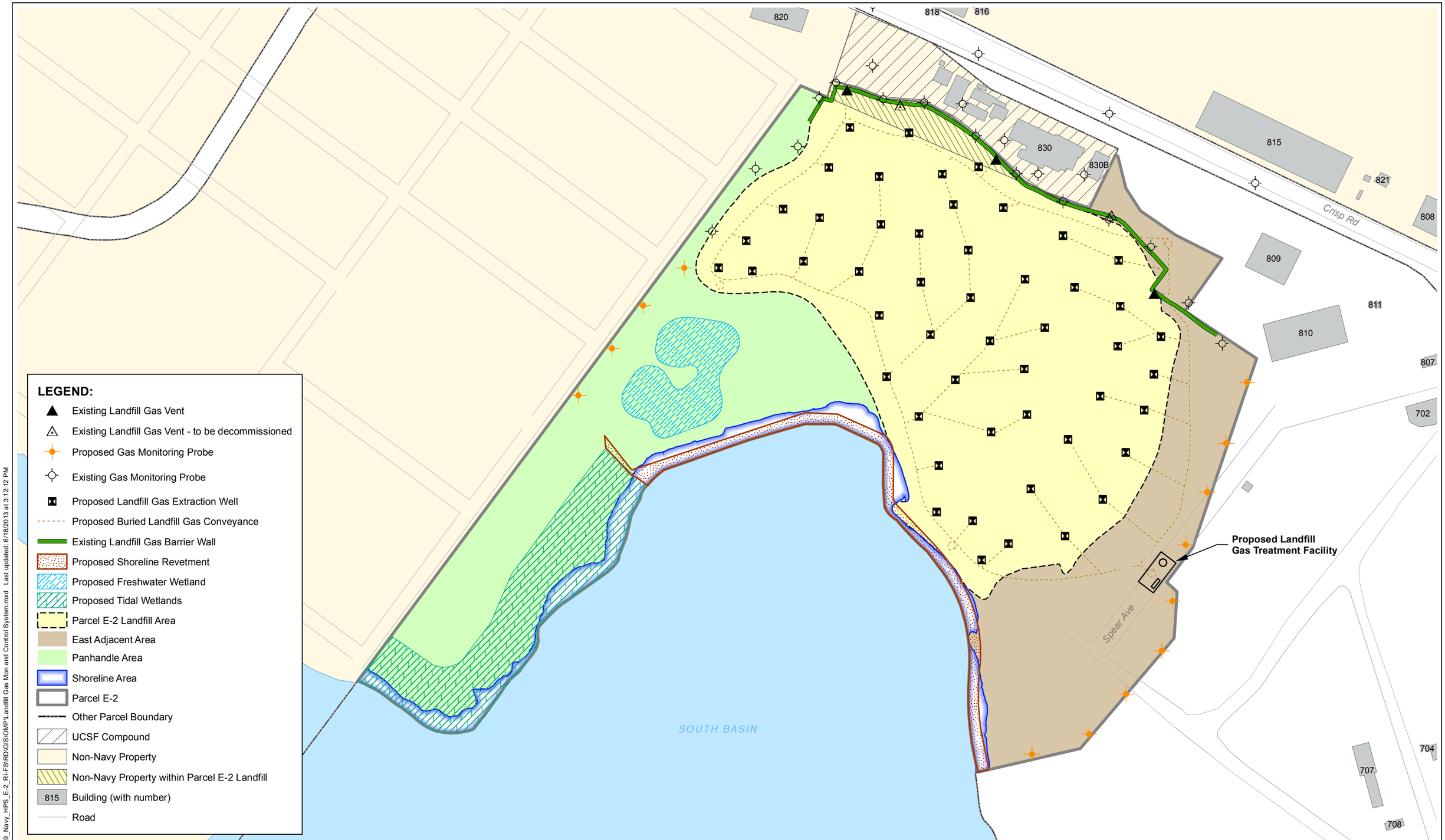

ERRG Engineering/Remediation Resources Group, Inc.
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CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	LANDFILL GAS MONITORING AND CONTROL SYSTEM		
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: JS 02/20/13	PROJECT NO. 25-049	FIG NO. 5

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0 240

SCALE: 1" = 240 FEET

ERRG Engineering/Remediation Resources Group, Inc.
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CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	STORMWATER MONITORING LOCATIONS			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 06/19/13	CHECKED BY: DB 06/19/13	PROJECT NO. 25-049	FIG NO. 6

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Tables

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a]

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Groundwater		
Safe Drinking Water Act (42 USC, ch. 6A, § 300[f] through 300[j]-26)[c]		
National primary drinking water standards are health-based standards for public water systems (MCLs).	40 CFR §§ 141.11 [excluding § 141.11(d)(3)], 141.13, 141.15, 141.16, 141.61(a) and (c), and 141.62(b)]	Design includes excavation and offsite disposal of areas designated as nearshore and upland hot spots and consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations as the RAOs presented in the ROD.
Clean Water Act (General Pretreatment Regulations)[b]		
POTW discharge permit details prohibited discharges, categorical standards, monitoring, and reporting requirements.	40 CFR Part 403	Design includes an active LFG extraction and treatment system that includes a condensate / knockout container and a landfill leachate monitoring network. Water and leachate generated from these remedies will be treated and discharged in accordance with the POTW discharge permit requirements.
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i])[b]		
Operate a leachate collection and removal system until leachate is no longer detected (this regulation does not require the installation of a leachate collection system).	Cal. Code Regs. tit. 22, § 66264.310(b)(2)	Design will accommodate the relevant and appropriate control of leachate as required based on the results of future groundwater monitoring. Design of south perimeter landfill cap termination includes a 6-inch collection pipe and leachate monitoring/extraction well at each end of the cap termination, and approximately every 200 feet between each end of nearshore cap. The collection pipe and leachate monitoring/extraction wells will be used for monitoring the subsurface drainage system and for future groundwater and leachate extraction.
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i])[b]		
After final closure, maintain and monitor the groundwater system and comply with all other applicable requirements of Article 6, Chapter 14.	Cal. Code Regs. tit. 22, § 66264.310(b)(3)	Design includes RAMP describing maintenance of the groundwater monitoring well network and monitoring of groundwater. Design includes requirements and guidelines for preparing an OMP that includes an emergency response plan. Monitoring wells located on the cover designed to be flush-mounted to minimize the risk of damage by vehicle traffic and vandalism.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Groundwater *(continued)*		
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i]) [b]		
COCs are the waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from the waste contained in the regulated unit.	Cal. Code Regs. tit. 22, § 66264.93	Design includes RAMP describing maintenance of the groundwater monitoring well network and monitoring of groundwater. Design includes requirements and guidelines for preparing an operations, maintenance, and monitoring plan that includes an emergency response plan. Monitoring wells located on the cover designed to be flush-mounted to minimize the risk of damage by vehicle traffic and vandalism
The POC is a vertical surface, located at the hydraulically downgradient limit of the waste management area that extends through the uppermost aquifer underlying the regulated unit.	Cal. Code Regs. tit. 22, § 66264.95	Design includes contamination of the regulated unit upgradient of the POC. The multilayer geosynthetic landfill cap, landfill perimeter drainage system, upland slurry wall, French drain, and nearshore slurry wall will adequately contain the landfill, ensure compliance with the RAOs, and adequately protect human health and the environment. Design includes modeling (using HELP3) of percolation through the multilayer geosynthetic cap and into the waste to estimate cover performance. Design includes groundwater modeling of the upland slurry wall and the nearshore slurry wall.
Owner or operator of will establish a groundwater monitoring system for each regulated unit and include a sufficient number of monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of groundwater passing the POC.	Cal. Code Regs. tit. 22, § 66264.97(b)(1)(A), (b)(1)(D)(1) and (b)(1)(D)(2)	Design includes RAMP describing maintenance of the groundwater monitoring well network and monitoring of groundwater. Design includes requirements and guidelines for preparing an OMP that includes an emergency response plan. Monitoring wells located on the cover designed to be flush-mounted to minimize the risk of damage by vehicle traffic and vandalism.
Requirements for monitoring well construction and sampling intervals.	Cal. Code Regs. tit. 22, § 66264.97(b)(4), (5), (6), and (7)	Design includes the protection of existing groundwater monitoring wells. Monitoring wells located on the cover designed to be flush-mounted to minimize the risk of damage by vehicle traffic and vandalism. Design includes RAMP describing maintenance of the groundwater monitoring well network and the monitoring of groundwater. Design includes requirements and guidelines for preparing an OMP that includes an emergency response plan.
Collection of groundwater samples.	Cal. Code Regs. tit. 22, § 66264.97(e)(6), (e)(12)(A), (e)(12)(B), (e)(13), and (e)(15)	Design includes the protection of existing groundwater monitoring wells during implementation of the remedy. Design includes RAMP describing maintenance of the groundwater monitoring well network and monitoring of groundwater. Design includes requirements and guidelines for preparing an OMP that includes an emergency response plan.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Groundwater *(continued)*		
State and Regional Water Quality Control Boards [c]		
Authorizes SWRCB and the Water Board to establish, in water quality control plans, beneficial uses and numerical and narrative standards to protect both surface water and groundwater quality.	California Water Code, div. 7, §§ 13241, 13243, 13263(a), 13269, and 13360	The Navy accepts the substantive provisions of these sections of the California Water Code as enabling legislation, as implemented through the beneficial uses, WQOs, waste discharge requirement, and promulgated policies of the San Francisco Basin Plan as ARARs. Design includes excavation and offsite disposal of areas designated as nearshore and upland hot spots and the consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations as the RAOs presented in the ROD.
Department of Toxic Substances Control [c] / State and Regional Water Quality Control Boards [c]		
State MCL list—Source of drinking water.	Cal. Code Regs. tit. 22, §§ 64431 and 64444	State MCLs are ARARs for containment of in-place waste within the Parcel E-2 Landfill and adjacent areas (Panhandle, East Adjacent, and Shoreline Areas) for which MCLs are state ARARs for groundwater in portions of the B-aquifer downgradient of the POC. Design includes excavation and offsite disposal of areas designated as nearshore and upland hot spots and consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations at the POC as the RAOs presented in the ROD.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Groundwater *(continued)*		
Department of Toxic Substances Control [c] / State and Regional Water Quality Control Boards [c]		
State secondary MCL list—Source of drinking water.	Cal. Code Regs. tit. 22, § 64449(a)	State secondary MCLs are ARARs for containment of in-place waste within the Parcel E-2 Landfill and adjacent areas (Panhandle, East Adjacent, and Shoreline Areas), for which MCLs are state ARARs for groundwater in portions of the B-aquifer downgradient of the POC. Design includes excavation and offsite disposal of areas designated as nearshore and upland hot spots and consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations at the POC as the RAOs presented in the ROD.
ARARs for Landfill Gas		
Clean Air Act (Title 42 USC § 7401 et seq.) [b]		
LFG system will not discharge into the atmosphere from any miscellaneous operation an emission containing more than 6.8 kilograms (15 pounds) per day and containing a concentration of more than 300 parts per million of total carbon on a dry basis.	BAAQMD Regulation 8, Rule 2	Design includes an active LFG abatement system to control LFG migration and to allow for long-term monitoring of gases generated by landfill waste. System and perimeter LFG monitoring network is incorporated into the design to allow for compliance with system and boundary sampling.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Landfill Gas		
Department of Toxic Substances Control [c] / State Water Resources Control Board [c] / California Department of Resources Recycling and Recovery		
This requirement controls release of methane.	Cal. Code Regs, tit. 27, § 20921(a)	Provides that methane must not exceed 1.25 percent by volume in air within onsite structures, and concentrations of methane migrating from the Parcel E-2 Landfill must not exceed 5 percent by volume in air at the property boundary (or an alternative boundary) in accordance with Cal. Code Regs, tit. 27, § 20925. Design includes an active LFG abatement system to control LFG migration and to allow for long-term monitoring of gases generated by landfill waste. System and perimeter LFG monitoring network is incorporated into the design to allow for compliance with system and boundary sampling. Design includes a RAMP that details monitoring of LFG, and a work plan with a sampling and analysis plan will be prepared that will establish the frequency of LFG monitoring during the operational life of the active system.
ARARs for Wetlands		
Clean Water Act, as Amended, § 404 (Title 33 USC § 1344) [b]		
These sections identify ecological performance standards and monitoring requirements for mitigation projects.	40 CFR §§ 230.95 and 230.96	Ecological performance standards and monitoring requirements will be incorporated, as appropriate, into site-specific mitigation plans for Parcel E-2.
This section identifies the long-term management methods for compensatory mitigation projects.	40 CFR § 230.97	Long-term management methods will be incorporated, as appropriate, into site-specific mitigation plans for Parcel E-2.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Wetlands *(continued)*		
McAteer-Petris Act (California Government Code §§ 66600 through 66661) [b]		
Reduce fill and disposal of dredged material in San Francisco Bay, maintain marshes and mudflats to the fullest extent possible to conserve wildlife, abate pollution, and protect the beneficial uses of the San Francisco Bay.	Bay Plan at Cal. Code Regs, tit. 14, §§ 10110 through 11990	The selected remedial design includes the requirement of a work plan, which includes a San Francisco Bay Water Monitoring Plan (SF-BWMP) specifying the monitoring requirements for nearshore excavations and revetment construction, and BMPs that will minimize the discharge of dredged or fill material into waters of the United States. The SF-BWMP for the proposed shoreline construction will comply with the specified discharge restrictions, will incorporate appropriate steps to minimize adverse impacts to waters of the United States, and will comply with the substantive provisions of the permit during implementation of the remedy. Design includes a Wetlands Mitigation and Monitoring Plan (WMMP) in accordance with the substantive provisions of the Bay Plan. The proposed cleanup and wetlands restoration will create conditions that have a higher ecological value relative to existing conditions. No mitigation is required for other (nonwetland) aquatic resources at Parcel E-2 that will be lost as part of the cleanup process The WMMP includes a monitoring program with biological and physical goals and success criteria for the restoration project.
Describes the water basins in the San Francisco Region, establishes beneficial uses of groundwater and surface water, and establishes WQOs, including narrative and numerical standards.	Comprehensive Water Quality Control Plan for the San Francisco Region (Basin Plan) Chapters 2 and 3 (California Water Code § 13240), except the MUN designation for the A-aquifer	The substantive groundwater provisions of Chapters 2 and 3 of the Basin Plan, except the MUN designation, are ARARs. According to the Basin Plan, which incorporates SWRCB Resolution 88-63, A-aquifer groundwater at Parcel E-2 is not a potential drinking water source. The only beneficial use of A-aquifer groundwater is freshwater replenishment of San Francisco Bay. B-aquifer groundwater has a moderate potential for use as a drinking water source. Design includes excavation and offsite disposal of areas designated as nearshore and upland hot spots and consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations at the POC as the RAOs presented in the ROD.

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Design Requirement	Citation[b]	Element to Address Basis of Design Criteria
ARARs for Surface Water		
Clean Water Act of 1977, as Amended (33 USC, ch. 26, §§ 1313–1314)[c]		
Surface water quality standards for discharges to waters of the United States.	40 CFR § 131.38	These standards, known as the CTR, are applicable surface water ARARs. The Navy has identified the CTR as ARARs for Parcel E-2 because groundwater and surface water bodies (i.e., new tidal and freshwater wetlands) discharge to San Francisco Bay. Design includes the excavation and offsite disposal of areas designated as nearshore and upland hot spots and consolidation of remaining waste under a multilayer geosynthetic cap to isolate the landfill from surface and groundwater to achieve the RAOs. The RAOs were established based on attainment of regulatory requirements, standards, and guidance; contaminated media; COCs and COPECs; potential receptors and exposure scenarios; and human health and ecological risks. Ultimately, the success of a remedial action is measured by its ability to meet the RAOs. Planned future land use is an important component in developing RAOs, and the RAOs for Parcel E-2 are based on future open space reuse. The RAOs for Parcel E-2 were developed in conjunction with the regulatory agencies. Design includes a RAMP that details monitoring of LFG, groundwater, and leachate formation downgradient of the landfill and specifies groundwater and surface water discharge limitations as the RAOs presented in the ROD.
State Water Resources Control Board [c]		
Surface water quality standards. Marine water with salinities equal to or greater than 10 parts per thousand (Table 3-3), and fresh water with salinities less than 1 parts per thousand (Table 3-4).	Basin Plan Tables 3-3 and 3-4	These standards are applicable surface water ARARs. The Navy has identified Tables 3-3 and 3-4 as ARARs for Parcel E-2 because groundwater and surface water bodies (i.e., new tidal and freshwater wetlands) discharge to the bay. The Navy will meet these ARARs in the bay, the interface of the A-aquifer (or surface water bodies) and the bay. These ARARs will also be applied to discharges to new tidal and freshwater wetlands at Parcel E-2. The Navy has identified MCLs as ARARs for the B-aquifer, which will be protective of any discharge of B-aquifer groundwater to the permeable zones underlying the bay. Therefore, these are not ARARs for the interface of the B-aquifer and the permeable zones underlying the bay.
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901-6991[i]) [b]		
Owner or operator will establish a surface water monitoring system for each regulated unit and include a sufficient number of monitoring points installed at appropriate locations and depths to yield samples that provide the best assurance of the earliest possible detection of a release from a regulated unit.	Cal. Code Regs. tit. 22, § 66264.97(c)(1) and (c)(2)(B)	Design includes requirement for implementation of a SWPPP, including stormwater BMPs, during construction to control suspended sediment migration off site and into waters of the United States. Design includes a perimeter French drain system surrounding the landfill to limit groundwater migration through waste. Design includes surface water runoff and erosion controls to minimize discharges of sediment and toxic substances that might adversely affect surface water quality. Finished cover will be designed to accommodate vegetation for erosion control. Cover to be seeded with native species mixture established by the Vegetative Establishment Plan within the OMP .

Table 1. ARARs for Groundwater, Landfill Gas, Wetlands, and Surface Water[a] *(continued)*

Notes:

a = Many action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables.

b = Only the substantive provisions of the requirements cited in this table are ARARs.

c = Statutes and policies and their citations are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Navy accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only pertinent substantive requirements of the specific citations are considered ARARs.

d = For waters in which the salinity is between 1 and 10 parts per thousand, the applicable objectives are the more stringent of the marine (Table 3-3) and freshwater (Table 3-4) objectives specified in the Basin Plan.

ARARs = applicable or relevant and appropriate requirements
BAAQMD = Bay Area Air Quality Management District
BMPs = best management practices
Cal. Code Regs. = California Code of Regulations
CFR = Code of Federal Regulations
ch. = Chapter
COCs = chemicals of concern
COPECs = chemicals of potential ecological concern
CTR = California Toxics Rule
div. = Division
LFG = landfill gas
MCLs = maximum contaminant levels
MUN = municipal
Navy = Department of the Navy
OMP = Operation and Maintenance Plan
POTW = publicly owned treatment works
RAMP = remedial action monitoring plan
RAOs = remedial action objectives
ROD = Record of Decision
SF-BWMP = San Francisco Bay Water Monitoring Plan
SWPPP = stormwater pollution prevention plan
SWRCB = State Water Resources Control Board
tit. = Title
USC = United States Code
Water Board = San Francisco Bay Regional Water Quality Control Board
WMMP = wetlands mitigation and monitoring plan
WQOs = water quality objectives
§ = Section

Table 2. Remediation Goals for Groundwater

Exposure Scenario	COC/COEC	Remediation Goal (µg/L)	Exposure Scenario	COC/COEC	Remediation Goal (µg/L)
Construction Worker Exposure to A-Aquifer Groundwater	Benzo(a)anthracene	0.67	Domestic Use of B-Aquifer Groundwater	Bis(2-ethylhexyl)phthalate	10
	Benzo(a)pyrene	0.05		beta-BHC	0.05
	Benzo(b)fluoranthene	0.45		Carbon tetrachloride	0.5
	Benzo(k)fluoranthene	0.45		Chloroform	80
	Dibenz(a,h)anthracene	0.05		Chromium VI	109
	Indeno(1,2,3-cd)pyrene	0.31		Chrysene	0.56
	Lead	15		Dibenz(a,h)anthracene	2
Domestic Use of B-Aquifer Groundwater	1,1-Dichloroethane	5		Dieldrin	0.02
	1,2,3-Trichloropropane	1		Heptachlor	0.01
	1,2-Dichloroethane	0.5		Heptachlor epoxide	0.01
	1,4-Dichlorobenzene	5		Heptachlor epoxide A	0.01
	4-Nitrophenol	3.4		Heptachlor epoxide B	0.01
	Aroclor-1016	0.5		Indeno(1,2,3-cd)pyrene	0.2
	Aroclor-1242	0.5		Iron	10,950
	Aroclor-1254	0.5		Lead	15
	Aroclor-1260	0.5		Methylene chloride	5
	Arsenic	10		Naphthalene	1
	Benzene	1		Tetrachloroethene	5
	Benzo(a)anthracene	0.2		Thallium	2
	Benzo(a)pyrene	0.2		Trichloroethene	5
	Benzo(b)fluoranthene	0.2		Vinyl chloride	0.5
	Benzo(k)fluoranthene	0.2	Wildlife in the bay	TPH (goals vary based on distance from the bay)[a]	1,400 to 20,000

Notes: The basis (risk-based, regulatory limit, or ambient level) for the remediation goals is presented in Sections 7 and 9 of the RI/FS Report.

a =The distance-based TPH criteria are as follows:

Distance from shoreline (feet)	TPH (µg/L)	Distance from shoreline (feet)	TPH (µg/L)
0–<25	1,400	125–<150	6,949
25–<50	1,467	150–<175	9,539
50–<75	2,092	175–<200	12,604
75–<100	3,216	200–<225	16,145
100–<125	4,839	≥225	20,000

BHC = benzene hexachloride

COC = chemical of concern

COEC = chemical of ecological concern

TPH = total petroleum hydrocarbons

µg/L = micrograms per liter

Table 3. Surface Water Screening Criteria *(continued)*

Analyte Monitored Under Hunters Point Shipyard Groundwater Program	San Francisco Bay Basin Plan[a] (µg/L)		California Toxics Rule Criteria for Enclosed Bays and Estuaries[e] (µg/L)								National Recommended Water Quality Criteria[k] (µg/L) Saltwater Aquatic Life					National Ambient Water Quality Criteria (AWQC) for Protection of Saltwater Aquatic Life[l] (µg/L) Lowest Observed Effect Level (LOEL)							Other Criteria (footnotes indicate source) (µg/L)		Surface Water Criteria Selected for Aquatic Evaluation (µg/L)
			Chronic[g]		Acute[g]			Instantaneous Maximum			Chronic[g]		Acute[g]			Chronic[h]		Acute[i]			Other[j]				
	Concentration	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	10% of Concentration[f]	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	Footnotes	Other	Footnotes	
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31,200	6,240	--	--	--	--	--	6,240
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9,020	1,804	--	--	--	--	--	1,804
1,1-Dichloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	224,000	44,800	(27)	--	--	--	--	44,800
1,2,4,5-Tetrachlorobenzene	--	--	--	--	--	--	--	--	--	--		--	--	--	--	129	(22)	160	--	(22)	--	--	--	--	129
1,2,4-Trichlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	129	(22)	160	--	(22)	--	--	--	--	129
1,2-Dichlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	129	(22)	1,970	--	(24)	--	--	--	--	129
1,2-Dichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	113,000	22,600	--	--	--	--	--	22,600
1,2-Dichloroethene (total)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	224,000	44,800	(27)	--	--	--	--	44,800
1,2-Dichloropropane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,040	(28)	10,300	--	(28)	--	--	--	--	3,040
1,3-Dichlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	129	(22)	1,970	--	(24)	--	--	--	--	129
1,3-Dichloropropene (total)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	790	158	(29)	--	--	--	--	158
1,4-Dichlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	129	(22)	1,970	--	(24)	--	--	--	--	129
2,4-Dinitrophenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,850	970	(88)	--	--	--	--	970
2,4-Dinitrotoluene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	590	118	(53)	370	(53, 82)	--	--	118
2,6-Dinitrotoluene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	590	118	(53)	370	(53, 82)	--	--	118
2-Chloronaphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.5	1.5	(48)	--	--	--	--	1.5
2-Nitrophenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,850	970	(88)	--	--	--	--	970
4,4'-DDD	--	--	--	--	--	--	--	--	--	--	0.001	(114,172)	--	--	--	--	--	3.6	0.72	--	--	--	--	--	0.001
4,4'-DDE	--	--	--	--	--	--	--	--	--	--	0.001	(114,172)	--	--	--	--	--	14	2.8	--	--	--	--	--	0.001
4,4'-DDT	--	--	0.001	(114)	--	--	--	0.13	--	--	0.001	,aa,ii,(114, 17	0.13	--	G,ii	--	--	--	--	--	--	--	--	--	0.001
4,6-Dinitro-2-methylphenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,850	970	(88)	--	--	--	--	970
4-Amino-2,6-dinitrotoluene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	590	118	--	370	(82)	--	--	118
4-Nitrophenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4,850	970	(88)	--	--	--	--	970
Acenaphthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	710	--	970	--	--	--	--	--	--	710
Acenaphthylene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Aldrin	--	--	--	--	--	--	--	1.3	--	II	--	--	1.3	0.26	G	--	--	--	--	--	--	--	--	--	0.26
Alpha-chlordane	--	--	0.004	(114)	--	--	--	0.09	--	--	0.004	G,aa,o	0.09	--	G,o	--	--	--	--	--	--	--	--	--	0.004
Ammonia (un-ionized)	25	s	--	--	--	--	--	--	--	--	35	(112)	223	--	(112)	--	--	--	--	--	--	--	400	t	25
Anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Aroclor 1016	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1221	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1232	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1242	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1248	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1254	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Aroclor 1260	--	--	0.03	(114, 116) rr	--	--	--	--	--	--	0.03	(114,173)	--	--	--	--	--	10	2	--	--	--	--	--	0.03
Arsenic	36	b	36	(142, 1) oo	69	--	oo	--	--	--	36	(1) A,D,bb	69	--	(1) A,D,bb	--	--	--	--	--	--	--	--	--	36
Atrazine	--	--	--	--	--	--	--	--	--	--	17	r,(68, 179)	760	--	r,(68, 179)	--	--	--	--	--	--	--	--	--	17
Benzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,100	1,020	--	700	(83)	--	--	700
Benzo(a)anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Benzo(b)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Benzo(g,h,i)perylene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Benzo(k)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Bromochloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	--	--	--	--	6,400
Bromodichloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	--	--	--	--	6,400
Bromoform	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	--	(20, 82)	--	--	6,400
Bromomethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	--	(20, 82)	--	--	6,400
Butylbenzylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,944	589	(45)	3.4	(38, 45)	--	--	3.4
Cadmium	9.3	b	9.3	(1, 142)	42	--	(1, 142)	--	--	--	8.8	D,bb,gg	40	--	D,bb,gg	--	--	--	--	--	--	--	--	--	8.8
Carbon tetrachloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	50,000	--	--	11,500	(20, 82)	--	--	6,400
Chlordane		--	0.004	(114)	--	--	--	0.09	--	--	0.004	G,aa	0.09	--	G	--	--	--	--	--	--	--	--	--	0.004
Chlorobenzene	--	--	--	--	--		--				--	--	--	--	--	129	(22)	160	--	(22)	--	--	--	--	129
Chloroform	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	11,500	(20, 82)	--	--	6,400
Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	11,500	(20, 82)	--	--	6,400
Chromium VI	50 (VI)	b,o	50 (VI)	o, (1, 142)	1100 (VI)	--	(1,142)	--	--	--	50 (VI)	(1) D,bb,o	1100 (VI)	--	(1) D,bb,o	--	--	--	--	--	--	--	--	--	50
Chrysene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Cis-1,2-dichloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	224,000	44,800	(27)	--	--	--	--	44,800
Copper	3.1	e	3.1	oo	4.8	--	oo	--	--	--	3.1	D,cc,ff	4.8	--	(1) D,cc,ff	--	--	--	--	--	--	--	--	--	3.1
Cyanide	1	e	1	pp	1	--	pp	--	--	--	1	(137) Q,bb	1	--	(137) Q,bb	--	--	--	--	--	--	--	--	--	1
Dibenz(a,h)anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Dibromochloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	11,500	(20, 82)	--	--	6,400
Dichlorodiflouromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	11,500	(20, 82)	--	--	6,400
Dieldrin	--	--	0.0019	(114), II	--	--	--	0.71	--	II	0.0019	(114) G,aa	0.71	--	G	--	--	--	--	--	--	--	--	--	0.0019
Diethylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,944	589	(45)	3.4	(38, 45)	--	--	3.4
Dimethylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,944	589	(45)	3.4	(38, 45)	--	--	3.4
Di-n-butylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,944	589	(45)	3.4	(38, 45)	--	--	3.4
Di-n-octylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,944	589	(45)	3.4	(38, 45)	--	--	3.4
Endosulfan I	--	--	0.0087	(114, 115), II	--	--	--	0.034	--	(115), II	0.0087	G,Y,o	0.034	--	G,Y,o	--	--	--	--	--	--	--	--	--	0.0087
Endosulfan II	--	--	0.0087	(114, 115), II	--	--	--	0.034	--	(115), II	0.0087	G,Y,o	0.034	--	G,Y,o	--	--	--	--	--	--	--	--	--	0.0087
Endrin	--	--	0.0023	(114), II	--	--	--	0.037	--	II	0.0023	(114) G,aa	0.037	--	G	--	--	--	--	--	--	--	--	--	0.0023
Ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	430	86	--	--	--	--	--	86
Fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	40	--	--	--	--	--	--	16

Table 3. Surface Water Screening Criteria *(continued)*

Analyte Monitored Under Hunters Point Shipyard Groundwater Program	San Francisco Bay Basin Plan[a] (µg/L)		California Toxics Rule Criteria for Enclosed Bays and Estuaries[e] (µg/L)								National Recommended Water Quality Criteria[k] (µg/L) Saltwater Aquatic Life					National Ambient Water Quality Criteria (AWQC) for Protection of Saltwater Aquatic Life[l] (µg/L) Lowest Observed Effect Level (LOEL)							Other Criteria (footnotes indicate source) (µg/L)		Surface Water Criteria Selected for Aquatic Evaluation (µg/L)
			Chronic[g]		Acute[g]			Instantaneous Maximum			Chronic[g]		Acute[g]			Chronic[h]		Acute[i]			Other[j]				
	Concentration	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	10% of Concentration[f]	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	Footnotes	Concentration	20% of Concentration[f]	Footnotes	Concentration	Footnotes	Other	Footnotes	
Fluorene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Gamma-BHC (lindane)	--	--	--	--	--	--	--	0.16	0.016	II	--	--	0.16	0.032	G	--	--	--	--	--	--	--	--	--	0.032
Gamma-chlordane	--	--	0.004	(114)	--	--	--	0.09	0.009	--	0.004	G,aa,o	0.09	--	G,o	--	--	--	--	--	--	--	--	--	0.004
Heptachlor	--	--	0.0036	(114)	II	--	--	0.053	0.005	II	0.0036	(114) G,aa	--	--	--	--	--	--	--	--	--	--	--	--	0.0036
Heptachlor epoxide	--	--	0.0036	(114)	II		--	0.053	0.005	II	0.0036	(114) G,V,aa	--	--	--	--	--	--	--	--	--	--	--	--	0.0036
Hexachlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	129	(22)	160	--	(22)	--	--	--	--	129
Hexachlorobutadiene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	6.4	--	--	--	--	--	6.4
Hexachlorocyclopentadiene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.0	1.4	--	--	--	--	--	1.4
Hexachloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	940	188	--	--	--	--	--	188
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Isophorone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12,900	2,580	--	--	--	--	--	2,580
Lead	8.1	b	8.1	(1, 142), m	210	--	(1, 142), m	--	--	--	8.1	(1) D,bb	210	--	(1) D,bb	--	--	--	--	--	--	--	--	--	8.1
Mercury	0.025	b	--	--	--	--	--	--	--	--	0.94	D,ee,hh	1.8	--	D,ee,hh	--	--	--	--	--	--	--	--	--	0.025
Methoxychlor	--	--	--	--	--	--	--	--	--	--	0.03	F	--	--	--	--	--	--	--	--	--	--	--	--	0.03
Methyl-tert-butyl-ether	--	--	--	--	--	--	--	--	--	--	18,000	--	53,000	--	--	--	--	--	--	--	--	--	8,000	p	8,000
Methylene chloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,400	(20)	12,000	--	(20)	11,500	(20, 82)	--	--	6,400
Mirex	--	--	--	--	--	--	--	--	--	--	0.001	F	--	--	--	--	--	--	--	--	--	--	--	--	0.001
Naphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,350	470	--	--	--	--	--	470
Nickel	8.2	b	8.2	(2, 142), oo	74	--	(1, 142), oo	--	--	--	8.2	(1, 142) D,bb	74	--	(1, 142) D,bb	--	--	--	--	--	--	--	--	--	8.2
Nitrobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,680	1,336	--	--	--	--	--	1,336
N-Nitroso-di-methylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,300,000	660,000	(56)	--	--	--	--	660,000
N-Nitroso-di-n-propylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,300,000	660,000	(56)	--	--	--	--	660,000
N-nitrosodiphenylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,300,000	660,000	(56)	--	--	--	--	660,000
Pentachlorophenol	--	--	7.9	--	13	--	--	--	--	--	7.9	bb	13	--	bb	--	--	--	--	--	--	--	--	--	7.9
Phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Phenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,800	1,160	--	--	--	--	--	1,160
Pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	300	60	(52)	--	--	--	--	60
Selenium	--	--	71	(1, 142)	290	--	(1, 142)	--	--	--	71	l, 136) D,bb,d	290	--	(1) D,bb,dd	--	--	--	--	--	--	--	--	--	71
Silver	1.9	c	--	--	1.9	0.38	(1, 142)	--	--	--	--	--	1.9	0.38	D,G	--	--	--	--	--	--	--	--	--	0.38
Sulfide-Hydrogen sulfide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	(51)	2
Tetrachloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	450	--	10,200	--	--	--	--	--	--	450
Thallium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,130	426	--	--	--	--	--	426
Toluene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,000	--	6,300	--	--	--	--	--	--	5,000
Toxaphene	--	--	0.0002	--	0.21	--	--	--	--	--	0.0002	aa	0.21	--	--	--	--	--	--	--	--	--	--	--	0.0002
TPH-Diesel	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,400 - 20,000	q,v	1,400 - 20,000
TPH-Gasoline	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,400 - 20,000	q,v	1,400 - 20,000
TPH-Motor Oil	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,400 - 20,000	q,v	1,400 - 20,000
trans-1,2-Dichloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	224,000	44,800	(27)	--	--	--	--	44,800
Tributyl Tin	--	--	--	--	--	--	--	--	--	--	0.0047	--	0.42	--	--	--	--	--	--	--	--	--	--	--	0.0047
Trichloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,000	400	--	--	--	--	--	400
Zinc	81	b	81	mm, oo	90	--	mm, oo	--	--	--	81	(1) D,bb	90	--	(1) D,bb	--	--	--	--	--	--	--	--	--	81

Notes:

Footnotes and references are detailed below.

--	No criterion available	DDD	Dichlorodiphenyldichloroethane	Fed Reg	Federal Register
µg/L	Microgram per liter	DDE	Dichlorodiphenyldichloroethene	RWQCB	Regional Water Quality Control Board, San Francisco Bay
CFR	Code of Federal Regulations	DDT	Dichlorodiphenyltrichloroethane	TPH	Total petroleum hydrocarbons
BHC	Hexachlorocyclohexane	EPA	U.S. Environmental Protection Agency	TtEMI	Tetra Tech EM, Inc.

Footnotes:

a	California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region (RWQCB). 2007. "San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)." January. Table 3-3 Marine Water Quality Objectives for Toxic Pollutants for Surface Waters.
b	From RWQCB "Basin Plan" 4-Day Average (Chronic)
c	From RWQCB "Basin Plan" 24-Hour and 1-Hour Average (Acute)
d	From RWQCB "Basin Plan" Instantaneous Maximum
e	From "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (CTR) (EPA 2000) and "Water Quality Control Plan, San Francisco Bay Basin Region" (RWQCB 2007a). The most appropriate criteria were used.
f	Criterion made more suitably protective by means of standard convention of lowering acute values by 80 percent and instantaneous values by 90 percent to make them more appropriate for use under chronic exposure scenarios.
g	An acute criterion (EPA identified as Criteria Maximum Concentration [CMC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The chronic concentration (EPA identified as Criterion Continuous Concentration [CCC]) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The CMC and CCC are just two of the six parts of an aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedence, and chronic frequency of allowed exceedence. Because 304(a) aquatic life criteria are national guidance, they are intended to be protective of the vast majority of the aquatic communities in the United States.
h	EPA National "AWQC Lowest Observed Effect Level (Chronic)" (RWQCB 2007b)
i	EPA National "AWQC Lowest Observed Effect Level (Acute)" (RWQCB 2007b)
j	EPA National "AWQC Lowest Observed Effect Level (Other)" (RWQCB 2007b)
k	From "National Recommended Water Quality Criteria" (EPA 2006), unless otherwise noted.
l	From "Final Technical Memorandum Estimation of Ambient Concentrations of Metals in Groundwater" (TtEMI 2001)
m	In instances where criteria from "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000) refer to the "Water Quality Control Plan, San Francisco Bay Basin Region" (RWQCB 2006), RWQCB 2006 criteria were used.
o	Detailed application of this toxicity criterion may require the review and/or summation of analyte isomer, congener, or speciation results, as applicable. Please see applicable regulatory agency source document for additional detail.
p	RWQCB 1998
q	TtEMI 1999
r	RWQCB 2007b
s	From RWQCB 2007a, "Basin Plan" Annual Median
t	From RWQCB 2007a "Basin Plan" Maximum, Lower Bay
u	EPA National "AWQC for Saltwater Aquatic Life Protection, Recommended Criteria, Continuous Concentration (4-Day Average)" (RWQCB 2007b)
v	Total TPH aquatic criteria assigned as a function of distance from shoreline; the source of these criteria is the "Final New Preliminary Screening Criteria and Petroleum Program Strategy, Hunters Point Shipyard, San Francisco, California." December 21. (Shaw Environmental, Inc. 2007)

Table 3. Surface Water Screening Criteria *(continued)*

Footnotes (Continued):

The following lettered footnotes are derived from EPA "National Recommended Water Quality Criteria" (EPA 2006), Table 1 - Priority Toxic Pollutants (unless otherwise noted):

A	This recommended water quality criterion was derived from data for arsenic (III), but is applied here to total arsenic, which might imply that arsenic (III) and arsenic (V) are equally toxic to aquatic life and that their toxicities are additive. In the arsenic criteria document (EPA 440/5-84-033, January 1985), Species Mean Acute Values are given for both arsenic (III) and arsenic (V) for five species and the ratios of the SMAVs for each species range from 0.6 to 1.7. Chronic values are available for both arsenic (III) and arsenic (V) for one species; for the fathead minnow, the chronic value for arsenic (V) is 0.29 times the chronic value for arsenic (III). No data are known to be available concerning whether the toxicities of the forms of arsenic to aquatic organisms are additive.
B	This criterion has been revised to reflect The Environmental Protection Agency's q1* or RfD (Reference Dose), as contained in the Integrated Risk Information System (IRIS) as of May 17, 2002. The fish tissue bioconcentration factor (BCF) from the 1980 Am
C	This criterion is based on carcinogenicity of 10^{-6} risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10^{-5}, move the decimal point in the recommended criterion one place to the right).
D	Freshwater and saltwater criteria for metals are expressed in terms of the dissolved metal in the water column. The recommended water quality criteria value was calculated by using the previous 304(a) aquatic life criteria expressed in terms of total recoverable metal, and multiplying it by a conversion factor (CF). The term "Conversion Factor" (CF) represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. (Conversion Factors for saltwater CCCs are not currently available. Conversion factors derived for saltwater CMCs have been used for both saltwater CMCs and CCCs). See "Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria,@ October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water, available from the Water Resource center, USEPA, 401 M St., SW, mail code RC4100, Washington, DC 20460; and 40CFR'131.36(b)(1). Conversion Factors applied in the table can be found in Appendix A to the Preamble- Conversion Factors for Dissolved Metals.
F	Freshwater aquatic life values for pentachlorophenol are expressed as a function of pH, and are calculated as follows: CMC = exp(1.005(pH)-4.869); CCC = exp(1.005(pH)-5.134). Values displayed in table correspond to a pH of 7.8.
G	This Criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80- 019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047), Heptachlor (EPA 440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a CMC derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.
N	This criterion applies to total polychlorinated biphenyls (e.g. the sum of all congener or all isomer or homolog or Aroclor analyses.)
Q	This recommended water quality criterion is expressed as mg free cyanide (as CN)/L.
S	This recommended water quality criterion for arsenic refers to the inorganic form only.
U	The organoleptic effect criterion is more stringent than the value for priority toxic pollutants.
V	This value was derived from data for heptachlor, and the criteria document provides insufficient data to estimate the relative toxicities of heptachlor and heptachlor epoxide.
Y	This value was derived from data for endosulfan and is most appropriately applied to the sum of alpha-endosulfan and beta-endosulfan.
aa	This criterion is based on a 304(a) aquatic life criterion issued in 1980 or 1986, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endrin (EPA 440/5-80-047), Heptachlor (EPA 440/5-80-052), Polychlorinated biphenyls (EPA 440/5-80-068), Toxaphene (EPA 440/5-86-006). This CCC is currently based on the Final Residue Value (FRV) procedure. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60FR15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria. Therefore, the Agency anticipates that future revisions of this CCC will not be based on the FRV procedure.
bb	This water quality criterion is based on a 304(a) aquatic life criterion that was derived using the 1985 Guidelines (Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses, PB85-227049, January 1985) and was issued in one of the following criteria documents: Arsenic (EPA 440/5-84-033), Cadmium (EPA-822-R-01-001), Chromium (EPA 440/5-84-029), Copper (EPA 440/5-84-031), Cyanide (EPA 440/5- 84-028), Lead (EPA 440/5-84-027), Nickel (EPA 440/5-86-004), Pentachlorophenol (EPA 440/5-86-009), Toxaphene, (EPA 440/5-86-006), Zinc (EPA 440/5-87- 003).
cc	When the concentration of dissolved organic carbon is elevated, copper is substantially less toxic, and use of Water-Effect Ratios might be appropriate.
dd	The selenium criteria document (EPA 440/5-87-006, September 1987) provides that if selenium is as toxic to saltwater fishes in the field as it is to freshwater fishes in the field, the status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 Fg/L in salt water because the saltwater CCC does not take into account uptake via the food chain.
ee	This recommended water quality criterion was derived on page 43 of the mercury criteria document (EPA 440/5-84-026, January 1985). The saltwater CCC of 0.025 ug/L given on page 23 of the criteria document is based on the Final Residue Value procedure in the 1985 Guidelines. Since the publication of the Great Lakes Aquatic Life Criteria Guidelines in 1995 (60FR15393-15399, March 23, 1995), the Agency no longer uses the Final Residue Value procedure for deriving CCCs for new or revised 304(a) aquatic life criteria.
ff	This recommended water quality criterion was derived in *Ambient Water Quality Criteria Saltwater Copper Addendum* (draft, April 14, 1995) and was promulgated in the Interim final National Toxics Rule (60 FR 22228-222237, May 4, 1995).
gg	EPA is actively working on this criterion, and so this recommended water quality criterion may change substantially in the near future.
hh	This recommended water quality criterion was derived from data for inorganic mercury (II), but is applied here to total mercury. If a substantial portion of the mercury in the water column is methylmercury, this criterion will probably be under protective. In addition, even though inorganic mercury is converted to methylmercury and methylmercury bioaccumulates to a great extent, this criterion does not account for uptake via the food chain because sufficient data were not available when the criterion was derived.
ii	This criterion applies to DDT and its metabolites (that is, the total concentration of DDT and its metabolites should not exceed this value.)

The following lettered footnotes are derived from EPA "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California" (EPA 2000).

jj	Criteria revised to reflect the EPA q1* or RfD, as contained in the Integrated Risk of RfD, as contained in the IRIS as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case (originally footno
kk	Criteria are based on carcinogenicity of 10 (-6) risk. (Originally footnote c in CTR)
ll	This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5–80–019), Chlordane (EPA 440/5–80–027), DDT (EPA 440/5–80–038), Endosulfan (EPA 440/5–80–046), Endrin (EPA 440/5–80–047), Heptachlor (440/5–80–052), Hexachlorocyclohexane (EPA 440/5–80–054), Silver (EPA 440/5–80–071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a ''CMC'' derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines (originally footnote g in the CTR).
mm	Criteria for these metals are expressed as a function of the water-effect ratio (WER) (originally footnote i in the CTR).
nn	No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document (originally footnote j in the CTR).
oo	These freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in § 131.36(b)(1) and (2) (originally footnote m in the CTR).
pp	These criteria were promulgated for specific waters in California in the National Toxics Rule (''NTR''), at § 131.36. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries and waters of the State defined as inland, i.e., all surface waters of the State not ocean waters. These waters specifically include the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for this criterion (originally footnote o in the CTR).
qq	These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply included: Waters of the State defined as bays or estuaries including the San Francisco Bay upstream to and including Suisun
rr	PCBs are a class of chemicals that include Aroclors 1242,1254,1221,1232,1248,1260, and 1016. The aquatic life criteria apply to the sum of this set of seven Aroclors (originally footnote u in the CTR).
ss	This criterion has been recalculated pursuant of all congener or isomer or homolog or Aroclor analyses.

The following numbered footnotes are derived from "A Compilation of Water Quality Goals" (RWQCB 2007b). These footnotes directly correlate with the source document.

1	Expressed as dissolved
2	Expressed as total recoverable.
2	Expressed as total recoverable
6	Pentavalent arsenic [As(V)] effects on plants.
18	Applies separately to Endrin and Endrin aldehyde.
20	For halomethanes
22	For chlorinated benzenes
23	Toxicity to a fish species exposed for 7.5 days
24	For dichlorobenzenes
27	For dichloroethylenes
28	For dichloropropanes
29	For dichloropropenes
38	Toxicity to algae occurs
45	For sum of phthalate esters
48	For chlorinated naphthalenes
51	From U.S. Environmental Protection Agency, *Quality Criteria for Water* (1976) "The Red Book," and also appears in current list of recommended criteria.
52	For polynuclear aromatic hydrocarbons
53	For dinitrotoluenes
56	For nitrosamines
68	Draft / tentative / provisional; applies only to second value if two separate values are listed; applies to range if a range of values is listed.
82	A decrease in the number of algal cells occurs.
83	Adverse effects on a fish species exposed for 168 days.
88	For nitrophenols
95	For the pentavalent form
113	Based on carcinogenicity at 1-in-a-million risk level.
114	Developed as 24-hour average using 1980 EPA guidelines, but applied as 4-day average in the National Toxics Rule.

Table 3. Surface Water Screening Criteria *(continued)*

Footnotes (Continued):

115	Criterion most appropriately applied to the sum of alpha-endosulfan and beta-endosulfan.
116	Applies separately to Aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016; based on carcinogenicity at 1-in-a-million risk level.
136	Draft Chronic Criterion: The concentration of selenium in whole-body fish tissue should not exceed 7.91 ug/g dw (dry weight). In addition, if whole-body fish tissue concentrations exceed 5.85 ug/g dw during summer or fall, fish tissue should be monitored during the winter to determine whether the selenium concentration exceeds 7.91 ug/g dw.
137	Expressed as free cyanide (as CN).
140	Criterion derived from data for inorganic mercury (II), but is applied to total mercury. It will probably be underprotective if a substantial portion of mercury in the water column is methylmercury. Derivation of criterion did not consider exposure through the diet, which is probably important for aquatic life occupying upper trophic levels.
142	Criteria do not apply to waters subject to water quality objectives in Tables III-2A and III-2B of the San Francisco Bay Regional Water Quality Control Board's 1986 Basin Plan.
143	These criteria were promulgated for specific California waters in the National Toxics Rule.
144	The ambient level was set at or below the minimum reported detection limit.
145	The ambient concentration represents the 95th percentile of the distribution. Additionally, the 95th percentile of the distribution was calculated using distribution dependent formulae. For normal and lognormal distributions, the 95th percentile calcula

References:

Gilbert, R.O. 1987 *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York.

Regional Water Quality Control Board (RWQCB). 1998. "Recommended Interim Water Quality Objectives (or Aquatic Life Criteria) for Methyl Tertiary-Butyl Ether (MTBE)." San Francisco Bay Region. October 1.

RWQCB. 2007a. "San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan)." San Francisco Bay Region. January.

RWQCB. 2007b. "A Compilation of Water Quality Goals." Prepared by Jon B. Marshack, Central Valley Region. August.

Shaw Environmental, Inc. 2007. "Final New Preliminary Screening Criteria and Petroleum Program Strategy, Hunters Point Shipyard, San Francisco, California." December 21.

TtEMI 1999. "Draft Remedial Investigation Report, Site 12 Operable Unit, Naval Station Treasure Island, San Francisco, California." June 1.

TtEMI 2001. "Final Technical Memorandum Estimation of Ambient Concentrations of Metals in Groundwater, Naval Station Treasure Island, San Francisco, California." March 30.

U.S. Environmental Protection Agency (EPA). 2000. "Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California." 40 CFR Part 131, RIN 2040-AC44. May 18.

EPA. 2006. "National Recommended Water Quality Criteria."

Table 4. Hunters Point Groundwater Ambient Levels[1]

Metal	HGAL (µg/L)
Aluminum	NA
Antimony	43.3
Arsenic	27.3
Barium	504
Beryllium	1.40
Cadmium	5.08
Calcium	NE
Chromium	15.7
Chromium VI	NA
Cobalt	20.8
Copper	28.0
Iron	2,380
Lead	14.4
Magnesium	1,440,000
Manganese	8,140
Mercury	0.60
Molybdenum	61.9
Nickel	96.5
Potassium	448,000
Selenium	14.5
Silver	7.43
Sodium	9,242,000
Thallium	13.0
Vanadium	26.62
Zinc	75.7

Notes:

1 = PRC Environmental Management, Inc., 1996. "Estimation of Hunters Point Shipyard Groundwater Ambient Levels Technical Memorandum." September 16.

HGAL = Hunters Point groundwater ambient level

NA = not available

µg/L = milligrams per liter

Table 5. Groundwater Evaluation Results and Proposed Monitoring Locations

Analytical Group	COPEC	Aquatic Evaluation Criterion (µg/L)[a]	Attenuation Factor Selected for Inland Area[b]	Calculated Inland Trigger Level (µg/L)[c,d]	Applicable Trigger Level for RAMP Proposed Monitoring Locations (nearshore)[e]	RAMP Proposed Monitoring Locations[f]
Anions	Un-ionized Ammonia	25	1	25	25	IR01MW48A, IR01MW60A, IR01MW64A, IR01MW403A[k], IR01MWLF2A[k], NMW02A, NMW03A, and NMW04A
	Cyanide	1	NA	NA	1	IR01MW48A, IR01MW60A, IR01MW62A, IR01MW63A, IR01MW65A, IR01MW403A[k], IR01MWLF2A[k], and NMW02A
	Sulfide	2[g,h]	NA	NA	2	IR01MW48A, IR01MW60A, IR01MW64A, IR01MW403A[k], and IR01MWLF2A[k],
Metals	Copper	28[i]	2	56	28	IR01MW48A, IR01MW53B, IR01MW403A[k], IR01MWLF2A[k], NMW03A, and NMW04A
	Lead	14.4[i]	NA	NA	14.4	IR01MW48A, IR01MW64A, IR01MW403A[k], IR01MWLF2A[k], NMW04A, and NMW06A
	Zinc	81	NA	NA	81	IR01MW48A, IR01MW64A, IR01MW66A, IR01MW403A[k], IR01MWLF2A[k], NMW03A, NMW04A, and NMW06A

Table 5. Groundwater Evaluation Results and Proposed Monitoring Locations *(continued)*

Analytical Group	COPEC	Aquatic Evaluation Criterion (µg/L)[a]	Attenuation Factor Selected for Inland Area[b]	Calculated Inland Trigger Level (µg/L)[c,d]	Applicable Trigger Level for RAMP Proposed Monitoring Locations (nearshore)[e]	RAMP Proposed Monitoring Locations[f]
PCBs	PCBs (Total)	0.03[i]	2	0.06	0.03	IR01MW60A, IR01MW64A, IR01MW66A, IR01MW403A[k], IR01MWLF2A[k], NMW02A, and NMW04A
Petroleum Hydrocarbons	TPH (Total)	1,400–20,000[j]	NA	NA	1,400–20,000	IR01MW48A, IR01MW60A, IR01MW64A, IR01MW403A[k], IR01MWLF2A[k], NMW02A, and NMW03A

Notes:

a = References for the aquatic evaluation criteria are included in Appendix M of the RI/FS Report (ERRG and Shaw, 2011).

b = Attenuation factor assigned based on nomographs developed specifically for HPNS groundwater (see Appendix M, Attachment M-1 of the RI/FS Report [ERRG and Shaw, 2011]).

c = Inland monitoring wells are located more than 250 feet inland from the Parcel E-2 shoreline.

d = Value calculated by multiplying the aquatic evaluation criterion (surface water criterion or HGAL, whichever most conservative) by the attenuation factor.

e = Nearshore wells are located within 250 feet of the Parcel E-2 shoreline. Most nearshore wells are located within the TIZ (where the maximum tidal fluctuation exceeds 0.10 foot in the A-aquifer based on data collected during the Phase III groundwater data gaps investigation [TtEMI, 2004b]). All wells selected for trigger-level monitoring as part of the RAMP are located within the nearshore; however, inland trigger levels are included for comparison. For wells located in the TIZ, the attenuation factor is equal to 1 (i.e., the trigger levels are equal to the screening criteria).

f = Wells IDs preceded by NMW indicate that this is a proposed new monitoring well location. Well locations were selected to replace original sampling locations that were decommissioned during remedial or removal actions or where samples were collected from temporary wells. Although not all sampling locations from the RI/FS were recommended for further evaluation in the RAMP, the selected well locations should provide an accurate picture of groundwater concentrations migrating into San Francisco Bay. Values shown in the "NM06A (TW029)" format indicate the new monitoring well and the well or temporary well the new well is meant to replace.

g = Criterion shown applies to hydrogen sulfide, not total sulfide

h = Criterion is significantly lower (at least 10 times less) than reporting limit for current, routinely used analytical methods

i = Value shown has been adjusted for HGAL (see Table 4) and is applicable to the A-aquifer.

j = Range of values shown; aquatic criteria for total TPH assigned as a function of distance from shoreline; the source of these criteria is the “Final New Preliminary Screening Criteria and Petroleum Program Strategy, Hunters Point Shipyard, San Francisco, California” (Shaw, 2007).

k = Data from future monitoring at upgradient (background) wells will be compared with data for downgradient wells.

Table 5. Groundwater Evaluation Results and Proposed Monitoring Locations *(continued)*

Notes *(continued)*:
COPECs = chemicals of potential ecological concern
ERRG = Engineering/Remediation Resources Group, Inc.
HGAL = Hunters Point groundwater ambient level
NA = not available
PCBs = polychlorinated biphenyls
RAMP = remedial action monitoring plan
RI/FS = remedial investigation/feasibility study
Shaw = Shaw Environmental, Inc.
TIZ = tidal influence zone
TPH = total petroleum hydrocarbons
TtEMI = Tetra Tech EM Inc.
µg/L = micrograms per liter

Table 6. Analysis and Evaluation Criteria by Well

Well	Analytes[1]	Evaluation Criteria[2]
IR01MW48A	Un-ionized Ammonia, Cyanide, Sulfide, Copper, Zinc, Lead, and TPH (Total)	Aquatic Wildlife COPEC trigger levels
IR01MW60A	Un-ionized Ammonia, Cyanide, Sulfide, PCBs (Total), TPH (Total), and Radionuclides[3]	Aquatic Wildlife COPEC trigger levels; drinking water standard for radionuclides, or a more appropriate criteria if one becomes available
IR01MW62A	Cyanide	Aquatic Wildlife COPEC trigger levels
IR01MW63A	Cyanide	Aquatic Wildlife COPEC trigger levels
IR01MW64A	Un-ionized Ammonia, Sulfide, Lead, Zinc, PCBs (Total), TPH (Total), and Radionuclides[3]	Aquatic Wildlife COPEC trigger levels; drinking water standard for radionuclides, or a more appropriate criteria if one becomes available
IR01MW65A	Cyanide and Radionuclides[3]	Aquatic Wildlife COPEC trigger levels
IR01MW66A	Zinc and PCBs (Total)	Aquatic Wildlife COPEC trigger levels
IR01MW402A	Un-ionized Ammonia, Cyanide, Sulfide, Copper, Zinc, Lead, PCBs, TPH, VOCs, and Radionuclides[3]	To be determined[4]
IR01MW403A	Un-ionized Ammonia, Cyanide, Sulfide, Copper, Zinc, Lead, PCBs, TPH, VOCs, and Radionuclides[3]	To be determined[4]
IR01MWLF2A	Un-ionized Ammonia, Cyanide, Sulfide, Copper, Zinc, Lead, PCBs, TPH, and VOCs	To be determined[4]
IR04MW13A[6]	VOCs	Risk-based soil gas action levels (see Appendix A)[7]
IR12MW11A	VOCs	Risk-based soil gas action levels (see Appendix A)[7]
IR76MW13A[6]	Un-ionized Ammonia, Cyanide, Sulfide, Copper, Zinc, Lead, PCBs, TPH, VOCs and Radionuclides[3]	To be determined[4]
NMW02A[2]	Un-ionized Ammonia, PCBs (Total), TPH (Total), Cyanide, and Radionuclides[3]	Aquatic Wildlife COPEC trigger levels; drinking water standard for radionuclides, or a more appropriate criteria if one becomes available

Table 6. Groundwater Evaluation Results and Proposed Monitoring Locations *(continued)*

Well	Analytes[1]	Evaluation Criteria[2]
NMW03A[2]	Un-ionized Ammonia, Copper, Zinc, and TPH (Total)	Aquatic Wildlife COPEC trigger levels
NMW04A[2]	Un-ionized Ammonia, Copper, Lead, Zinc, PCBs (Total)	Aquatic Wildlife COPEC trigger levels
NMW06A[2]	Lead, Zinc, and Radionuclides[3]	Aquatic Wildlife COPEC trigger levels
NMW07A[2]	VOCs	Risk-based soil gas action levels (see Appendix A)[7]
IR01MW09B	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Remediation Goals for Domestic Use of Groundwater
IR01MW53B	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Aquatic Wildlife COPEC trigger levels (copper only); Remediation Goals for Domestic Use of Groundwater
IR01MW366B	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Remediation Goals for Domestic Use of Groundwater
IR01MW403B	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Remediation Goals for Domestic Use of Groundwater
NMW01B[2]	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Remediation Goals for Domestic Use of Groundwater
NMW05B[2]	Metals, VOCs, SVOCs, pesticides, and PCBs[5]	Remediation Goals for Domestic Use of Groundwater

Notes

1 = Individual analytes listed are for specific wells are based upon COPECs for aquatic wildlife (un-ionized ammonia, cyanide, sulfide, copper, lead, zinc, total PCBs [total], and TPH [total]). Trigger levels for each COPEC are identified in Table 5 of this RAMP.

2 = Proposed monitoring well location. Results of the trigger-level evaluation performed as part of the RI/FS were used to guide placement of the well for future monitoring.

3 = Radionuclide samples will be analyzed for the following ROCs: Cesium-137, Radium-226, and Strontium-90.

4 = Data from future monitoring at upgradient (background) wells will be compared with data at downgradient wells.

5 = Specific analytes and corresponding remediation goals for domestic use of deep groundwater are identified in Table 2 of this RAMP.

6 = Well IR04MW13A was destroyed to facilitate excavation during the Phase 2 TCRA at the PCB Hot Spot Area; this well will be replaced for remedial action monitoring. The replacement well will be reconstructed to its original specifications; the RA contractor will coordinate with the basewide groundwater monitoring program contractor to establish well placement and construction details.

7 = Consistent with the Final FS Report for Parcel E, actions and decisions to address the indoor inhalation of vapors at Parcel E will be based on soil gas data and the soil gas action levels. Soil gas data will be collected along the eastern boundary of Parcel E-2 (adjacent to Parcel E) as part of the landfill gas monitoring program that is described in Section 3 of this RAMP and will be compared with risk-based soil gas action levels.

Table 6. Groundwater Evaluation Results and Proposed Monitoring Locations *(continued)*

Notes *(continued)*:

COPECs = chemicals of potential ecological concern

PCBs = polychlorinated biphenyls

RAMP = remedial action monitoring plan

RI/FS = remedial investigation/feasibility study

ROCs = radionuclides of concern

SVOCs = semivolatile organic compounds

TPH = total petroleum hydrocarbons

VOCs = volatile organic compounds

Table 7. Monitoring Wells for Groundwater Elevations

Well ID No.	Comments
IR01MW02B	Existing well located in Parcel E-2 Landfill (northern portion)
IR01MW05A	Existing well located in Parcel E-2 Landfill (northern portion)
IR01MW09B	Existing well located in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
IR01MW10A	Existing well located in East Adjacent Area (north of existing landfill gas barrier wall)
IR01MW12A	Existing well located in Parcel E-2 Landfill (immediately south of well IR01MW10A, south of existing landfill gas barrier wall)
IR01MW16A	Existing well located in Parcel E-2 Landfill (central portion)
IR01MW18A	Existing well located in Parcel E-2 Landfill (central portion)
IR01MW26B	Existing well located in Parcel E-2 Landfill (central portion)
IR01MW31A	Existing well located in Parcel E-2 Landfill (southern portion, east of upland slurry wall)
IR01MW38A	Existing well located in Parcel E-2 Landfill (southern portion)
IR01MW48A	Existing well located in Panhandle Area (adjacent to proposed freshwater wetlands)
IR01MW53B	Existing well located in Panhandle Area (adjacent to proposed freshwater wetlands)
IR01MW60A	Existing well located in Parcel E-2 Landfill (adjacent to nearshore slurry wall)
IR01MW62A	Existing well located in Panhandle Area (adjacent to proposed tidal wetlands)
IR01MW63A	Existing well located in Panhandle Area (adjacent to proposed tidal wetlands)
IR01MW64A	Existing well located in Parcel E-2 Landfill (adjacent to nearshore slurry wall)
IR01MW65A	Existing well located in Panhandle Area (within proposed tidal wetlands)
IR01MW66A	Existing well located in Parcel E-2 Landfill (adjacent to nearshore slurry wall)
IR01MW366A	Existing well located in Parcel E-2 Landfill (eastern portion)
IR01MW366B	Existing well located in East Adjacent Area (downgradient of Parcel E-2 Landfill)
IR01MW402A	Existing well located outside Parcel E-2 (upgradient of Panhandle Area)
IR01MW403A	Existing well located outside Parcel E-2 (upgradient of Parcel E-2 Landfill and west of upland slurry wall)
IR01MW403B	Existing well located in Panhandle Area (upgradient of Parcel E-2 Landfill and west of upland slurry wall)
IR01MWI-5	Existing well located in Parcel E-2 Landfill (central portion)
IR01MWI-9	Existing well located in Panhandle Area (adjacent to proposed freshwater wetlands)
IR01MWLF1A	Existing well located in Parcel E-2 Landfill (southern portion)
IR01MWLF2A	Existing well located in Parcel E-2 Landfill (northern portion)
IR01MWLF4B	Existing well located in Parcel E-2 Landfill (eastern portion)
IR04MW13A[1]	Existing well located in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)

Table 7. Monitoring Wells for Groundwater Elevations *(continued)*

Well ID No.	Comments
IR04MW31A	Existing well located in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
IR12MW11A	Existing well located in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
IR76MW13A	Existing well located outside Parcel E-2 (upgradient of Parcel E-2 Landfill and within UCSF facility)
NMW01B	Proposed new well in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
NMW02A	Proposed new well in Parcel E-2 Landfill (adjacent to nearshore slurry wall, and in the approximate location of former temporary well TW031)
NMW03A	Proposed new well in Panhandle Area (at the northern end of the nearshore slurry wall, and in the approximate location of former temporary well TW013)
NMW04A	Proposed new well in Panhandle Area (adjacent to the proposed freshwater wetlands and in the approximate location of former temporary well TW021)
NMW05B	Proposed new well near the location of former temporary well TW038
NMW06A	Proposed new well in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
NMW07A	Proposed new well in East Adjacent Area (downgradient of Parcel E-2 Landfill and adjacent to Parcel E)
NPZ01A	Proposed new piezometer on the bay side of nearshore slurry wall, adjacent from IR01MW66A
NPZ03A	Proposed new piezometer on the bay side of nearshore slurry wall, adjacent from IR01MW60A
NPZ02A	Proposed new piezometer on the bay side of nearshore slurry wall, adjacent from IR01MW64A
NPZ04A	Proposed new piezometer on the bay side of nearshore slurry wall, adjacent from TW031

Notes

1 = Well IR04MW13A was destroyed to facilitate excavation during the Phase 2 TCRA at the PCB Hot Spot Area; this well will be replaced for remedial action monitoring. The replacement well will be reconstructed to its original specifications; the RA contractor will coordinate with the basewide groundwater monitoring program contractor to establish well placement and construction details.

Table 8. Preliminary Acceptable Operating Ranges for LFG Extraction Wells and Vents

Well Location	LFG Oxygen Concentration (%V)	LFG Methane Concentration (%V)	Wellhead LFG Temperature (°F)	Wellhead Static Pressure (Inch W.C.)
Interior gas wells (wells more than 100 feet inside edge of cap)	0 to 1	35 to 52	80 to 125	-0.5 to -4.0
Perimeter gas wells (wells less than 100 feet inside edge of cap)	0 to 3	25 to 40	65 to 90	-0.25 to -2.0
Perimeter vents	0 to 8	5 to 20	55 to 70	-0.1 to -1.5
Treatment facility inlet	0 to 3	15 to 50	60 to 80	-10 to -25

Notes:

All initial monitoring data ranges suggested above are preliminary. Location-specific ranges should be developed based on initial operation data for the gas collection and control system.

Data ranges based on quarterly monitoring reports for January 2008 through March 2012.

LFG = landfill gas

W.C. = water column

Table 9. Routine LFG Monitoring Locations and Frequencies

Gas Collection / Control Component Monitored	Parameter Recorded	Monitoring Frequency	Data Objective
Gas Pretreatment System			
Treatment facility inlet header	Fixed gases, static pressure	Weekly	Track gas well field operating conditions
Knock-out pot	Pressure drop, condensate level	Weekly	Detect filter clogging or drain malfunction
Adsorption vessels	Pressure drop	Weekly	Detect filter clogging or channeling
1st GAC vessel influent	Fixed gases, NMOC	Weekly	Track untreated NMOC concentration
		Annual	Confirm screening-level method results
1st GAC effluent	Fixed gases, NMOC	Weekly	Detect pending adsorbent breakthrough
2nd GAC effluent	Fixed gases, NMOC	Weekly	Detect pending adsorbent breakthrough
Hydrosil effluent	Fixed gases, NMOCs	Weekly	Detect pending adsorbent breakthrough
		Annual	Confirm screening-level method results
Adsorption vessel change-out	Start date / End date	Weekly	Document useful life of adsorption beds
Enclosed Gas Flare			
Gas flare inlet	Fixed gases, static pressure	Weekly	Track gas composition and heat value
Blower	Differential pressure	Weekly	Track blower efficiency
Flame arrestor	Pressure drop	Weekly	Detect arrestor or burner obstructions
Influent gas flow	Flow rate and total flow volume	Continuous	Track gas volume throughput
Flare stack exhaust	Burner and exhaust temperature	Continuous	Track combustion temperature compliance
Gas flare burner	Presence of flame	Continuous	Confirm no emission of raw gas

Table 9. Routine LFG Monitoring Locations and Frequencies *(continued)*

Gas Collection / Control Component Monitored	Parameter Recorded	Monitoring Frequency	Data Objective
Enclosed Gas Flare *(continued)*			
Influent gas flow	Fixed gases, NMOCs	Annual	Calculate total organic compounds destruction efficiency
Stack exhaust emissions	Constituents of concern, secondary pollutants	Annual	Confirm compliant emissions operation
Gas Collection System			
Gas extraction well heads	Fixed gases, static pressure, gas temperature	Monthly	Track and adjust well operating conditions
Gas header sample ports	Fixed gases, static pressure	Monthly	Track piping system operating conditions
LFG Migration Monitoring System			
Gas monitoring probes	Methane, NMOC, static pressure	Quarterly	Confirm LFG migration compliance
On-site or near site structures	Methane, NMOC	Quarterly	Confirm LFG migration compliance
Routine grid monitoring	Total organic compounds	Quarterly	Scan for potential cover cap defects
Cover integrity inspection	Total organic compounds	Quarterly	Locate cover cap leaks
Collection component leak	Total organic compounds	Continuous	Locate gas collection component leaks
Meteorological Station	Wind speed and direction	Continuous	Document site conditions during monitoring or reported emission events
	Precipitation	Continuous	Document site conditions during monitoring or reported emission events
	Atmospheric pressure	Continuous	Document site conditions during monitoring or reported emission events

Table 9. Routine LFG Monitoring Locations and Frequencies *(continued)*

Gas Collection / Control Component Monitored	Parameter Recorded	Monitoring Frequency	Data Objective
LFG Condensate Treatment			
LFG Condensate Treatment	Permit constituents of concern	Quarterly	Confirm condensate discharge compliance

Notes:

LFG = landfill gas

GAC = granular activated carbon

NMOCs = nonmethane organic compounds

Table 10. Methane Concentrations at Landfill Gas Monitoring Locations

Well ID	4-Year Average Raw % Methane	3/12 Raw % Methane	4-Year Average Undiluted % Methane	3/12 Undiluted % Methane
PV-01	17	0	32	7
PV-02	7	19	26	33
PV-04	27	0	49	0
IR01MWI-5	33	1	65	15
IR01MW16A	13	7	55	45
IR01MW18A	25	25	60	61
IR01MW366A	32	17	47	33
Averages:	**22**	**10**	**48**	**40**

Notes:

Data obtained from quarterly monitoring reports for January 2008 through March 2012.

Raw methane concentrations based on data as reported.

Undiluted methane concentrations were normalized by removal of dilution air concentrations in the ratio of 1:5 oxygen to nitrogen.

Table 11. Wetland Performance Standards

Vegetation
A minimum survival of 70 percent of all planted vegetation during the 5-year monitoring period to be determined during each of the monitoring events (Galloway, 2006).
By the end of the second growing season, a minimum of 40 percent COVER of dominant native plant species that have a wetland indicator status of FAC, FACW, or OBL for all planted wetland areas; 40 percent cover for upland vegetation (Galloway, 2006).
By the end of the 5-year monitoring period, at least 70 percent cover of dominant native plant species that have a wetland indicator status of FAC, FACW, or OBL for all areas planted higher than the low marsh vegetation; 40 percent or greater area cover for the low marsh; the percent cover of bare ground should be minimal (i.e., less than 15 percent) (Galloway, 2006).
Within 5 years, control invasive cordgrass species and its hybrids and invasive species on the RWB Invasive Plant List (Tier 1) and the California Invasive Plant Inventory (ranked as highly invasive) to less than 10% cover (as per concurrence from BRAC Closure Team on June 25, 2009).
Soil
Evaluate the presence and continued formation of hydric soil in situ and the existence of environments of deposition, accretion, and/or erosion in seasonal freshwater and tidal wetlands (in accordance with USDA hydric soil identification criteria [USDA Soil Conservation Service, 2012]).
Hydrology
Tidal wetland mitigation area will exhibit an adequate tidal range between at least +2 feet NGVD 29 and +3.7 feet NGVD 29.
Soils in the freshwater wetland will be saturated to a minimum depth of 12 inches for a period consistent with the USACE 1987 Wetland Delineation Manual (USACE, 1987).

Note:

Soil that meets the definition of "hydric soil" must have developed under saturated and anaerobic conditions during the growing season. Field indicators of hydric soil are morphological properties associated with their formation and are important to recognize because, once formed, they will persist under both wet and dry seasonal periods (USDA Soil Conservation Service, 2012). A Qualified wetlands scientist will use the field criteria to verify that appropriate saline and freshwater hydric soil is used to construct and restore the tidal and freshwater wetland, respectively.

BRAC = Base Realignment and Closure

FAC = facultative

FACW = facultative wetland

RWB = Rainwater Basin Wetland Complex

NGVD = National Geodetic Vertical Datum

OBL = obligate wetland

USACE = U.S. Army Corps of Engineers

USDA = U.S. Department of Agriculture

Appendix A. Soil Gas Action Levels

TABLE 7: PRELIMINARY SOIL GAS ACTION LEVELS

Approach for Developing Soil Gas Action Levels for Vapor Intrusion Exposure at Hunters Point Naval Shipyard

Chemical	CAS Number	Soil Gas RBC (Lowest between Cancer- and Noncancer-Based RBC)				Soil Gas RBC Based on Surrogate Chemical for Toxicity Data	Soil Gas RBC Based on Oral Route Extrapolated Toxicity Data	Laboratory Reporting Limit		Reporting Limit Less Than Soil Gas RBC?		Preliminary Soil Gas Action Level (c)								Revision Code
		Residential		Industrial						Cal/EPA Res α_{sg} = 0.0009 Ind α_{sg} = 0.0004	EPA Res α_{sg} = 0.01 Ind α_{sg} = 0.001	Residential				Industrial				
		Cal/EPA α_{sg} = 0.0009	EPA α_{sg} = 0.01	Cal/EPA α_{sg} = 0.0004	EPA α_{sg} = 0.001			Concentration (a)	Analytical Method (b)			Cal/EPA α_{sg} = 0.0009		EPA α_{sg} = 0.01		Cal/EPA α_{sg} = 0.0004		EPA α_{sg} = 0.001		
Metals																				
MERCURY	7439976	3.48E+02	3.13E+01	3.29E+03	1.31E+03			1.00E+00	NIOSH 6009	Yes	Yes	3.48E+02	nc	3.13E+01	nc	3.29E+03	nc	1.31E+03	nc	--
Polycyclic Aromatic Hydrocarbons																				
1-METHYLNAPHTHALENE	90120	3.26E+02	2.94E+01	3.70E+03	1.48E+03		X	1.60E+00	TO-13A	Yes	Yes	3.26E+02	ca	2.94E+01	ca	3.70E+03	ca	1.48E+03	ca	--
2-METHYLNAPHTHALENE	91576	1.62E+04	1.46E+03	1.53E+05	6.13E+04		X	1.60E+00	TO-13A	Yes	Yes	1.62E+04	nc	1.46E+03	nc	1.53E+05	nc	6.13E+04	nc	--
ACENAPHTHENE	83329	2.43E+05	2.19E+04	2.30E+06	9.20E+05		X	1.60E+00	TO-13A	Yes	Yes	2.43E+05	nc	2.19E+04	nc	2.30E+06	nc	9.20E+05	nc	--
ACENAPHTHYLENE	208968	2.43E+05	2.19E+04	2.30E+06	9.20E+05	X	X	1.60E+00	TO-13A	Yes	Yes	2.43E+05	nc	2.19E+04	nc	2.30E+06	nc	9.20E+05	nc	--
BENZO(B)FLUORANTHENE	205992	2.46E+01	2.21E+00	2.79E+02	1.11E+02			1.60E+00	TO-13A	Yes	Yes	2.46E+01	ca	2.21E+00	ca	2.79E+02	ca	1.11E+02	ca	--
CHRYSENE	218019	2.46E+02	2.21E+01	2.79E+03	1.11E+03			1.60E+00	TO-13A	Yes	Yes	2.46E+02	ca	2.21E+01	ca	2.79E+03	ca	1.11E+03	ca	--
FLUORENE	86737	1.62E+05	1.46E+04	1.53E+06	6.13E+05		X	1.60E+00	TO-13A	Yes	Yes	1.62E+05	nc	1.46E+04	nc	1.53E+06	nc	6.13E+05	nc	--
NAPHTHALENE	91203	7.95E+01	7.16E+00	9.02E+02	3.61E+02			1.60E+00	TO-13A	Yes	Yes	7.95E+01	ca	7.16E+00	ca	9.02E+02	ca	3.61E+02	ca	--
1,6,7-TRIMETHYL-NAPHTHALENE	2245387	1.62E+04	1.46E+03	1.53E+05	6.13E+04	X	X	NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
2,6-DIMETHYL-NAPHTHALENE	581420	1.62E+04	1.46E+03	1.53E+05	6.13E+04	X	X	NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
PHENANTHRENE	85018	1.22E+06	1.10E+05	1.15E+07	4.60E+06	X	X	1.60E+00	TO-13A	Yes	Yes	1.22E+06	nc	1.10E+05	nc	1.15E+07	nc	4.60E+06	nc	--
PYRENE	129000	1.22E+05	1.10E+04	1.15E+06	4.60E+05		X	1.60E+00	TO-13A	Yes	Yes	1.22E+05	nc	1.10E+04	nc	1.15E+06	nc	4.60E+05	nc	--
Pesticides																				
2,4'-DDE	3424826	2.79E+01	2.51E+00	3.16E+02	1.26E+02	X		NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
4,4'-DDE	72559	2.79E+01	2.51E+00	3.16E+02	1.26E+02			1.60E-01	TO-10A	Yes	Yes	2.79E+01	ca	2.51E+00	ca	3.16E+02	ca	1.26E+02	ca	--
ALDRIN	309002	5.52E-01	4.97E-02	6.26E+00	2.50E+00			1.60E-01	TO-10A	Yes	No (> Res)	5.52E-01	ca	1.60E-01	RL	6.26E+00	ca	2.50E+00	ca	--
ALPHA-BHC	319846	1.50E+00	1.35E-01	1.70E+01	6.81E+00			1.60E-01	TO-10A	Yes	No (> Res)	1.50E+00	ca	1.60E-01	RL	1.70E+01	ca	6.81E+00	ca	--
ALPHA-CHLORDANE	5103719	2.70E+01	2.43E+00	3.07E+02	1.23E+02	X		1.60E-01	TO-10A	Yes	Yes	2.70E+01	ca	2.43E+00	ca	3.07E+02	ca	1.23E+02	ca	--
BETA-BHC	319857	5.10E+00	4.59E-01	5.78E+01	2.31E+01			1.60E-01	TO-10A	Yes	Yes	5.10E+00	ca	4.59E-01	ca	5.78E+01	ca	2.31E+01	ca	--
DELTA-BHC	319868	5.10E+00	4.59E-01	5.78E+01	2.31E+01	X		1.60E-01	TO-10A	Yes	Yes	5.10E+00	ca	4.59E-01	ca	5.78E+01	ca	2.31E+01	ca	--
DIELDRIN	60571	5.88E-01	5.29E-02	6.67E+00	2.67E+00			1.60E-01	TO-10A	Yes	No (> Res)	5.88E-01	ca	1.60E-01	RL	6.67E+00	ca	2.67E+00	ca	--
ENDOSULFAN I	959988	2.43E+04	2.19E+03	2.30E+05	9.20E+04	X	X	1.60E-01	TO-10A	Yes	Yes	2.43E+04	nc	2.19E+03	nc	2.30E+05	nc	9.20E+04	nc	--
ENDOSULFAN II	33213659	2.43E+04	2.19E+03	2.30E+05	9.20E+04	X	X	1.60E-01	TO-10A	Yes	Yes	2.43E+04	nc	2.19E+03	nc	2.30E+05	nc	9.20E+04	nc	--
GAMMA-BHC (LINDANE)	58899	8.72E+00	7.85E-01	9.89E+01	3.96E+01			1.60E-01	TO-10A	Yes	Yes	8.72E+00	ca	7.85E-01	ca	9.89E+01	ca	3.96E+01	ca	--
GAMMA-CHLORDANE	5103742	2.70E+01	2.43E+00	3.07E+02	1.23E+02	X		1.60E-01	TO-10A	Yes	Yes	2.70E+01	ca	2.43E+00	ca	3.07E+02	ca	1.23E+02	ca	--
HEPTACHLOR	76448	2.08E+00	1.87E-01	2.36E+01	9.43E+00			1.60E-01	TO-10A	Yes	Yes	2.08E+00	ca	1.87E-01	ca	2.36E+01	ca	9.43E+00	ca	--
METHOXYCHLOR	72435	2.03E+04	1.83E+03	1.92E+05	7.67E+04		X	NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
Semivolatile Organic Compounds																				
2-CHLORONAPHTHALENE	91587	3.24E+05	2.92E+04	3.07E+06	1.23E+06		X	1.60E+00	TO-13A	Yes	Yes	3.24E+05	nc	2.92E+04	nc	3.07E+06	nc	1.23E+06	nc	--
2-CHLOROPHENOL	95578	2.03E+04	1.83E+03	1.92E+05	7.67E+04		X	8.00E+00	TO-13A	Yes	Yes	2.03E+04	nc	1.83E+03	nc	1.92E+05	nc	7.67E+04	nc	--
ACETOPHENONE	98862	4.06E+05	3.65E+04	3.83E+06	1.53E+06		X	NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
AZOBENZENE	103333	8.72E+01	7.85E+00	9.89E+02	3.96E+02			NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
BIPHENYL	92524	4.63E+02	4.17E+01	4.38E+03	1.75E+03			NE	--	--	--	NE	--	NE	--	NE	--	NE	--	2
DIBENZOFURAN	132649	4.06E+03	3.65E+02	3.83E+04	1.53E+04		X	1.60E+00	TO-13A	Yes	Yes	4.06E+03	nc	3.65E+02	nc	3.83E+04	nc	1.53E+04	nc	--
HEXACHLOROBENZENE	118741	5.30E+00	4.77E-01	6.01E+01	2.40E+01			1.60E+00	TO-13A	Yes	No (> Res)	5.30E+00	ca	1.60E+00	RL	6.01E+01	ca	2.40E+01	ca	1A

TABLE 7: PRELIMINARY SOIL GAS ACTION LEVELS

Approach for Developing Soil Gas Action Levels for Vapor Intrusion Exposure at Hunters Point Naval Shipyard

Chemical	CAS Number	Soil Gas RBC (Lowest between Cancer- and Noncancer-Based RBC)				Soil Gas RBC Based on Surrogate Chemical for Toxicity Data	Soil Gas RBC Based on Oral Route Extrapolated Toxicity Data	Laboratory Reporting Limit		Reporting Limit Less Than Soil Gas RBC?		Preliminary Soil Gas Action Level (c)				Revision Code
		Residential		Industrial								Residential		Industrial		
		Cal/EPA α_{sg} = 0.0009	EPA α_{sg} = 0.01	Cal/EPA α_{sg} = 0.0004	EPA α_{sg} = 0.001			Concentration (a)	Analytical Method (b)	Cal/EPA Res α_{sg} = 0.0009 Ind α_{sg} = 0.0004	EPA Res α_{sg} = 0.01 Ind α_{sg} = 0.001	Cal/EPA α_{sg} = 0.0009	EPA α_{sg} = 0.01	Cal/EPA α_{sg} = 0.0004	EPA α_{sg} = 0.001	
Volatile Organic Compounds																
1,1,1-TRICHLOROETHANE	71556	5.79E+06	5.21E+05	5.48E+07	2.19E+07			1.76E-01	TO-15	Yes	Yes	5.79E+06 nc	5.21E+05 nc	5.48E+07 nc	2.19E+07 nc	--
1,1,2,2-TETRACHLOROETHANE	79345	4.66E+01	4.20E+00	5.29E+02	2.11E+02			2.24E-01	TO-15	Yes	Yes	4.66E+01 ca	4.20E+00 ca	5.29E+02 ca	2.11E+02 ca	2
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	76131	3.48E+07	3.13E+06	3.29E+08	1.31E+08			1.23E+00	TO-15	Yes	Yes	3.48E+07 nc	3.13E+06 nc	3.29E+08 nc	1.31E+08 nc	--
1,1,2-TRICHLOROETHANE	79005	1.69E+02	1.52E+01	1.92E+03	7.67E+02			1.76E-01	TO-15	Yes	Yes	1.69E+02 ca	1.52E+01 ca	1.92E+03 ca	7.67E+02 ca	2
1,1-DICHLOROETHANE	75343	1.69E+03	1.52E+02	1.92E+04	7.67E+03			1.30E-01	TO-15	Yes	Yes	1.69E+03 ca	1.52E+02 ca	1.92E+04 ca	7.67E+03 ca	--
1,1-DICHLOROETHENE	75354	2.32E+05	2.09E+04	2.19E+06	8.76E+05			6.40E-02	TO-15	Yes	Yes	2.32E+05 nc	2.09E+04 nc	2.19E+06 nc	8.76E+05 nc	--
1,1-DICHLOROPROPENE	542756	1.69E+02	1.52E+01	1.92E+03	7.67E+02			NA - NS	TO-15 (NS)	ND	ND	ND --	ND --	ND --	ND --	1A
1,2,3-TRICHLOROBENZENE	87616	3.24E+03	2.92E+02	3.07E+04	1.23E+04		X	NA - NS	TO-15 (NS)	ND	ND	ND --	ND --	ND --	ND --	--
1,2,3-TRICHLOROPROPANE	96184	3.15E-01	2.84E-02	3.58E+00	1.43E+00		X	NA - NS	TO-15 (NS)	ND	ND	ND --	ND --	ND --	ND --	--
1,2,4-TRICHLOROBENZENE	120821	3.26E+02	2.94E+01	3.70E+03	1.48E+03		X	5.92E+00	TO-15	Yes	Yes	3.26E+02 ca	2.94E+01 ca	3.70E+03 ca	1.48E+03 ca	--
1,2,4-TRIMETHYLBENZENE	95636	8.11E+03	7.30E+02	7.67E+04	3.07E+04			7.84E-01	TO-15	Yes	Yes	8.11E+03 nc	7.30E+02 nc	7.67E+04 nc	3.07E+04 nc	--
1,2-DICHLOROBENZENE	95501	2.32E+05	2.09E+04	2.19E+06	8.76E+05			9.60E-01	TO-15	Yes	Yes	2.32E+05 nc	2.09E+04 nc	2.19E+06 nc	8.76E+05 nc	--
1,2-DICHLOROETHANE	107062	1.04E+02	9.36E+00	1.18E+03	4.72E+02			1.30E-01	TO-15	Yes	Yes	1.04E+02 ca	9.36E+00 ca	1.18E+03 ca	4.72E+02 ca	2
1,2-DICHLOROETHENE (TOTAL)	540590	3.65E+04	3.29E+03	3.45E+05	1.38E+05		X	4.79E-01	TO-15	Yes	Yes	3.65E+04 nc	3.29E+03 nc	3.45E+05 nc	1.38E+05 nc	--
1,2-DICHLOROPROPANE	78875	2.70E+02	2.43E+01	3.07E+03	1.23E+03			7.36E-01	TO-15	Yes	Yes	2.70E+02 ca	2.43E+01 ca	3.07E+03 ca	1.23E+03 ca	--
1,3,5-TRIMETHYLBENZENE	108678	4.06E+04	3.65E+03	3.83E+05	1.53E+05		X	7.84E-01	TO-15	Yes	Yes	4.06E+04 nc	3.65E+03 nc	3.83E+05 nc	1.53E+05 nc	--
1,3-DICHLOROBENZENE	541731	2.32E+05	2.09E+04	2.19E+06	8.76E+05	X		9.60E-01	TO-15	Yes	Yes	2.32E+05 nc	2.09E+04 nc	2.19E+06 nc	8.76E+05 nc	--
1,4-DICHLOROBENZENE	106467	2.46E+02	2.21E+01	2.79E+03	1.11E+03			9.60E-01	TO-15	Yes	Yes	2.46E+02 ca	2.21E+01 ca	2.79E+03 ca	1.11E+03 ca	--
1,4-DIOXANE	123911	3.51E+02	3.16E+01	3.98E+03	1.59E+03			8.00E+00	TO-15	Yes	Yes	3.51E+02 ca	3.16E+01 ca	3.98E+03 ca	1.59E+03 ca	--
2-BUTANONE	78933	5.79E+06	5.21E+05	5.48E+07	2.19E+07			4.64E-01	TO-15	Yes	Yes	5.79E+06 nc	5.21E+05 nc	5.48E+07 nc	2.19E+07 nc	--
2-HEXANONE	591786	3.48E+04	3.13E+03	3.29E+05	1.31E+05			3.20E+00	TO-15	Yes	Yes	3.48E+04 nc	3.13E+03 nc	3.29E+05 nc	1.31E+05 nc	--
4-METHYL-2-PENTANONE	108101	3.48E+06	3.13E+05	3.29E+07	1.31E+07			6.56E-01	TO-15	Yes	Yes	3.48E+06 nc	3.13E+05 nc	3.29E+07 nc	1.31E+07 nc	--
ACETONE	67641	3.59E+07	3.23E+06	3.39E+08	1.36E+08			1.92E+00	TO-15	Yes	Yes	3.59E+07 nc	3.23E+06 nc	3.39E+08 nc	1.36E+08 nc	--
BENZALDEHYDE	100527	4.06E+05	3.65E+04	3.83E+06	1.53E+06		X	NE	--	--	--	NE --	NE --	NE --	NE --	--
BENZENE	71432	9.32E+01	8.39E+00	1.06E+03	4.23E+02			2.56E-01	TO-15	Yes	Yes	9.32E+01 ca	8.39E+00 ca	1.06E+03 ca	4.23E+02 ca	1A
BROMODICHLOROMETHANE	75274	7.31E+01	6.58E+00	8.29E+02	3.31E+02			1.07E+00	TO-15	Yes	Yes	7.31E+01 ca	6.58E+00 ca	8.29E+02 ca	3.31E+02 ca	--
BROMOFORM	75252	2.46E+03	2.21E+02	2.79E+04	1.11E+04			1.60E+00	TO-15	Yes	Yes	2.46E+03 ca	2.21E+02 ca	2.79E+04 ca	1.11E+04 ca	--
BROMOMETHANE	74839	5.79E+03	5.21E+02	5.48E+04	2.19E+04			6.24E-01	TO-15	Yes	Yes	5.79E+03 nc	5.21E+02 nc	5.48E+04 nc	2.19E+04 nc	--
CARBON DISULFIDE	75150	8.11E+05	7.30E+04	7.67E+06	3.07E+06			2.56E+00	TO-15	Yes	Yes	8.11E+05 nc	7.30E+04 nc	7.67E+06 nc	3.07E+06 nc	--
CARBON TETRACHLORIDE	56235	6.44E+01	5.79E+00	7.30E+02	2.92E+02			1.01E+00	TO-15	Yes	Yes	6.44E+01 ca	5.79E+00 ca	7.30E+02 ca	2.92E+02 ca	1A, 2
CHLOROBENZENE	108907	5.79E+04	5.21E+03	5.48E+05	2.19E+05			7.36E-01	TO-15	Yes	Yes	5.79E+04 nc	5.21E+03 nc	5.48E+05 nc	2.19E+05 nc	--
CHLOROETHANE	75003	1.16E+07	1.04E+06	1.10E+08	4.38E+07			4.16E-01	TO-15	Yes	Yes	1.16E+07 nc	1.04E+06 nc	1.10E+08 nc	4.38E+07 nc	--
CHLOROFORM	67663	1.18E+02	1.06E+01	1.33E+03	5.33E+02			7.84E-01	TO-15	Yes	Yes	1.18E+02 ca	1.06E+01 ca	1.33E+03 ca	5.33E+02 ca	--
CHLOROMETHANE	74873	1.04E+05	9.39E+03	9.86E+05	3.94E+05			3.36E-01	TO-15	Yes	Yes	1.04E+05 nc	9.39E+03 nc	9.86E+05 nc	3.94E+05 nc	--
CIS-1,2-DICHLOROETHENE	156592	8.11E+03	7.30E+02	7.67E+04	3.07E+04		X	1.26E-01	TO-15	Yes	Yes	8.11E+03 nc	7.30E+02 nc	7.67E+04 nc	3.07E+04 nc	2
CIS-1,3-DICHLOROPROPENE	10061015	1.69E+02	1.52E+01	1.92E+03	7.67E+02	X		7.20E-01	TO-15	Yes	Yes	1.69E+02 ca	1.52E+01 ca	1.92E+03 ca	7.67E+02 ca	1A
CYCLOHEXANE	110827	6.95E+06	6.26E+05	6.57E+07	2.63E+07			5.44E-01	TO-15	Yes	Yes	6.95E+06 nc	6.26E+05 nc	6.57E+07 nc	2.63E+07 nc	--
DIBROMOCHLOROMETHANE	124481	1.00E+02	9.01E+00	1.14E+03	4.54E+02			1.36E+00	TO-15	Yes	Yes	1.00E+02 ca	9.01E+00 ca	1.14E+03 ca	4.54E+02 ca	--
DICHLORODIFLUOROMETHANE	75718	1.16E+05	1.04E+04	1.10E+06	4.38E+05			7.84E-01	TO-15	Yes	Yes	1.16E+05 nc	1.04E+04 nc	1.10E+06 nc	4.38E+05 nc	2
ETHYLBENZENE	100414	1.08E+03	9.73E+01	1.23E+04	4.91E+03			1.39E-01	TO-15	Yes	Yes	1.08E+03 ca	9.73E+01 ca	1.23E+04 ca	4.91E+03 ca	--
HEXACHLOROETHANE	67721	2.46E+02	2.21E+01	2.79E+03	1.11E+03			1.60E+00	TO-13A	Yes	Yes	2.46E+02 ca	2.21E+01 ca	2.79E+03 ca	1.11E+03 ca	1A, 2

TABLE 7: PRELIMINARY SOIL GAS ACTION LEVELS

Approach for Developing Soil Gas Action Levels for Vapor Intrusion Exposure at Hunters Point Naval Shipyard

Chemical	CAS Number	Soil Gas RBC (Lowest between Cancer- and Noncancer-Based RBC)				Soil Gas RBC Based on Surrogate Chemical for Toxicity Data	Soil Gas RBC Based on Oral Route Extrapolated Toxicity Data	Laboratory Reporting Limit		Reporting Limit Less Than Soil Gas RBC?		Preliminary Soil Gas Action Level (c)								Revision Code
		Residential		Industrial						Cal/EPA Res α_{sg} = 0.0009 Ind α_{sg} = 0.0004	EPA Res α_{sg} = 0.01 Ind α_{sg} = 0.001	Residential				Industrial				
		Cal/EPA α_{sg} = 0.0009	EPA α_{sg} = 0.01	Cal/EPA α_{sg} = 0.0004	EPA α_{sg} = 0.001			Concentration (a)	Analytical Method (b)			Cal/EPA α_{sg} = 0.0009		EPA α_{sg} = 0.01		Cal/EPA α_{sg} = 0.0004		EPA α_{sg} = 0.001		
ISOPROPYLBENZENE	98828	4.63E+05	4.17E+04	4.38E+06	1.75E+06			NA - NS	TO-15 (NS)	ND	ND	ND	--	ND	--	ND	--	ND	--	--
M,P-XYLENES	108383, 106423	1.16E+05	1.04E+04	1.10E+06	4.38E+05	X		2.72E-01	TO-15	Yes	Yes	1.16E+05	nc	1.04E+04	nc	1.10E+06	nc	4.38E+05	nc	1B
METHYL ACETATE	79209	4.06E+06	3.65E+05	3.83E+07	1.53E+07		X	NA - NS	TO-15 (NS)	ND	ND	ND	--	ND	--	ND	--	ND	--	--
METHYLCYCLOHEXANE	108872	6.95E+06	6.26E+05	6.57E+07	2.63E+07	X		3.20E+00	TO-15	Yes	Yes	6.95E+06	nc	6.26E+05	nc	6.57E+07	nc	2.63E+07	nc	--
METHYLENE CHLORIDE	75092	2.70E+03	2.43E+02	3.07E+04	1.23E+04			1.10E+00	TO-15	Yes	Yes	2.70E+03	ca	2.43E+02	ca	3.07E+04	ca	1.23E+04	ca	1A
N-BUTYLBENZENE	104518	2.03E+05	1.83E+04	1.92E+06	7.67E+05		X	4.32E+00	TO-15	Yes	Yes	2.03E+05	nc	1.83E+04	nc	1.92E+06	nc	7.67E+05	nc	2
O-XYLENE	95476	1.16E+05	1.04E+04	1.10E+06	4.38E+05	X		1.39E-01	TO-15	Yes	Yes	1.16E+05	nc	1.04E+04	nc	1.10E+06	nc	4.38E+05	nc	1B
PARA-ISOPROPYL TOLUENE	99876	4.63E+05	4.17E+04	4.38E+06	1.75E+06	X		NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
PROPYLBENZENE	103651	1.16E+06	1.04E+05	1.10E+07	4.38E+06			7.84E-01	TO-15	Yes	Yes	1.16E+06	nc	1.04E+05	nc	1.10E+07	nc	4.38E+06	nc	--
SEC-BUTYLBENZENE	135988	4.63E+05	4.17E+04	4.38E+06	1.75E+06	X		NA - NS	TO-15 (NS)	ND	ND	ND	--	ND	--	ND	--	ND	--	--
STYRENE	100425	1.16E+06	1.04E+05	1.10E+07	4.38E+06			6.72E-01	TO-15	Yes	Yes	1.16E+06	nc	1.04E+05	nc	1.10E+07	nc	4.38E+06	nc	--
TERT-BUTYL METHYL ETHER	1634044	1.04E+04	9.36E+02	1.18E+05	4.72E+04			NE	--	--	--	NE	--	NE	--	NE	--	NE	--	--
TERT-BUTYLBENZENE	98066	4.63E+05	4.17E+04	4.38E+06	1.75E+06	X		NA - NS	TO-15 (NS)	ND	ND	ND	--	ND	--	ND	--	ND	--	--
TETRACHLOROETHENE	127184	4.58E+02	4.12E+01	5.20E+03	2.08E+03			2.24E-01	TO-15	Yes	Yes	4.58E+02	ca	4.12E+01	ca	5.20E+03	ca	2.08E+03	ca	--
TOLUENE	108883	5.79E+06	5.21E+05	5.48E+07	2.19E+07			1.20E-01	TO-15	Yes	Yes	5.79E+06	nc	5.21E+05	nc	5.48E+07	nc	2.19E+07	nc	--
TRANS-1,2-DICHLOROETHENE	156605	6.95E+04	6.26E+03	6.57E+05	2.63E+05			6.40E-01	TO-15	Yes	Yes	6.95E+04	nc	6.26E+03	nc	6.57E+05	nc	2.63E+05	nc	--
TRANS-1,3-DICHLOROPROPENE	10061026	1.69E+02	1.52E+01	1.92E+03	7.67E+02	X		7.20E-01	TO-15	Yes	Yes	1.69E+02	ca	1.52E+01	ca	1.92E+03	ca	7.67E+02	ca	1A
TRICHLOROETHENE	79016	6.59E+02	5.93E+01	7.48E+03	2.99E+03			1.76E-01	TO-15	Yes	Yes	6.59E+02	ca	5.93E+01	ca	7.48E+03	ca	2.99E+03	ca	2
TRICHLOROFLUOROMETHANE	75694	8.11E+05	7.30E+04	7.67E+06	3.07E+06			8.96E-01	TO-15	Yes	Yes	8.11E+05	nc	7.30E+04	nc	7.67E+06	nc	3.07E+06	nc	--
VINYL ACETATE	108054	2.32E+05	2.09E+04	2.19E+06	8.76E+05			2.88E+00	TO-15	Yes	Yes	2.32E+05	nc	2.09E+04	nc	2.19E+06	nc	8.76E+05	nc	--
VINYL CHLORIDE	75014	3.47E+01	3.12E+00	3.93E+02	1.57E+02			4.16E-02	TO-15	Yes	Yes	3.47E+01	ca	3.12E+00	ca	3.93E+02	ca	1.57E+02	ca	1A
XYLENE (TOTAL)	1330207	1.16E+05	1.04E+04	1.10E+06	4.38E+05			2.57E-01	TO-15	Yes	Yes	1.16E+05	nc	1.04E+04	nc	1.10E+06	nc	4.38E+05	nc	--

Notes:

All concentrations are in microgram per cubic meter.

a Reporting limits were adjusted by a factor of 1.6 to account for dilution from pressurization of a 6-liter Summa canister

b The analytical methods listed are a few among several possible methods for soil gas analysis; final analytical methods will be identified in the sampling and analysis plan.

c The prelminary SGAL is based on the lowest concentration between the cancer- and noncancer-based soil gas RBC. If the soil gas RBC is less than the laboratory RL, then the laboratory RL is used as the SGAL.

--	Not applicable
α_{sg}	Soil gas-to-indoor air attenuation factor
>Res	Exceeds residential soil gas RBC
BHC	Benzene hexachloride
ca	Cancer risk
Cal/EPA	California Environmental Protection Agency
CAS	Chemical Abstract Service
DDE	Dichlorodiphenyldichloroethene
EPA	U.S. Environmental Protection Agency
Ind	Industrial
NA	Not available
nc	Noncancer effects
ND	Not determined
NE	Not evaluated; analysis not available for analytical method shown
NS	Non-standard analysis
RBC	Risk-based concentration
Res	Residential
RL	Reporting limit
SGAL	Soil gas action level

Revision 1, Final Technical Memorandum	
Revision Code	**Description**
1A	Correction to most conservative inhalation unit risk
1B	Correction to higher-tier reference concentration
2	New toxicity value available
--	No change

Appendix B. Groundwater Monitoring Well Information

Monitoring Well Construction Details

Well ID[1]	Parcel	Top of Casing (feet msl)	Top of Screen (feet BTOC)	Bottom of Screen (feet BTOC)	Dedicated Pump Intake (feet BTOC)
IR01MW02B	NNP	20.61	28.4	38.4	NA
IR01MW05A	NNP	22.56	11.6	28.6	NA
IR01MW09B	E-2	10.05	31.7	41.7	37.0
IR01MW10A	E-2	13.75	4.8	21.8	15.0
IR01MW12A	E-2	18.25	7.0	24.0	NA
IR01MW16A	E-2	24.55	12.8	27.8	NA
IR01MW18A	E-2	23.58	12.9	30.9	NA
IR01MW26B	E-2	23.95	44.4	54.4	54.0
IR01MW31A	E-2	13.81	8.2	26.2	17.0
IR01MW366A	E-2	17.31	6.6	16.5	NA
IR01MW366B	E-2	16.70	46.4	56.4	NA
IR01MW38A	E-2	17.36	9.5	22.5	19.0
IR01MW402A	NNP	12.51	4.7	19.7	NA
IR01MW403A	NNP	13.00	5.6	20.6	NA
IR01MW403B	E-2	10.54	26.2	36.2	31.0
IR01MW48A	E-2	10.96	6.8	19.8	14.7
IR01MW53B	E-2	10.01	35.3	45.3	41.8
IR01MW60A	E-2	14.60	10.1	20.1	16.0
IR01MW62A	E-2	7.91	4.5	14.5	10.4
IR01MW63A	E-2	7.88	5.5	19.5	12.8
IR01MW64A	E-2	14.27	8.7	18.7	14.0
IR01MW65A	E-2	8.69	7.9	21.9	14.6
IR01MW66A	E-2	10.66	9.7	14.7	15.0
IR01MWI-5	E-2	24.18	8.6	23.6	--
IR01MWI-9	E-2	8.04	3.6	13.6	--
IR01MWLF1A	E-2	20.83	7.3	22.3	20.0
IR01MWLF2A	E-2	19.62	8.5	23.5	18.5
IR01MWLF4B	E-2	14.48	41.2	56.2	48.5
IR04MW13A[2]	E-2	12.55	7.1	22.1	NA
IR04MW31A	E-2	12.53	13.5	28.5	18.8
IR12MW11A	E-2	14.10	6.6	19.6	15.9

Monitoring Well Construction Details *(continued)*

Well ID[1]	Parcel	Top of Casing (feet msl)	Top of Screen (feet BTOC)	Bottom of Screen (feet BTOC)	Dedicated Pump Intake (feet BTOC)
IR76MW13A	NNP	19.69	8.7	23.7	NA

Notes:

BTOC = below top of casing

msl = mean sea level

NNP = Non-Navy Property

NA = not applicable (no dedicated pump in well)

1 = Construction well details for proposed new monitoring wells will be provided following installation

2 = Well IR04MW13A was destroyed to facilitate excavation during the Phase 2 TCRA at the PCB Hot Spot Area; this well will be replaced for remedial action monitoring, consistent with the specifications identified in this table.

Draft

Land Use Control Remedial Design
Parcel E-2

Hunters Point Naval Shipyard
San Francisco, California

June 2013

Prepared for:
Department of the Navy
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
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Prepared under:
Naval Facilities Engineering Command Southwest
Contract No. N68711-05-C-6011
Document Control No. ERRG-6011-0000-0034

Draft
Land Use Control Remedial Design
Parcel E-2
Hunters Point Naval Shipyard
San Francisco, California

Submitted by:

Engineering/Remediation Resources Group, Inc.

Signature	June 25, 2013 Date
Doug Bielskis, P.E. Name	Project Manager/Engineer of Record Title

ERRG-6011-0000-0034

Table of Contents

SECTION 1. PURPOSE 1-1

SECTION 2. SITE DESCRIPTION 2-1

SECTION 3. AREA REQUIRING INSTITUTIONAL CONTROLS 3-1

SECTION 4. INSTITUTIONAL CONTROL PERFORMANCE OBJECTIVES AND ASSOCIATED LAND USE AND ACTIVITY (IC) RESTRICTIONS 4-1

4.1. IC Performance Objectives and Associated Land Use and Activity (IC) Restrictions 4-1

4.1.1. Land Use and Activity Restrictions that Apply throughout Parcel E-2 4-1

4.1.2. Additional Activity Restrictions Related to Radionuclides at Parcel E-2 4-2

4.1.3. Additional Activity Restrictions Related to Subsurface Gas at Parcel E-2 4-3

4.2. Legal Mechanisms to Implement IC Restrictions 4-4

4.2.1. Legal Mechanisms Following Conveyance 4-4

4.2.2. Legal Mechanisms for Property Owned by UCSF 4-5

SECTION 5. REMEDY IMPLEMENTATION ACTIONS 5-1

5.1. Navy Responsibilities 5-1

5.2. Inspection and Enforcement Entity Responsibilities 5-5

SECTION 6. REVIEW OF DOCUMENTS 6-1

SECTION 7. REFERENCES 7-1

List of Figures

Figure 1. Site Vicinity Map
Figure 2. Parcel E-2 Areas
Figure 3. Radiologically Impacted Areas
Figure 4. Areas Requiring Institutional Controls

List of Attachments

Attachment A. Interested Parties for Parcel E-2 Land Use Control Remedial Design Report
Attachment B. Parcel E-2 IC Compliance Monitoring Report and Annual IC Compliance Certificate
Attachment C. Parcel E-2 Land Use Controls Remedial Design Checklist

Acronyms and Abbreviations

ARIC	area requiring institutional control
CCR	California Code of Regulations
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
HPNS	Hunters Point Naval Shipyard
HRA	historical radiological assessment
ICs	institutional controls
IR	Installation Restoration
LUC	Land Use Control
MOA	Memorandum of Agreement
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRDL	Naval Radiological Defense Laboratory
PCB	polychlorinated biphenyl
RD	Remedial Design
ROD	record of decision
UCSF	University of California, San Francisco
Water Board	San Francisco Bay Regional Water Quality Control Board
§	Section

Section 1. Purpose

This Land Use Control (LUC) Remedial Design (RD) addresses the institutional controls (ICs) required by Section 2.9.2.3 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision (ROD) for Parcel E-2 at Hunters Point Naval Shipyard (HPNS) in San Francisco, California (Department of the Navy [Navy], 2012; Figure 1). The ROD requires implementation of ICs, which are legal and administrative mechanisms for the continued protection of human health and the environment. In Parcel E-2, the objectives of the ICs are to implement land use and activity restrictions that are used to limit the exposure of future landowner(s) or user(s) of the property to hazardous substances present on the property and in groundwater, and to ensure the integrity of the remedial action, including any current or future remedial or monitoring systems such as monitoring wells, landfill gas monitoring and collection systems, and subsurface groundwater control barriers. ICs are required on a property where the selected remedial action results in contamination remaining at the property above levels that allow for unlimited use and unrestricted exposure. The ICs for Parcel E-2 will restrict the development, land use, and activities on Parcel E-2 property as described in this LUC RD.

After this introductory section, the information in this LUC RD is organized as follows:

- Section 2 summarizes the environmental setting and historical operations at Parcel E-2.
- Section 3 identifies the area requiring institutional controls (ARIC).
- Section 4 describes the IC performance objectives and associated land use and activity restrictions, and identifies the legal mechanisms that will be used to implement the land use and activity restrictions.
- Section 5 describes the responsibilities of the Navy and future inspection and enforcement entities for implementing IC restrictions.
- Section 6 identifies the process for reviewing documents related to implementation of IC restrictions.
- Section 7 lists the reference documents used in preparing this LUC RD.

Figures and supporting attachments are presented following Section 7.

This LUC RD report is a component of the RD for Parcel E-2, which is a primary document under the HPNS Federal Facility Agreement (FFA). This report was prepared in accordance with the "Navy Principles and Procedures for Specifying Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions" attached to the January 16, 2004, Department of Defense Memorandum titled

"Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision (ROD) and Post-ROD Policy" (U.S. Department of Defense, 2004).

FFA signatories include the Navy, the U.S. Environmental Protection Agency (EPA), and the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) and San Francisco Bay Regional Water Quality Control Board (Water Board). The California Department of Public Health (CDPH) regulates activities related to remediation of radionuclides and, therefore, is also involved in oversight of actions at the portion of Parcel E-2 that is radiologically impacted. All references in this document to CDPH, including but not limited to requirements for approvals and reviews by CDPH, are intended to refer to and apply only within the ARIC for radionuclides (also referred to as the radiological ARIC).

The inspections and reporting requirements described in this report will be effective upon approval of the LUC RD report. The IC performance objectives will be achieved through access controls until the time of transfer. The land use and activity restrictions described in this LUC RD report will be incorporated into the Quitclaim Deed and Covenant to Restrict Use of Property and will take effect upon transfer and issuance of those documents.

Section 2. Site Description

HPNS is located in southeastern San Francisco on a peninsula that extends east into San Francisco Bay (see Figure 1). HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. In 1940, the Navy obtained ownership of HPNS for shipbuilding, repair, and maintenance activities. After World War II, activities at HPNS shifted to submarine maintenance and repair. HPNS was deactivated in 1974 and remained relatively unused until 1976. Between 1976 and 1986, the Navy leased most of HPNS to Triple A Machine Shop, Inc., a private ship repair company. In 1987, the Navy resumed occupancy of HPNS. Because past shipyard operations left hazardous substances on site, the HPNS property was placed on the National Priorities List in 1989 pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. In 1991, HPNS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPNS involve conducting environmental remediation and making the property available for nondefense use.

Parcel E-2, which includes about 47 acres of shoreline and lowland coast along the southwestern portion of the shipyard (see Figure 1), consists of the following four distinct study areas that were designated to organize the information presented in the Remedial Investigation/Feasibility Study Report (Engineering/Remediation Resources Group, Inc., and Shaw Environmental, Inc., 2011) (see Figure 2):

- The Parcel E-2 Landfill, located in the north-central part of Parcel E-2
- The Panhandle Area, located west and southwest of the Parcel E-2 Landfill
- The East Adjacent Area, located to the east of the Parcel E-2 Landfill
- The Shoreline Area, located at the edge of San Francisco Bay

A small portion of the Parcel E-2 Landfill extends north onto property owned by the University of California, San Francisco (UCSF) (see Figure 2).

Parcel E-2 was created by filling in the bay margin with various materials, including native soil, rock, and sediment, as well as construction and industrial debris. The ground surface elevation at Parcel E-2 varies from approximately 30 feet above mean sea level in the northern portion of the parcel to a few feet above mean sea level along the southwestern portion of the parcel. The Parcel E-2 Landfill is a 22-acre area where the Navy disposed of various shipyard wastes from the mid-1950s to the early-1970s. These wastes include:

- Construction debris (including wood, steel, concrete, and soil)
- Municipal-type trash (including paper, plastic, and metal)
- Industrial waste (including sandblast waste, paint sludge, solvents, and polychlorinated biphenyl [PCB]-containing waste oils)

Fill materials in the East Adjacent, Panhandle, and Shoreline Areas of Parcel E-2 are distinct from the Parcel E-2 Landfill. Specifically, fill materials in the East Adjacent, Panhandle, and Shoreline Areas consist primarily of soil, sediment, and rock with isolated solid waste locations that are not contiguous with solid waste in the Parcel E-2 Landfill. The solid waste in the East Adjacent, Panhandle, and Shoreline Areas consist primarily of construction debris with lesser quantities of industrial waste. Two areas with industrial waste (the PCB Hot Spot Area in the East Adjacent Area, and the Metal Slag Area in the Panhandle Area) were partially excavated under previous CERCLA removal actions.

HPNS was also the site of the Naval Radiological Defense Laboratory (NRDL). A history of Navy radiological operations at HPNS is provided in Volume II of the Historical Radiological Assessment (HRA). The HRA identified areas where low-level radiological material may be located at Parcel E-2 (Naval Sea Systems Command [NAVSEA], 2004). These areas are shown on Figure 3. The following radiological operations were identified at Parcel E-2:

- Dials, gauges, and deck markers painted with radioactive paint to make the devices glow in the dark) were disposed of at the Parcel E-2 Landfill and portions of the Panhandle Area and the East Adjacent Area (located within Installation Restoration [IR] Sites 01/21 and 02).
- Industrial debris and metal slag with dials, gauges, and deck markers painted with radioactive paint were disposed of at the Metal Slag Area (removed during a previous removal action).
- Small amounts of low-level radionuclides may be present in drain lines in the eastern part of Parcel E-2. Low-level radionuclides may have been released into drain lines at former NRDL buildings located outside of Parcel E-2 (in Parcel E), which led to drain lines in the eastern part of Parcel E-2. The drain lines in Parcel E and any contamination in them are currently being excavated as part of an ongoing removal action being performed throughout HPNS.
- Materials used during radiological experiments by NRDL may have been disposed of at the Parcel E-2 Landfill and portions of the Panhandle Area and the East Adjacent Area (located within IR Sites 01/21 and 02). However, historical records presented in the HRA suggest that such material was strictly controlled, particularly after 1954 when the U.S. Atomic Energy Commission began regulating the use of radionuclides at HPNS (NAVSEA, 2004). This information indicates that the volume of NRDL waste potentially disposed of in and around the Parcel E-2 Landfill was relatively low because most of these areas were filled after 1955.
- Sandblast waste from cleaning ships used during weapons testing in the South Pacific may have been disposed of at the Parcel E-2 Landfill, the Panhandle Area, and portions of the East Adjacent Area (located within IR Sites 01/21 and 02). However, historical records presented in the HRA indicate that waste with the highest levels of radioactivity was controlled and not disposed of anywhere at HPNS, including Parcel E-2 (NAVSEA, 2004).

Section 3. Area Requiring Institutional Controls

Figure 4 shows the ARIC for Parcel E-2. The ARIC is the same as shown on Figure 14 in the Final ROD for Parcel E-2 at HPNS (Navy, 2012). The entire area of Parcel E-2 (about 47 acres) will be subject to IC land use and activity restrictions (hereinafter referred to as "IC restrictions" for brevity) related to non-radioactive chemicals, including a small portion of the Parcel E-2 Landfill that extends north onto property owned by UCSF (see Figure 2). The activity restrictions related to non-radioactive chemicals include activity restrictions related to subsurface gas at Parcel E-2. The FFA signatories may modify the ARIC for subsurface gas, which will initially include all of Parcel E-2, based on the results of additional soil, vapor, and groundwater sampling and analysis that establishes that areas now included in the ARIC do not pose an unacceptable risk to human health.

Most of Parcel E-2, about 43 acres, will also be subject to additional activity restrictions related to radionuclides (see green pattern area on Figure 4; this area is also referred to as the radiological ARIC). The radiological ARIC consists of all of Parcel E-2 except for portions of the East Adjacent Area located outside of the IR Site 01/21 boundary (see Figure 3). Outside of the radiological ARIC, potential radioactive contamination exceeding the remediation goals would be removed as part of the remedial action, thus these areas would not be subject to activity restrictions regarding exposure to radioactivity.

Section 4. Institutional Control Performance Objectives and Associated Land Use and Activity (IC) Restrictions

The following sections describe the IC performance objectives and associated IC restrictions for Parcel E-2and the legal mechanisms that will be used to implement the IC restrictions.

4.1. IC PERFORMANCE OBJECTIVES AND ASSOCIATED LAND USE AND ACTIVITY (IC) RESTRICTIONS

IC performance objectives and associated IC restrictions were developed and presented in the ROD and are intended to limit exposure of future users of the property to hazardous substances and to maintain the integrity of the remedy. The following sections present the IC restrictions for Parcel E-2 .

4.1.1. Land Use and Activity Restrictions that Apply throughout Parcel E-2

The following sections describe the IC restrictions that apply throughout Parcel E-2 for the continued protection of human health and the environment.

4.1.1.1. Land Use Restrictions

Use of Parcel E-2 is restricted to open space and recreational uses, unless prior written approval for other uses is granted by the FFA signatories. In addition, the following land uses are specifically prohibited in all Parcel E-2 areas unless prior written approval for these uses is granted by the FFA signatories:

a. A residence, including any mobile home or factory built housing, constructed or installed for use as residential human habitation.

b. A hospital for humans.

c. A school for persons under 21 years of age.

d. A daycare facility for children.

e. Any permanently occupied human habitation, including those used for commercial or industrial purposes.

4.1.1.2. General Activity Restrictions

The following activities are restricted throughout Parcel E-2 unless prior written approval for these activities is granted by the FFA signatories (and CDPH within the radiological ARIC):

a. "Land-disturbing activity," which includes but is not limited to (1) excavation of soil; (2) construction of roads, utilities, facilities, structures, and appurtenances of any kind; (3) demolition or removal of "hardscape" (for example, concrete roadways, parking lots, foundations, and sidewalks); (4) any other activity that involves movement of soil to the surface from below the surface of the land; and (5) any other activity that causes or facilitates the movement of groundwater known to be contaminated with radionuclides or nonradioactive chemicals. Land-disturbing activities are not intended to include placement of additional clean, imported fill on top of the soil cover that the Navy will construct at Parcel E-2.

b. Alteration, disturbance, or removal of any component of a response or cleanup action (including but not limited to pump-and-treat facilities, revetment walls and shoreline protection, and soil cap/containment systems); groundwater extraction, injection, and monitoring wells and associated piping and equipment; or associated utilities.

c. Extraction of groundwater and installation of new groundwater wells with the exception of environmental sampling and monitoring requirements as described in the Remedial Action Monitoring Plan for Parcel E-2.

d. Removal of or damage to security features (e.g., locks on monitoring wells, survey monuments, fencing, signs, or monitoring equipment and associated pipelines and appurtenances).

4.1.1.3. Prohibited Activities

The following activities are prohibited throughout Parcel E-2:

a. Growing vegetables, fruits, or any edible items in native soil for human consumption.

b. Use of or access to groundwater.

4.1.2. Additional Activity Restrictions Related to Radionuclides at Parcel E-2

The following activities are restricted within the radiological ARIC at Parcel E-2 unless prior written approval for these activities is granted by the FFA signatories and CDPH:

a. Excavation below the demarcation layer.

   i. The demarcation layer is a visual cue to identify the potential presence of radionuclides to anyone excavating into the soil cover in the radiological ARIC. The demarcation layer will provide an additional warning beyond the other ICs. The demarcation layer will have two components: (1) an orange-colored geotextile and (2) a marking tape with the message "Caution Do Not Dig Below." The geotextile will cover the entire radiological ARIC; the marking tape will be secured on top of the geotextile in a rectangular grid pattern on a 10-foot by 10-foot spacing. Refer to the RD for details of the demarcation layer and the soil cover in general.

ii. Any proposed excavation shall be required to be described in a work plan that will include but not be limited to a radiological work plan, the identification of a radiological safety specialist, a soil management plan, soil sampling and analysis requirements, and a plan for offsite disposal of any excavated radionuclides by the transferee in accordance with federal and state law. This work plan must also specify appropriate procedures for the proper identification and handling of material potentially presenting an explosive hazard. This work plan must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures and timeframes that are set forth in Section 6 of this LUC RD. The integrity of the cover/cap must be restored upon completion of excavation as provided in the Operation and Maintenance Plan for Parcel E-2. A completion report describing the details of implementation of the work plan, the sampling and analysis (if required), the offsite disposal (if required), and the restoration of the integrity of the cover/cap must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures and timeframes that are set forth in Section 6 of this LUC RD.

iii. Installation of water lines, storm drains, or sanitary sewers above the demarcation layer and within the soil cover constructed by the Navy.

b. Installation of water lines, storm drains, or sanitary sewers above the demarcation layer and within the soil cover constructed by the Navy shall be required to be described in a work plan that will identify the procedures to restore the soil cover following excavation and ensure the integrity of the demarcation layer and underlying cap. This work plan must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures and timeframes that are set forth in Section 6 of this LUC RD. The soil cover must be restored upon completion of excavation as provided in the Operation and Maintenance Plan for Parcel E-2. A completion report describing the details of implementation of the work plan must be submitted to and approved in writing by the FFA signatories and CDPH in accordance with procedures and timeframes that are set forth in Section 6 of this LUC RD.

c. Installation of water lines, storm drains, or sanitary sewers in any additional clean, imported fill placed on top of the soil cover that the Navy has constructed at Parcel E-2 is not intended to be restricted if the property owner demarcates the interface between the preexisting cover and any new imported soil.

4.1.3. Additional Activity Restrictions Related to Subsurface Gas at Parcel E-2

Any proposed construction of enclosed structures must be approved in writing by the FFA signatories prior to conducting such activities within the ARIC (Figure 4) to ensure compliance with the substantive provisions of California Code of Regulations (CCR) Title 27 Section (§) 21190(a), (b), (d), (e), (f) and (g), which requires that postclosure land uses be designed and maintained to protect health and safety in areas affected by landfill gas migration. In particular, CCR Title 27 § 21190(g) specifies design and construction standards for "all on site construction within 1,000 feet of the boundary of any disposal area." The Navy has determined that the substantive provisions of CCR Title 27 § 21190(g) are relevant and appropriate for future construction within the Parcel E-2 boundary, including the portion of the

Parcel E-2 Landfill that extends onto UCSF property, because Parcel E-2 may be affected by subsurface gas emanating from the Parcel E-2 Landfill. However, these provisions are not relevant and appropriate to future offsite construction beyond the Parcel E-2 boundary because these areas are not affected by subsurface gas emanating from the Parcel E-2 Landfill. The interim gas control system and ongoing monitoring program are effectively controlling the migration of hazardous levels of landfill gas beyond the Parcel E-2 boundary. The permanent gas control system in the selected remedy would continue to control the migration of hazardous levels of landfill gas beyond the Parcel E-2 boundary.

Human health can be protected through engineered containment systems, such as landfill caps and gas control systems, or other design alternatives that meet the specifications set forth in the RD. As described in Section 3, the FFA signatories may modify the ARIC for subsurface gas, which will initially include all of Parcel E-2, based on the results of additional soil, vapor, and groundwater sampling and analysis that establishes that areas now included in the ARIC do not pose an unacceptable risk to human health.

4.2. LEGAL MECHANISMS TO IMPLEMENT IC RESTRICTIONS

The IC performance objectives will be achieved through access controls until the time of conveyance of the property containing Parcel E-2. The IC restrictions will be implemented through different legal mechanisms after conveyance of the property containing Parcel E-2 to a non-federal entity, as described in Section 4.2.1. For the small portion of the Parcel E-2 Landfill that extends north onto property owned by UCSF (see Figure 2), the IC restrictions will be implemented through different legal mechanisms as described in Section 4.2.2.

4.2.1. Legal Mechanisms Following Conveyance

Each transfer of fee title from the United States to a non-federal entity will include a description of the residual contamination on the property and the IC restrictions set forth in Section 4.1. Each deed will also contain a reservation of access to the property for the Navy, the FFA signatories, and their respective officials, agents, employees, contractors, and subcontractors for purposes consistent with the Navy IR Program or the FFA. The deed will contain appropriate provisions to ensure that the restrictions continue to run with the land and are enforceable by the Navy. The Navy will meet the statutory requirements of CERCLA § 120(h)(3) for any transfer of fee title.

The Navy has determined that it will rely on proprietary controls in the form of environmental restrictive covenants, as provided in the "Memorandum of Agreement between the United States Department of the Navy and the California Department of Toxic Substances Control" and attached covenant model (Navy and DTSC 2000) (the "Navy/DTSC MOA"). The following two proprietary legal mechanisms will incorporate and be relied upon to implement the IC restrictions when the property is conveyed to a non-federal entity and shall remain in effect until terminated, as provided below in Section 5.1 (Item 11):

1. Restrictive covenants included in one or more Quitclaim Deeds from the Navy to the property recipient.
2. Restrictive covenants included in one or more Covenants to Restrict Use of Property entered into by the Navy and DTSC, as provided in the Navy/DTSC MOA and consistent with the substantive provisions of CCR Title 22 § 67391.1.

The Covenant to Restrict Use of Property will incorporate the IC restrictions into environmental restrictive covenants that run with the land and that are enforceable by DTSC and EPA against future transferees and users. The Quitclaim Deed will include the identical IC restrictions in environmental restrictive covenants that run with the land and that will be enforceable by the Navy against future transferees.

IC restrictions will be maintained until the concentrations of hazardous substances in soil and groundwater are at such levels as to allow for unrestricted use and exposure. See Section 5.1 (Item 11) for procedures for termination.

In addition to the legal mechanisms described above, the City and County of San Francisco may prepare a risk management plan that will be approved by the FFA signatories and may set forth certain requirements and protocols used to conduct restricted activities identified in Section 4.1.

4.2.2. Legal Mechanisms for Property Owned by UCSF

The Navy will access the portion of the Parcel E-2 Landfill extending onto UCSF property (as identified on Figure 2) to perform the remedial action pursuant to easements, or another appropriate legal mechanism, entered into with UCSF. In addition, the Navy and the regulatory agencies will also control use, through easements or another appropriate legal mechanism entered into with UCSF, of the portion of the Parcel E-2 Landfill extending onto UCSF property to ensure that its future use is compatible with the selected remedy. Specific requirements for accessing or controlling use of the portion of the Parcel E-2 Landfill extending onto UCSF property will be specified in the Draft Final LUC RD Report.

Section 5. Remedy Implementation Actions

This section describes the responsibilities of the Navy and future inspection and enforcement entities for implementing IC restrictions.

5.1. NAVY RESPONSIBILITIES

The Navy is responsible for implementing, maintaining, reporting on, and enforcing the IC restrictions described in Section 4.1. Although the Navy may later transfer these procedural responsibilities to the Successor Agency to the San Francisco Redevelopment Agency, the Navy will retain ultimate responsibility for integrity of the remedy. It is the Navy's intent to later transfer these procedural responsibilities to the Successor Agency to the San Francisco Redevelopment Agency. Agreement on the details of the transfer responsibilities will be the subject of future negotiation. Should any IC restrictions fail to be properly implemented, the Navy will ensure that appropriate actions are taken to reestablish the protectiveness of the remedy and may initiate legal action to either compel action by a third party or to recover the Navy's costs for mitigating any discovered actions inconsistent with selected restrictions.

The Navy will undertake the following actions to ensure that the IC restrictions for Parcel E-2 are properly implemented and maintained:

1. **LUC RD Distribution**: Within 30 days of receiving approval of this LUC RD report from the FFA signatories and CDPH, the Navy will place the LUC RD report in the information repositories for HPNS. A copy of the LUC RD report will also be sent to the following interested parties. Attachment A includes a table with mailing addresses for these entities.
   a. EPA
   b. DTSC
   c. Water Board
   d. CDPH
   e. Successor Agency to the San Francisco Redevelopment Agency
2. **Site Access**: Each deed will contain a reservation of access to the property for the Navy, the FFA signatories (and CDPH within the radiological ARIC), and their respective officials, agents, employees, contractors, and subcontractors for purposes consistent with the Navy IR Program or the FFA.

3. **Site Inspections**: The Navy will undertake annual site inspections to ensure that all IC restrictions are complied with as long as it owns the property. At the time of conveyance of the site, the Navy and DTSC will require, via appropriate provisions to be placed in the Navy's Quitclaim Deed of conveyance and DTSC's Covenant to Restrict Use of Property, that the transferee shall, prior to transfer, propose a mechanism for the Navy's and DTSC's approval that will provide for performance of future annual inspections by a single entity on behalf of multiple owners of the property if the property is subdivided into more than two separate subparcels creating either of the following conditions: (1) there will be more than two owners of different subparcels on the property, or (2) any of the subparcels will become a common interest development as defined in California Civil Code § 1351 or would in any other way become subject to multiple separate ownership interests. This inspection and enforcement entity shall undertake continuing annual site inspections to ensure that all IC restrictions are complied with by all future users as provided in Section 5.2 (Item 1).

4. **Compliance Reporting**: Beginning upon approval of this LUC RD and continuing until the effective date of property conveyance, the Navy will provide to the other FFA signatories and CDPH an annual IC Compliance Monitoring Report and Certificate for Parcel E-2 consistent with the form attached to this report as Attachment B. The annual IC Compliance Monitoring Report will address, among other things, whether the IC restrictions were communicated in the deed(s), whether the owners and state and local agencies were notified of the IC restrictions affecting the property, and whether use of the property has conformed with such IC restrictions. In addition, should any deficiencies be found during the annual inspection, the Navy will provide the FFA signatories and CDPH with a separate written explanation to accompany the IC Compliance Certificate indicating the specific deficiencies found and what efforts or measures have been or will be taken to correct those deficiencies. Copies of the completed and signed IC Compliance Monitoring Report and Certificate will be sent to the FFA signatories and CDPH by certified mail, return receipt requested, annually. Upon conveyance of fee title for the site to a non-federal entity, the Navy will require, via appropriate provisions to be placed in its deed of conveyance, that the inspection and enforcement entity respond to violations of IC restrictions as provided below in Section 5.2 and provide to the Navy, other FFA signatories, and CDPH an annual IC Compliance Monitoring Report and Certificate for Parcel E-2 consistent with the form attached hereto as Attachment B unless and until all ICs are terminated at the site. If the inspection and enforcement entity fails to provide an annual compliance monitoring report as described above to the Navy, the Navy will notify the FFA signatories as soon as practicable. If any of the FFA signatories and CDPH does not receive the annual monitoring report from the inspection and enforcement entity, it will notify the Navy as soon as practicable. The Navy will ensure appropriate measures have been taken to verify the status of the IC restrictions and that an annual compliance monitoring report is submitted to the FFA signatories and CDPH within 90 days after the report's due date.

5. **CERCLA 5-Year Reviews**: The Navy will conduct 5-year reviews of the remedy for Parcel E-2, as required by CERCLA § 121(c) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The 5-year review will evaluate, among other things, implementation and compliance with the IC restrictions to assess whether the remedy is or will be protective of human health and the environment in the future. The annual compliance monitoring reports prepared by the inspection and enforcement entity will be used in preparation of the 5-year review reports to evaluate the effectiveness of the remedy.

6. **Notice of Planned Property Conveyance**: The Navy will provide notice to the FFA signatories and CDPH at least 6 months prior to any transfer or sale of Parcel E-2 by the Navy, so all FFA signatories and CDPH can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for the facility to notify the FFA signatories and CDPH at least 6 months prior to any transfer or sale, then the facility will notify them as soon as possible but no later than 45 days prior to the transfer or sale of any property by the Navy subject to ICs. In addition to the land transfer notice and discussion provisions in this LUC RD report, the Navy further agrees to provide the FFA signatories and CDPH with similar notice, within the same time frames, as to federal-to-federal transfer of property. The Navy will provide a copy of the executed deed of conveyance to the FFA signatories and CDPH.

7. **Opportunity to Review the Text of Intended Deed Restrictions**: Prior to conveyance of the site, the FFA signatories and CDPH will be given reasonable opportunity to review and comment on the applicable language in the Quitclaim Deed and Covenant to Restrict Use of Property related to all IC restrictions and associated rights of entry for the FFA signatories and CDPH for IC oversight and enforcement. The provisions in that deed or other enforceable documents will be consistent with the IC restrictions in Section 4.1 of this LUC RD Report.

8. **Notification Should Actions that Interfere with IC Effectiveness be Discovered**: The Navy or transferee will notify the FFA signatories and CDPH as soon as practicable, but no longer than 10 working days after the Navy's or transferee's discovery of any activity that is inconsistent with the IC restrictions or any other action that may interfere with the effectiveness of the ICs. The Navy or the inspection and enforcement entity will notify the FFA signatories and CDPH regarding how a breach will be addressed or has been addressed as soon as practicable, but no more than 10 working days after notification of the breach. This reporting requirement does not preclude the Navy from taking immediate action pursuant to its CERCLA authorities to prevent any actual or perceived risks to human health or the environment.

9. **IC Enforcement**: Any activity that is inconsistent with the IC restrictions, or any other action that may interfere with the effectiveness of the ICs, will be addressed by the Navy or designee as soon as practicable, but in no case will the process be initiated later than 60 days after the Navy becomes aware of the breach. If a violation of an IC restriction is identified or documented by the FFA signatories (or CDPH for IC restrictions related to radionuclides within the radiological ARIC), or in the inspection and enforcement entity's annual IC compliance monitoring report, the entity identifying the violation will notify the others within 10 working days of identifying the violation. The FFA signatories and CDPH will then consult to evaluate what, if any, action should be taken; who shall take the action; and when it shall be undertaken. These actions may range from informal resolution with the owner or violator of an IC restriction as described in this LUC RD Report, to the pursuit of legal remedies or enforcement action under the auspices of state law or CERCLA. Alternatively, the Navy may choose to exercise its response authorities under CERCLA and seek cost recovery from the person or entity that violates a given IC restriction set forth in the deed transferring the property. Should the Navy become aware that any future owner or user of the property has violated any IC restriction over which a local agency may have independent jurisdiction, the Navy will notify these agencies of the violation and work cooperatively with them to reachieve owner or user compliance with the IC restrictions. DTSC and the Navy as signatories to the Covenant to Restrict Use of Property

(and EPA as a third-party beneficiary) will have independent authority to enforce violations of restrictions, requirements, and obligations under the Covenant. While DTSC may agree to consult with other parties before taking any enforcement action under the Covenant, it will not waive its authority to take action as necessary in the event of violations.

10. **Modification of Restrictions in Quitclaim Deed and DTSC Covenant to Restrict Use of Property**: Modifications to the IC restrictions may be required based on changes in site conditions (for example, reduction in the ARIC) during the expected duration for the ICs. When the Navy determines, with FFA signatory (and CDPH within the radiological ARIC) concurrence, that modifications to the IC restrictions are necessary, the modifications will be documented in accordance with procedures consistent with applicable laws and regulations. The Navy or inspection and enforcement entity shall be responsible for providing pertinent information on the modifications to the interested parties listed in Section 5.1 (Item 1). The Navy and FFA signatories shall determine whether a ROD amendment or explanation of significant differences, or some other procedure consistent with the NCP, is required to support the modification of the IC restrictions. The Navy shall not modify or terminate IC restrictions, implementation actions, or modify land use without prior approval by the FFA signatories and CDPH. The Navy or transferee shall obtain prior concurrence before any anticipated action by the Navy or transferee that may disrupt the effectiveness of the ICs or any action that may alter or negate the need for ICs.

11. **Termination of ICs**: When the Navy determines, with FFA signatory (and CDPH within the radiological ARIC) concurrence, that one or more of the IC restrictions at Parcel E-2 is no longer needed for protection of human health and the environment because the property is remediated to levels of contamination that allow for unrestricted residential use, the Navy and DTSC shall provide to the current landowner of the property an appropriate release of the restriction(s) (Navy for the deed and DTSC for the Covenant to Restrict Use of Property) in accordance with state law for recordation with the deed pertaining to the site. The Navy will also advise the interested parties listed in Section 5.1 (Item 1) of that action in a timely manner. Termination of some IC restrictions may be possible (for example, activity restrictions related to vapor intrusion); however, most IC restrictions (such as those requiring protection of the durable cover) will continue in perpetuity to provide protection of human health and the environment. IC restrictions will be maintained until the concentrations of hazardous substances in soil and groundwater are at such levels as to allow for unrestricted use and exposure.

12. **Survey Plat**: Prior to transfer, the Navy will survey the ARICs at Parcel E-2 to define the legal metes and bounds for inclusion in the property transfer documents. The Navy will forward copies of the survey to the FFA signatories and CDPH and will place a copy in the administrative record.

The requirements described above are consistent with a LUC RD checklist developed by EPA (2006). Attachment C consists of a site-specific LUC RD checklist that (1) lists the information suggested by EPA, and (2) identifies its location in either the ROD or this LUC RD.

5.2. INSPECTION AND ENFORCEMENT ENTITY RESPONSIBILITIES

The Navy will include appropriate provisions in the Quitclaim Deed or other enforceable documents pertaining to the conveyance of fee title to the site to a non-federal entity, that will require the transferee, prior to transfer, to propose a mechanism for the Navy's and DTSC's approval that will provide for execution of the following IC implementation responsibilities by a single entity on behalf of multiple owners of the property as described in Section 5.1, Item 3. This inspection and enforcement entity shall, upon the Navy's conveyance of the property, ensure that the IC restrictions for Parcel E-2 are complied with after property transfer:

1. **Site Inspections**: The inspection and enforcement entity will conduct annual physical inspections of the site to confirm continued compliance with all IC restrictions in the Quitclaim Deed and Covenant to Restrict Use of the Property unless and until all ICs at the site are terminated with approval of the FFA signatories and CDPH.
2. **Compliance Reporting**: The inspection and enforcement entity will notify the FFA signatories and CDPH within 5 working days of the inspection and enforcement entity's discovery of any actions inconsistent with selected IC restrictions and include in the notification a written explanation indicating the specific actions inconsistent with selected IC restrictions found and what efforts or measures have been or will be taken to correct those actions. The inspection and enforcement entity will also provide the FFA signatories and CDPH with an annual Compliance Monitoring Report and IC Compliance Certificate for Parcel E-2 consistent with the form attached to this report as Attachment B unless and until all ICs are terminated at the site. In addition, should any actions inconsistent with selected IC restrictions be discovered during the annual site inspection, the inspection and enforcement entity will provide to the FFA signatories and CDPH, along with the required IC Compliance Monitoring Report and Certificate, a separate written explanation indicating the specific actions inconsistent with selected IC restrictions found and what efforts or measures have been or will be taken to correct those actions. The annual Compliance Monitoring Report and certificate shall continue to be sent to the Navy, other FFA signatories, and CDPH by certified mail, return receipt requested, annually unless the FFA signatories agree to change this requirement. The need to continue to provide these inspections and certifications on an annual basis will be reevaluated every 5 years by the FFA signatories. Monitoring of the IC restrictions will be conducted annually by the inspection and enforcement entity. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to EPA and the other FFA signatories. The annual monitoring reports will be used in preparing the 5-year review to evaluate the effectiveness of the remedy. The annual monitoring report, submitted to the regulatory agencies by the inspection and enforcement entity, will evaluate the status of the IC restrictions and how any deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the IC restrictions referenced above were communicated in the deed(s), whether the owners and state and local agencies were notified of the IC restrictions affecting the property, and whether use of the property has conformed with such IC restrictions.

3. **Monitoring Well Protection**: The inspection and enforcement entity and other entities responsible for planning and development of future projects within the ARIC shall be required to add the monitoring well coordinates to their geographic information systems databases and applicable maps and drawings to preclude damage to the monitoring well network at Parcel E-2. The inspection and enforcement entity, or other entity responsible for review and approval of civil plans prepared for projects within the ARIC, shall identify any potential for the project to impact the IC effectiveness and coordinate with the Navy, other FFA signatories, and CDPH to prevent interference with the IC effectiveness. The Navy and other FFA signatories reserve the right to deny approval of projects within the ARIC deemed to interfere with IC effectiveness. This process will be reviewed during the 5-year review to evaluate whether any changes need to be implemented.
4. **Notification of Proposed Changes in Land Use**: Prior to seeking approval from the FFA signatories (and CDPH within the radiological ARIC), the inspection and enforcement entity and other entities responsible for planning and development of future projects within the ARIC must notify and obtain approval from the Navy of any proposals for a land use change at Parcel E-2 inconsistent with the IC restrictions and assumptions described in the final ROD.

Section 6. Review of Documents

As described above, the Navy or inspection and enforcement entity may prepare various documents during implementation of the IC restrictions. The documents will be subject to review and approval by the Navy and FFA signatories (and CDPH for the documents that may affect the radiological ARIC).

Draft documents will be subject to a review period of 45 days. Reviewing parties may request an extension of the review period for up to an additional 45 days from the party submitting the document. The party submitting the document will have 45 days to revise the document to address the comments received.

Draft final documents will be subject to a review period of 30 days. Reviewing parties may request an extension of the review period for up to an additional 30 days from the party submitting the document. The party submitting the document will have 45 days to revise the document to address the comments received. Draft final documents will be considered to be final if no comments are received within the 30-day comment period.

All parties preparing or reviewing documents will adhere to the scheduled document preparation and review times to the maximum extent practicable.

Section 7. References

Department of the Navy, 2012. "Final Record of Decision for Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." November.

Department of the Navy and Department of Toxic Substances Control, 2000. "Memorandum of Agreement Between the United States Department of the Navy and the California [Environmental Protection Agency] Department of Toxic Substances Control." March 10.

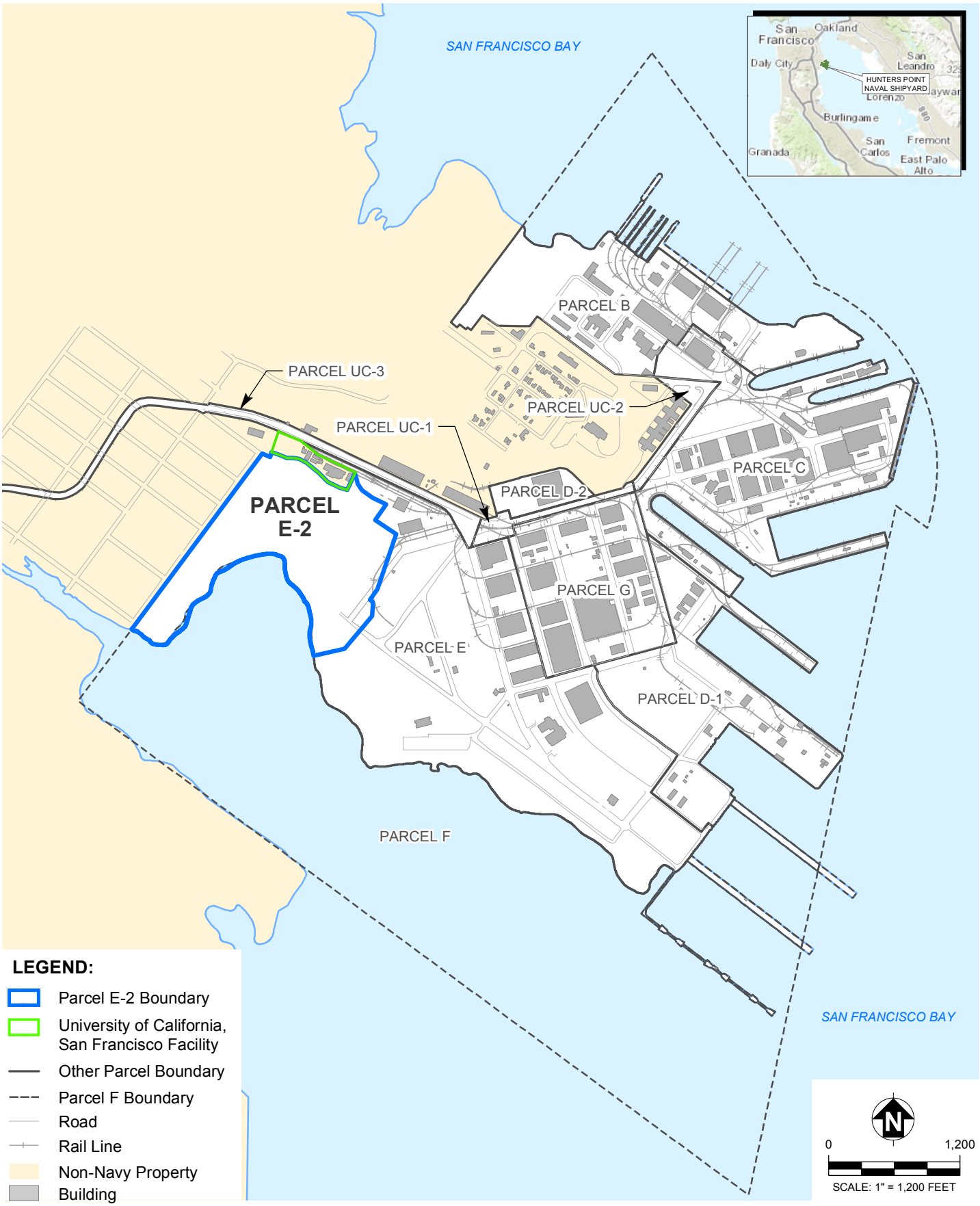
Engineering/Remediation Resources Group, Inc., and Shaw Environmental, Inc., 2011. "Final Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California." May.

Naval Sea Systems Command, 2004. "Hunters Point Shipyard Final Radiological Historical Assessment." Volume II.

U.S. Department of Defense, 2004. "Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision (ROD) and Post-ROD Policy." From Alex A. Beehler, Assistant Under Secretary of Defense (Environment, Safety, and Occupational Health). January 16.

U.S. Environmental Protection Agency, 2006. "Sample Federal Facility Land Use Control ROD Checklist with Suggested Language." October.

Figures



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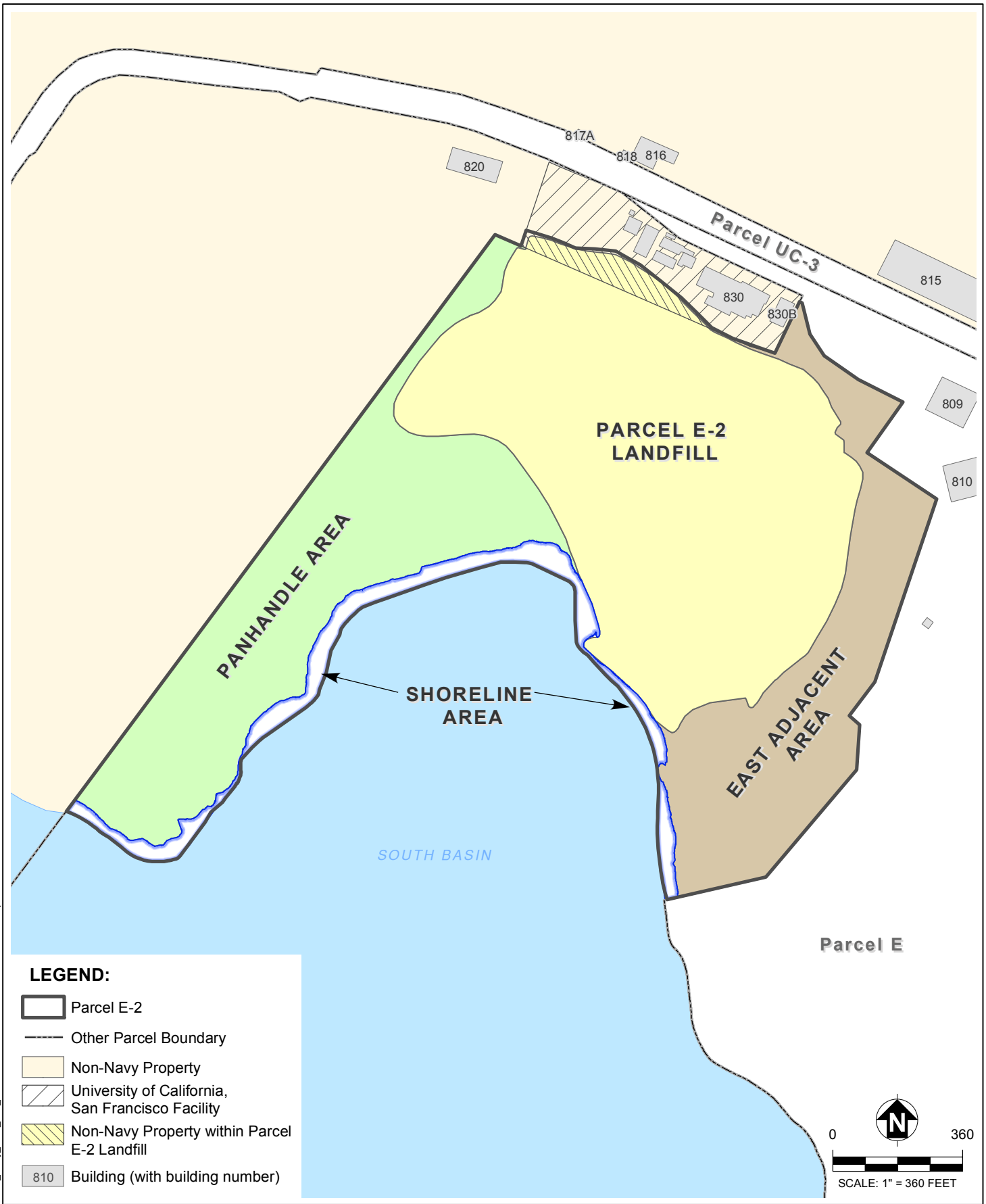
ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	SITE VICINITY MAP			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 1



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ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PARCEL E-2 AREAS			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 2

Notes:

Impacted sites are sites that have known radiological contamination or where site history indicates that radiological contamination may be present.

Impacted sites based on Historical Radiological Assessment (Naval Sea Systems Command, 2004).

For planning purposes, all storm drains and sanitary sewers should be considered impacted.

Storm drain and sanitary sewer line locations are based on data from the Navy's Caretaker Site Office and the Historical Radiological Assessment; locations will be verified in the field. Construction documentation for septic sewer lines does not exist. Potential septic sewer lines, if found to originate from radiologically impacted buildings near Parcel E-2 (Building 810), would be considered impacted.

N

0 200
SCALE: 1" = 200 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	RADIOLOGICALLY IMPACTED AREAS		
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	DB 02/20/13	25-049	3

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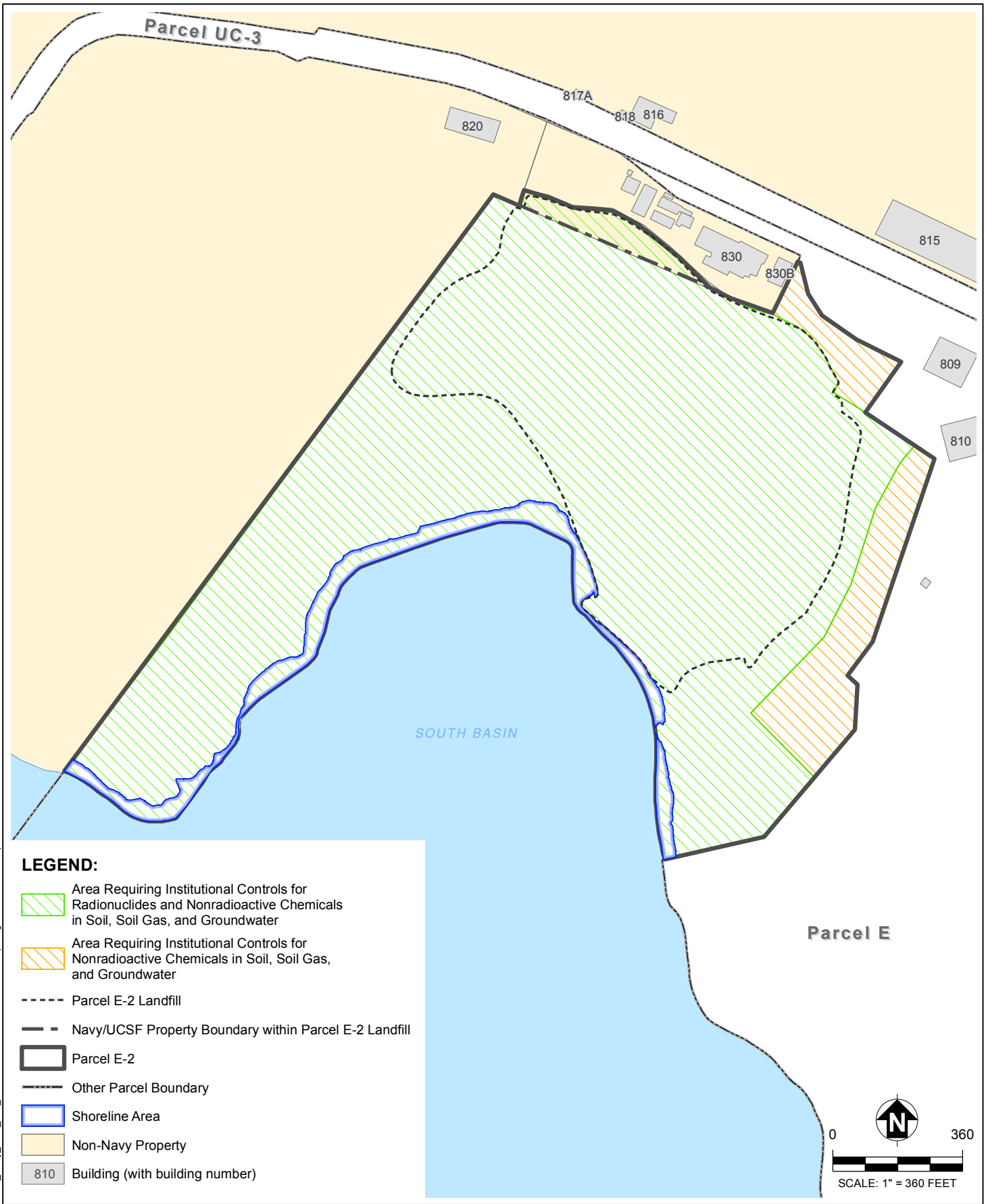

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ERRG
Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:				
DEPARTMENT OF THE NAVY, BRAC PMO WEST	AREAS REQUIRING INSTITUTIONAL CONTROLS			
LOCATION:	DRAWN BY:	CHECKED BY:	PROJECT NO.	FIG NO.
HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	JJC 02/20/13	JS 02/20/13	25-049	4

Attachment A. Interested Parties for Parcel E-2 Land Use Control Remedial Design Report

Interested Parties for Land Use Control Remedial Design Report
Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California

Agency	Mailing Address	Point of Contact
U.S. Environmental Protection Agency, Region 9	Superfund (SFD 8-3) 75 Hawthorne Street San Francisco, CA 94105-3901	Mr. Craig Cooper
Department of Toxic Substances Control	700 Heinz Avenue, Bldg. F Berkeley, CA 94710-2737	Mr. Ryan Miya
San Francisco Bay Regional Water Quality Control Board	1515 Clay Street, Suite 1400 Oakland, CA 94612	Ms. Tina Low
California Department of Public Health	Environmental Management Branch 1616 Capitol Avenue, MS 7402 Sacramento, CA 95899-7377	Mr. Ron Pilorin
Successor Agency to the San Francisco Redevelopment Agency	1 South Van Ness Avenue, Fifth Floor San Francisco, CA 94103	Mr. Thor Kaslofsky

Attachment B. Parcel E-2 IC Compliance Monitoring Report and Annual IC Compliance Certificate

Parcel E-2 Institutional Control Compliance Report
Hunters Point Naval Shipyard, San Francisco, California
U.S. EPA I.D. Number: CA1170090087

Inspection and Enforcement Entity: _____
This evaluation is the final Navy certification just prior to site conveyance (yes or no)
_____

If for an annual inspection, this evaluation covers the period from _____ through _____

Certification Checklist

	In Compliance	Non-Compliance	See Comment
1) No use of Parcel E-2 for a residence, including any mobile home or factory-built housing, constructed or installed for use as residential human habitation, a hospital for humans, a school for persons under 21 years of age, or a daycare facility for children.[a]	☐	☐	☐
2) No growing of vegetables, fruits, or any edible items in native soil for human consumption.	☐	☐	☐
3) No groundwater use for any purpose (no evidence of tampering with existing wells or evidence of new wells).	☐	☐	☐
4) No land-disturbing activity[a] (excavation; construction of roads, utilities, or structures; demolition of hardscape; movement of soil from below ground surface to the surface; or activity that facilitates movement of known contaminated groundwater).	☐	☐	☐
5) No installation of new groundwater wells of any type.[a]	☐	☐	☐
6) No altering, disturbing, or removing components of the remedy, including revetment, soil cover/cap, or groundwater monitoring wells and associated equipment.[a]	☐	☐	☐
7) No construction of enclosed structures.[a]	☐	☐	☐
8) No excavation beneath the demarcation layer in the area requiring institutional controls for radionuclides.[a]	☐	☐	☐

Parcel E-2 Institutional Control Compliance Report *(continued)*
Hunters Point Naval Shipyard, San Francisco, California
U.S. EPA I.D. Number: CA1170090087

	In Compliance	Non-Compliance	See Comment
9) No installation of water lines, storm drains, or sanitary sewers above the demarcation layer in the area requiring institutional controls for radionuclides.[a]	☐	☐	☐
10) No removal or damage to security features (such as locks on monitoring wells, site fencing, or signs) or to survey monuments, monitoring equipment, piping or other appurtenances.	☐	☐	☐
11) Notification provided for any unauthorized change in land use.	☐	☐	☐
12) Any violations of these land use and activity restrictions were reported within 10 business days of discovery and an explanation provided of those actions taken or to be taken was provided within 10 days of notification of discovery.	☐	☐	☐

I, the undersigned, hereby certify that the above-described land use and activity restrictions have been complied with for the period noted. Alternately, any known deficiencies and completed or planned actions to address such deficiencies are described in the attached explanation of deficiencies.

_____ _____
Signature Date

Notes:

[a] These prohibited or restricted activities may be conducted provided that the requirements in the LUC RD are followed. If the inspector finds that a prohibited or restricted activity has occurred, the inspector shall check whether the activity was conducted in accordance with approved plans for that activity. Activities that are conducted in accordance with the approved plans will be considered "in compliance." Comments should be attached to the compliance checklist to describe how the requirements in the plans were adhered to. Activities that are not conducted in accordance with the approved plans would be considered "non-compliance."

Photographs, in addition to other notes and forms, to document the conditions certified in this checklist should be provided.

Send the completed form and all accompanying information by certified mail, return receipt requested, to the Navy, EPA, DTSC, Water Board, and CDPH each calendar year.

Annual IC Compliance Certificate

Parcel E-2
Hunters Point Naval Shipyard, San Francisco, California

U.S. EPA I.D. Number: CA1170090087

I _____ hereby certify that the attached Parcel E-2 Institutional Control Compliance Monitoring Report is complete and accurate. The requirements of LUC RD report Section 4 have been met. I further certify that a copy of this compliance certificate and the attached Parcel E-2 Institutional Control Compliance Monitoring Report have been sent to the following addressees:

Department of the Navy
Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, CA 92108-4310

U.S. Environmental Protection Agency Region 9
Superfund (SFD 8-3)
75 Hawthorne Street
San Francisco, CA 94105-3901

Department of Toxic Substances Control
700 Heinz Avenue, Bldg. F
Berkeley, CA 94710-2737

San Francisco Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

California Department of Public Health
Environmental Management Branch
1616 Capitol Avenue, MS 7402
Sacramento, CA 95899-7377

_____ _____
Signature Date

_____ _____
Name Title

Attachment C. Parcel E-2 Land Use Controls Remedial Design Checklist

Land Use Controls Remedial Design Checklist
Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California

Item Number	Checklist Item [a]	Location in ROD	Location in LUC RD
1	Prepare map showing areas requiring ICs	Figure 14	Figure 4
2	Document risk exposure assumptions and reasonably anticipated land uses	Section 2.4	--
3	Describe the risks necessitating the ICs	Section 2.5.3	--
4	State the IC performance objectives	Section 2.9.2.3	Section 4.1
5	Describe the ICs and the logic for their selection	Section 2.9.2.3	Sections 4.2 and 4.3
6	Specify the duration for implementation of ICs	Section 2.9.2.3	Sections 1, 4.2, and 5.1 (Item 11)
7	Specify that the Navy is responsible for implementing, maintaining, reporting on, and enforcing ICs	Section 2.9.2.3	Section 5.1
8	Specify that the Navy may transfer procedural responsibilities to another party but shall retain ultimate responsibility for remedy integrity	Section 2.9.2.3	Section 5.1
9	Refer to a LUC RD that will identify the actions for implementation of ICs	Section 2.9.2.3	--
10	Specify the Navy's commitment to address any situation that may interfere with the effectiveness of ICs	--	Section 5.1 (Item 8)
11	Specify the Navy's commitment to notify EPA of and address any situation that may interfere with the effectiveness of ICs	--	Section 5.1 (Item 8)
12	Specify that EPA and the state will be notified regarding land use changes	--	Section 5.1 (Item 2)
13	Specify that EPA and the state will be notified regarding transfers and federal-to-federal transfers		Section 5.1 (Item 6)
14	Specify that EPA and state concurrence must be received prior to modification or termination of ICs	--	Section 5.1 (Items 10 and 11)

Land Use Controls Remedial Design Checklist *(continued)*
Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California

Item Number	Checklist Item [a]	Location in ROD	Location in LUC RD
15	Specify the Navy's commitment to perform annual inspections and compliance reporting for ICs	--	Section 5.1 (Item 4)
16	Provide a comprehensive list of ICs	--	Sections 4.2 and 4.3
17	For active facilities, describe the internal procedures for implementing the ICs (e.g., orders, instructions, Base Master Plan) and a commitment by the federal agency to notify EPA in advance of any changes to the internal procedures that would affect the ICs	--	--[b]
18	Provide property transfer language (deed restrictions, lease restrictions, and notices)	--	Sections 4.2 and 4.3
19	Ensure that the LUC RD adequately describes pre-transfer ICs, not just post-transfer ICs	--	Sections 4.2 and 4.3

Notes:

a This LUC RD checklist is based on a sample checklist, prepared by EPA in October 2006, to guide preparation of ROD and RD documents at federal facilities. Consistent with EPA's sample checklist, Items 1 through 9 are provided in the Final ROD for Parcel E-2, and Items 10 through 19 are provided in this LUC RD.

b Item 17 is not applicable because Hunters Point Naval Shipyard is not an active facility.

EPA = U.S. Environmental Protection Agency

ICs = institutional controls

LUC RD = land use controls remedial design

Navy = Department of the Navy

RD = remedial design

ROD = record of decision

-- = not applicable

Sources:

EPA, 2006. "Sample Federal Facility Land Use Control ROD Checklist with Suggested Language." October.

Navy, 2012. "Final Record of Decision for Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." November.

Draft

Preconstruction Operation and Maintenance Plan for Parcel E-2

Hunters Point Naval Shipyard
San Francisco, California

June 2013

Prepared for:
Department of the Navy
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104

Prepared under:
Naval Facilities Engineering Command Southwest
Contract No. N68711-05-C-6011
Document Control No. ERRG-6011-0000-0034

Draft
Preconstruction Operation and Maintenance Plan for Parcel E-2 Hunters Point Naval Shipyard San Francisco, California

June 2013

Submitted by:
Engineering/Remediation Resources Group, Inc.

Signature Doug Bielskis, P.E.	June 25, 2013 Date Project Manager / Engineer of Record

Table of Contents

SECTION 1. INTRODUCTION 1-1
1.1. Document Organization 1-2
1.2. Site Background 1-3
1.3. Nature and Extent of Contamination 1-4
1.4. Design Components 1-4
1.4.1. Soil Cover and Protective Liner 1-4
1.4.2. Constructed Wetlands 1-5
1.4.3. Shoreline Revetment 1-5
1.4.4. LFG and Groundwater Monitoring and Control Features 1-6
1.5. Regulatory Framework 1-6
SECTION 2. INSPECTION, MAINTENANCE, AND REPAIR 2-1
2.1. Signs 2-2
2.1.1. Inspection of Signs 2-3
2.1.2. Maintenance of Signs 2-4
2.1.3. Replacement of Signs 2-4
2.2. Site Security Fencing 2-4
2.2.1. Inspection of the Fence 2-4
2.2.2. Maintenance of the Fence 2-4
2.2.3. Replacement of the Fence 2-4
2.3. Soil Cover and Protective Liner 2-5
2.3.1. Inspection of Soil Cover 2-5
2.3.2. Maintenance of Soil Cover 2-7
2.3.3. Repair of Soil Cover 2-8
2.4. Constructed Wetlands 2-9
2.4.1. Inspection of Wetlands 2-9
2.4.2. Maintenance of Wetlands 2-9
2.4.3. Corrective Measures and Adaptive Management 2-10
2.5. Shoreline Revetment 2-11
2.5.1. Inspection of Revetment 2-11
2.5.2. Maintenance of Revetment 2-11
2.5.3. Repair of Revetment 2-11

2.6. Landfill Gas and Groundwater Monitoring Network 2-12
2.7. Landfill Gas Control System 2-12
2.8. Groundwater Control Features 2-12
2.9. Radiological Considerations 2-13

SECTION 3. REPORTING 3-1

SECTION 4. EMERGENCY RESPONSE PLAN 4-1
4.1. Potential Emergencies 4-1
4.1.1. Earthquakes 4-1
4.1.2. Floods or Major Storms 4-2
4.1.3. Fire 4-2
4.2. Emergency Response Procedures 4-2

SECTION 5. REFERENCES 5-1

List of Figures

Figure 1. Site Vicinity Map
Figure 2. Parcel E-2 Areas
Figure 3. Cover Features for Parcel E-2
Figure 4. Landfill Gas Monitoring and Collection System

List of Tables

Table 1. Required Content for Closure and Maintenance
Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment
Table 3. Operation and Maintenance Oversight Personnel
Table 4. Seed Mix
Table 5. Emergency Responses

List of Appendices

Appendix A. Inspection and Repair Procedures, Checklists, and Frequency

Acronyms and Abbreviations

ARARs	applicable or relevant and appropriate requirements
ARIC	area requiring institutional controls
BMPs	best management practices
CalRecycle	California Department of Resources Recycling and Recovery
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	chemicals of concern
CSO	Caretaker Site Office
DBR	Design Basis Report
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group, Inc.
FFA	Federal Facility Agreement
HDPE	high-density polyethylene
HPNS	Hunters Point Naval Shipyard
IPM	Integrative Pest Management
LFG	landfill gas
LUC RD	Land Use Control Remedial Design
Navy	Department of the Navy
OMP	Operation and Maintenance Plan
O&M	operation and maintenance
PCBs	polychlorinated biphenyls
RAMP	Remedial Action Monitoring Plan
RD	remedial design
RI/FS	remedial investigation/feasibility study
ROCs	radionuclides of concern
ROD	Record of Decision

Acronyms and Abbreviations *(continued)*

Shaw	Shaw Environmental, Inc.
Successor Agency	Successor Agency to the San Francisco Redevelopment Authority
TtEMI	Tetra Tech EM Inc.
UCSF	University of California San Francisco
Water Board	San Francisco Bay Regional Water Quality Control Board

Section 1. Introduction

The Department of the Navy (Navy) plans to implement the final remedy at Parcel E-2 at Hunters Point Naval Shipyard (HPNS) in San Francisco, California, pursuant to the Final Record of Decision (ROD) for Parcel E-2 (Navy, 2012). The final remedy for Parcel E-2 includes a soil cover and protective liner, constructed tidal and freshwater wetlands, shoreline revetment, and landfill gas (LFG) and groundwater control features. The Final ROD requires long-term operation and maintenance (O&M) be performed to ensure the integrity of the remedy components and comply with the substantive provisions of pertinent applicable or relevant and appropriate requirements (ARARs). This report includes:

- A description of inspection, maintenance, and repair of the landfill and wetlands soil cover and protective liners; constructed tidal and freshwater wetlands; shoreline revetment; and the LFG monitoring system, slurry wall monitoring system, leachate monitoring risers, and groundwater monitoring wells control features at Parcel E-2
- Inspection schedule and repair procedures that may be necessary during the life of the remedy for the landfill and wetland soil cover and protective liners; constructed tidal and freshwater wetlands; shoreline revetment; and the LFG, slurry wall, leachate, and groundwater control features
- Reporting requirements

Appendix A includes a list of the inspection items, inspection procedures, and inspection frequency. Appendix A also includes generalized repair procedures. Inspection, maintenance, and repair of the final remedy at Parcel E-2 are the responsibility of the owner. The Navy is the current owner; however, the Navy plans to transfer Parcel E-2 to the Successor Agency to the San Francisco Redevelopment Agency (Successor Agency), in the future. This Operation and Maintenance Plan (OMP) discusses the inspection and maintenance required of the Navy. The Navy will conduct the O&M described in this plan until ownership of the sites and the O&M obligations are transferred. Thereafter, the O&M will be the responsibility of the Successor Agency. Upon transfer of the property, it is anticipated that several documents will describe and require compliance with the OMP and will describe when the OMP must be revised to reflect changes to the remedy. The Successor Agency will be required to submit a revised OMP that addresses redevelopment of the sites. The revised OMP will address details of how redevelopment will either preserve or change the final remedy, and will require review and approval by the Federal Facility Agreement (FFA) signatories. FFA signatories include the Navy, the U.S. Environmental Protection Agency (EPA), the Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (Water Board). The OMP and other documents associated with site

operations, maintenance, and monitoring, will be maintained in the HPNS information repositories located at the City of San Francisco Public Library at 100 Larkin Street and at the HPNS office trailer at 690 Hudson Street.

This OMP is a component of the Remedial Design (RD) for Parcel E-2, which is a primary document under the HPNS FFA. This OMP was prepared in accordance with the content requirements provided in California Code of Regulations Title 27 Sections 21800(c) and 21830, and Table 1 identifies the locations in either this OMP or elsewhere in the RD, where the required information is presented. This OMP will be submitted for the review and approval of the FFA signatories.

The Final ROD also requires long-term monitoring of LFG, groundwater, wetlands, and surface water to demonstrate compliance with the remedial action objectives and comply with the substantive provisions of pertinent ARARs. The long-term monitoring requirements for Parcel E-2 are described in a separate document, the Remedial Action Monitoring Plan (RAMP), which is also a component of the RD. In addition, the ROD requires implementation of institutional controls to limit the exposure of future landowner(s) or user(s) of the property to hazardous substances present on the property and in groundwater, and to ensure the integrity of the remedy. The implementation requirements for institutional controls at Parcel E-2 are described in a separate document, the Land Use Control Remedial Design (LUC RD), which is also a component of the RD.

Some details in this OMP may change after construction is completed. As a result, this plan is considered the "preconstruction" OMP to highlight the fact that some items in the plan may change in the future. Likewise, changes to the OMP may be needed in the future to address changes in design standards or improved materials. Revisions to this OMP will be subject to review and approval by the FFA signatories, and the California Department of Public Health (CDPH) for the area requiring institutional controls (ARIC) for radionuclides. CDPH regulates activities related to remediation of radionuclides; therefore, they are involved in oversight of actions at the portions of Parcel E-2 that are considered potentially radiologically impacted.

1.1. DOCUMENT ORGANIZATION

This OMP describes how the soil cover and protective liner, constructed wetlands, shoreline revetment, LFG control features, and groundwater control features at Parcel E-2 will be inspected and maintained. Section 1 describes Parcel E-2 and its history, summarizes the nature and extent of contamination at the site, provides an overview of the design components, and describes the regulatory framework for O&M activities. Section 2 summarizes the inspection, maintenance, and repair procedures to be performed at Parcel E-2. Section 3 describes the reporting procedures for O&M activities. Section 4 summarizes the emergency response plan related to O&M of the site. Section 5 lists all documents and supporting information used to prepare this OMP. Figures and tables are presented following Section 5.

Appendix A includes a list of inspection items, procedures, and frequency. Generalized repair procedures are also included in Appendix A.

1.2. SITE BACKGROUND

HPNS is located in southeastern San Francisco on a peninsula that extends east into San Francisco Bay (see Figure 1). HPNS consists of 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. Parcel E-2 includes about 47 acres of shoreline and lowland coast along the southwestern portion of the shipyard (see Figure 1), and consists of four distinct study areas that were designated to organize the information presented in the Remedial Investigation/Feasibility Study (RI/FS) Report (see Figure 2):

- The Parcel E-2 Landfill, located in the north-central part of Parcel E-2
- The Panhandle Area, located west and southwest of the Parcel E-2 Landfill
- The East Adjacent Area, located to the east of the Parcel E-2 Landfill
- The Shoreline Area, located at the edge of San Francisco Bay

A small portion of the Parcel E-2 Landfill extends north onto property owned by the University of California at San Francisco (UCSF) (see Figure 2).

Parcel E-2 is part of an area created in the 1940s, 1950s, and 1960s by filling in the bay margin with various materials, including soil, crushed bedrock, dredged sediments, and debris. The overall composition of the fill material on which the Parcel E-2 Landfill was created is primarily sand and clay with intermixed construction debris (Tetra Tech EM Inc. [TtEMI], 2004). Between 1958 and 1974, the Navy created the Parcel E-2 Landfill by placing various shipyard wastes, including construction debris, municipal-type solid waste, and industrial waste (including sandblast waste, paint sludge, solvents, and waste oils) (Naval Energy and Environmental Support Activity, 1984). As a result, the landfill has a heterogeneous composition and includes solid waste intermixed with soil fill. The physical extent of the solid waste covers approximately 22 acres (TtEMI, 2004). Shortly after landfill operations ceased in 1974, the Navy implemented several preliminary landfill closure measures, including placing a minimum of 2 feet of compacted, imported fill on top of the Parcel E-2 Landfill.

On August 16, 2000, a brush fire burned approximately 45 percent of the landfill surface area. The surface fire was extinguished within 6 hours, but small subsurface areas (less than 5 acres) continued to smolder for approximately 1 month after the fire was extinguished (Agency for Toxic Substances and Disease Registry, 2001). As part of a removal action, an interim cap (covering approximately 14.5 acres) was constructed to extinguish the fire and prevent the occurrence of future fires under the capped areas. The interim cap, which will be integrated into the final remedy for Parcel E-2, consists of a multilayer system of sub-base soil, high-density polyethylene (HDPE) membrane, synthetic drainage layer, and

topsoil. Inspection and maintenance of the interim landfill cap is performed in accordance with an interim OMP (TtEMI, 2003). Pertinent information from the 2003 interim OMP was incorporated into this report.

1.3. NATURE AND EXTENT OF CONTAMINATION

The RI/FS Report for Parcel E-2 evaluated environmental investigations performed from 1984 to 2008 (Engineering/Remediation Resources Group, Inc. [ERRG] and Shaw Environmental, Inc. [Shaw], 2011). Based on the evaluation results, the following chemicals of concern (COCs) were identified in soil at Parcel E-2: metals; volatile organic compounds; semivolatile organic compounds; pesticides; polychlorinated biphenyls (PCBs); total petroleum hydrocarbons; and the radionuclides of concern (ROCs) cesium-137, radium-226, cobalt-60, and strontium-90. COCs in sediment along the shoreline at Parcel E-2 include metals, pesticides, PCBs, and the ROCs. The primary risk to human health and the environment from COCs and ROCs is through direct contact with soil or sediment.

1.4. DESIGN COMPONENTS

The selected remedy for Parcel E-2 consists of three primary components:

1. Excavation and offsite disposal of hot spots, which is contamination in soil and shoreline sediment that poses the most significant risk to humans.
2. Containment of remaining contamination.
3. Monitoring, maintenance, and institutional controls to protect human health and the environment and to ensure the integrity of the remedy.

Site remediation activities will also include the mitigation of freshwater and tidal wetlands. The soil cover and protective liner, constructed wetlands, shoreline revetment, and LFG and groundwater control features are shown on Figure 3. The complete design details are provided in the Design Basis Report (DBR) (and the associated design drawings and construction specifications). The following sections briefly summarize the design for the soil cover and protective liner, constructed wetlands, shoreline revetment, and LFG and groundwater control features. As described in Section 1, the long-term monitoring and institutional controls required at Parcel E-2 are described in separate documents (the RAMP and LUC RD, respectively), which are also components of the RD.

1.4.1. Soil Cover and Protective Liner

The soil cover will be placed over all of Parcel E-2, including a small portion of the landfill that extends north onto property owned by UCSF. As shown on Figure 3, the cover will include a minimum of 2 feet of clean soil along with a protective liner, consisting of a geomembrane with an overlying geocomposite drainage layer, placed under the soil cover in all areas except the new wetlands. The new protective liner would be contiguous with the existing landfill cap; however, portions of the existing landfill cap would be

removed to achieve the design elevations, and a new protective liner would be constructed in these areas. A liner will not be used in the new wetlands, so that they function more naturally. To prevent exposure to contaminated material, the soil cover in the new wetlands will be 4 feet thick.

The geomembrane will be made of HDPE that serves to limit infiltration of surface water into the buried solid waste and associated contamination. The geocomposite drainage layer will consist of three layers on top of the geomembrane: (1) a nonwoven polypropylene geotextile fabric placed over the HDPE geomembrane to cushion it from the overlying geonet; (2) a geonet comprising two bonded overlapping HDPE strands to transmit infiltrated water to drainage features at the top of the cap; and (3) another layer of geotextile fabric to prevent soil from clogging the underlying geonet. In areas that are radiologically impacted, a demarcation layer will be installed at the bottom of the soil cover to identify remaining radiological hazardous substances at depth. The demarcation layer will consist of an orange-colored geotextile fabric and magnetic marking tape to ensure proper identification of the bottom of the soil cap. In areas covered with a protective liner, the upper layer of geotextile fabric will also serve as the demarcation layer (i.e., the fabric will be orange-colored and overlain by magnetic marking tape) and will be covered by 2 feet of soil. In wetland areas, which will not have a protective liner but will require a demarcation layer, the orange-colored geotextile fabric and overlying magnetic marking tape will be placed at the bottom of the 4-foot-thick soil cover.

1.4.2. Constructed Wetlands

The freshwater and tidal wetlands are being constructed to offset the loss of wetlands at Parcel E-2 and other areas at HPNS. Tidal wetlands will be restored along the shoreline of the Panhandle Area (see Figure 3) in a manner that is ecologically contiguous with the tidal wetlands being restored at the adjacent property (Yosemite Slough restoration project). Freshwater wetlands will be restored at a similar location as the existing freshwater wetlands (which will be destroyed during the remedial action), and will receive surface water runoff (during storm events) and additional freshwater from the groundwater diversion system (Section 1.4.4). The freshwater wetlands include a surface outfall that is designed to minimize flooding during storm events.

1.4.3. Shoreline Revetment

A revetment structure, consisting of large rocks placed on the shoreline slope (excluding the new tidal wetlands area along the shoreline of the Panhandle Area), is needed to prevent erosion and protect the edge of the soil cover along the remaining Parcel E-2 shoreline areas (Figure 3). In addition to the armor facing, a geotextile filter fabric beneath the revetment will allow water to pass while preventing the migration of fine sediment. The revetment structure would be constructed at a 3:1 (horizontal:vertical) slope extending upward from the shoreline to where it intersects a future perimeter road that will dually serve as a maintenance access road and pedestrian walkway as a connection to the Bay Trail from the adjacent Yosemite Slough Restoration Project.

1.4.4. LFG and Groundwater Monitoring and Control Features

As noted in Section 1, the remedy includes long-term monitoring of LFG and groundwater to demonstrate compliance with the remedial action objectives and comply with the substantive provisions of pertinent ARARs. The long-term monitoring requirements for Parcel E-2 are described in a separate document, the RAMP, which is also a component of the RD. This OMP briefly describes the inspection, maintenance, and repair procedures for the permanent monitoring points that will be used during long-term monitoring of LFG and groundwater.

The remedy expands the existing LFG controls, which focus on the northern edge of the Parcel E-2 Landfill, by actively removing and treating gas from the entire Parcel E-2 Landfill. Extracted LFG would be treated by an enclosed flare and/or adsorbent material (such as a charcoal filter). The Navy will perform an LFG survey to better estimate the gas generation rates from the Parcel E-2 Landfill and to determine the content of the landfill gas. The survey will also more thoroughly evaluate soil gas concentrations in the Panhandle, East Adjacent, and Shoreline Areas to determine if gas collection and control (such as passive subsurface venting) is required. The Navy prepared a draft work plan for the LFG survey (Innovative Technical Solutions, Inc., 2013), and fieldwork is planned for summer 2013. The results of the LFG survey will support the design of the LFG control systems, which will be provided in the Draft Final RD and will detail the extraction and treatment of LFG. Accordingly, the Draft OMP does not include details on O&M of the LFG control systems and this information will be provided in the Draft Final OMP.

Flow of contaminated groundwater into San Francisco Bay will be limited by installing an upgradient below-ground barrier and French drain along the western boundary (Figure 3). This barrier and drain would divert groundwater flow from the landfill to the new freshwater wetland. In addition, a below-ground barrier will be installed near the shoreline (referred to as the nearshore slurry wall) to keep contaminants from flowing into San Francisco Bay at concentrations greater than the corresponding water quality criteria for aquatic wildlife. The nearshore slurry wall design includes the installation of leachate monitoring risers that will be used to monitor water levels behind the wall and may be used, if necessary, to extract contaminated groundwater (for offsite treatment and disposal).

1.5. REGULATORY FRAMEWORK

The ARARs that pertain to O&M of the soil cover and protective liner, constructed wetlands, shoreline revetment, and LFG and groundwater control features are identified in the ROD for Parcel E-2 (Navy, 2012) and are summarized in Table 2. The O&M activities would be performed pursuant to these ARARs for as long as necessary to protect human health and the environment.

The FFA signatories (and CDPH for the ARIC for radionuclides) will oversee the effectiveness of O&M activities. FFA signatories include the Navy, EPA, DTSC, and the Water Board. CDPH regulates activities related to remediation of radionuclides; therefore, they are also involved in oversight of actions

at the portion of Parcel E-2 that is radiologically impacted. EPA is the lead oversight agency for the federal government. DTSC is the lead oversight agency for the State of California. Any additions or modifications to the OMP, including the appendices and attachments, must be approved by the FFA signatories (and CDPH for the ARIC for radionuclides). In addition, the final remedy will be subject to statutory reviews every 5 years pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to ensure that it remains protective of human health and the environment.

Section 2. Inspection, Maintenance, and Repair

Inspection, maintenance, and repair schedules and practices will follow the ARARs identified in the ROD for Parcel E-2 (see Table 2). A clear delineation of responsibilities is crucial to the success of O&M in cases where the Navy may contract certain responsibilities for maintenance to either internal or external organizations. The Navy may modify the inspection materials or the appendices in this OMP for individual organizations or contractors that may be responsible for specific components of the remedy; however, any modification that reduces the substance or frequency of the inspections must be preapproved by the FFA signatories (and CDPH for the ARIC for radionuclides). In general, any modification to the OMP must be documented and submitted to the FFA signatories (and CDPH for the ARIC for radionuclides) for review and approval before it is adopted. Overall, the Navy will be responsible for inspection, maintenance, and repair until Parcel E-2 is transferred to the Successor Agency and that entity will be responsible after transfer.

The following sections describe the procedures for inspection, maintenance, and repair for each component of the soil cover and protective liner, constructed wetlands, shoreline revetment, and LFG and groundwater control features. The OMP should be revised when or if experience shows a deficiency in the identification, frequency, or adequacy of repair of inspected items. In general, any deficiencies that require repair will be corrected promptly to protect the integrity of each component. In some cases, damaged areas may need to be secured to prevent access by the public while repairs are planned and implemented. The Navy will evaluate the need for and type of security appropriate in relation to the repairs needed.

Appendix A also includes generalized repair procedures. In cases where repairs to the constructed remedy are needed, the guidelines included in this OMP should be followed; the design drawings and construction specifications (attached to the DBR) provide additional guidelines for future repairs. In cases where damages to the constructed remedy are being addressed, qualified contractors should complete the repair under the supervision of a licensed professional engineer.

Any significant repair to the constructed remedy must be proposed to the FFA signatories and CDPH (for the ARIC for radionuclides) in the form of a work plan. Approval to proceed with a significant repair must be received from the FFA signatories (and CDPH for the ARIC for radionuclides) before any repair work can begin. A significant repair is defined in Appendix A as one that requires specialized equipment and materials to complete (typically requiring a contractor with specialized experience and training). For example, significant repairs may include, but are not limited to, the addition of revetment armoring

material, filling of areas over the soil cover, and repairs associated with exposure of the demarcation layer or the revetment filter fabric.

Following an earthquake, the O&M contractor will assess the severity and follow emergency response procedures, as described in Section 4. The intensity of the earthquake should be determined based on public notification services such as the City and County of San Francisco Outdoor Warning System, the National Earthquake Information Center, and the U.S. Geological Survey Earthquake Notification Service. If a significant earthquake (as defined in Section 4) occurs, the Navy will have qualified personnel visually inspect the constructed remedy for signs of damage within 24 hours of the seismic event, or as soon as it is safe to do so. Any damage will be promptly repaired to ensure the integrity of the constructed remedy. Based on the stability analysis completed as part of the RD (attached to the DBR), potential damage from earthquake shaking will be adequately controlled through proper design and construction of the soil cover and shoreline revetment using methods that are well established for sites in the San Francisco Bay area.

Recording the inspection through forms, note taking, and photographs is a necessary part of the inspection. An O&M logbook or field forms should be maintained and include field notes recorded during inspections. Appendix A includes a list of inspection items, procedures, and frequency that will be modified as necessary during O&M.

It is essential that qualified personnel and contractors are used to perform O&M activities at the sites to provide adequate long-term support for the remedy. Table 3 of this OMP summarizes general qualifications that are required for supervisory personnel responsible for oversight of O&M-related work at Parcel E-2. These qualifications may change following transfer of the site to the Successor Agency and should be adapted for the specific site conditions as they change over time.

2.1. SIGNS

Signs are not required by the ROD but will be installed to help the Navy manage protection of the constructed remedy. The signs will inform the public of the potential hazards associated with excavating to a depth below the soil cover and shoreline revetment while under Navy ownership. Signs will be placed along the perimeter of the site. The signs will be installed in accordance with design drawings and construction specifications provided in the RD. The signs will be in English and Spanish, as shown below, in black capital letters on a yellow background.

CAUTION
POTENTIAL BURIED HAZARDOUS MATERIALS.
NO GROUND DISTURBANCE
ALLOWED WITHOUT APPROVAL.
CONTACT (619) 532-0913

AVISO
POSIBILIDAD DE SUSTENCIAS
PELIGROSAS EN EL SUBSUELO.
MOVER TIERRA NO PERMITIDO
SIN APROBACIÓN.
CONTACTE (619) 532-0913

Signs will also be posted (1) near the gated entrance to Parcel E-2 and (2) at the entrance to the LFG treatment system. The signs will read as follows:

AREA CLOSED
RESTRICTED ACCESS
AUTHORIZED PERSONNEL ONLY
NO EARTHMOVING OR DUMPING

SITIO CERRADO
ACCESO PERMITIDO
PERSONAL AUTORIZADO SOLAMENTE
NO MOVER TIERRA NI TIRAR BASURA

FOR ACCESS
OR MORE INFORMATION
CONTACT NAVY CSO
415-743-4720

The following subsections describe the planned inspection, maintenance, and repair for the signs to be installed at Parcel E-2.

2.1.1. Inspection of Signs

Signs will be inspected quarterly for the first year and semiannually thereafter for presence, legibility, vandalism, or other inadequacies. The effectiveness of the signs in restricting access to the site will be evaluated. Damage to signs could result from weathering or vandalism.

2.1.2. Maintenance of Signs

Signs typically require no maintenance; however, signs will be cleaned or replaced if legibility at a distance of 5 feet is impaired as a result of dirt or faded colors.

2.1.3. Replacement of Signs

Replacement of signs is recommended in place of repair and will be carried out as necessary to restore the legibility of the signs. Replacement signs will be installed in accordance with design drawings and construction specifications provided in the RD.

2.2. SITE SECURITY FENCING

Fencing is not required by the ROD, but will be installed, in accordance with design drawings and construction specifications provided in the RD, along the site perimeter (except along the shoreline) to help the Navy manage protection of the constructed remedy. Fencing is meant to restrict access to the site and to prevent damage that might occur under Navy ownership. The effectiveness of the fence will be assessed based on inspections, and modifications may be necessary over time. The proposed extent of the fence is shown in the design drawings provided in the RD. The following subsections describe the planned inspection, maintenance, and repair for the fencing to be installed at Parcel E-2.

2.2.1. Inspection of the Fence

The fence will be inspected quarterly for the first year and semiannually thereafter for damages both natural and human. Damages could include cut holes in the material, eroding soil from under the fence, digging under the fence, or natural corrosion and degradation of the materials. Inspection of the fence would include walking along the perimeter of the fence and assessing and recording damages.

2.2.2. Maintenance of the Fence

Fencing typically requires little routine maintenance. Damage to the fence over time can be expected from vandalism and tampering. Maintenance actions may include (1) promptly remove graffiti within the time frame set by the City and County of San Francisco, (2) removing blown trash or debris from along and lodged in fencing, and (3) repairing holes or damage to fence fabric and damage to fence posts upon discovery. Fence maintenance would only be required until the fence is removed following property transfer to the Successor Agency.

2.2.3. Replacement of the Fence

Sections of the fence may need to be replaced over time and should be replaced using the same material from the same manufacturer when available and cost effective. Repair work should follow the construction specifications included in the RD. Fence replacement would only be required until the fence is removed following property transfer to the Successor Agency.

2.3. SOIL COVER AND PROTECTIVE LINER

The soil cover throughout Parcel E-2 is designed to minimize contact with contamination remaining at the site. As shown on Figure 3, the cover will include a minimum of 2 feet of clean soil along with a protective liner to limit infiltration of surface water into the buried solid waste and associated contamination. The protective liner will be placed under the soil cover in all areas except the new wetlands. A liner will not be used in the new wetlands, so that they function more naturally. To prevent exposure to contaminated material, the soil cover in the new wetlands will be 4 feet thick. In areas that are radiologically impacted, a demarcation layer will be placed at the bottom of the soil cover to identify remaining radiological hazardous substances at depth. The soil cover and protective liner will be constructed in accordance with design drawings and construction specifications provided in the RD.

The following subsections describe the planned inspection, maintenance, and repair for the soil cover and protective liner.

2.3.1. Inspection of Soil Cover

A site walk will be conducted on a quarterly basis for the first 5 years of O&M activities, as well as after major storms (as defined in Section 4) to check for the formation of rills or gullies on the cover. Following an earthquake, the significance will be evaluated (as described in Section 4) and, if deemed necessary, the cover will also be inspected for settling, cracking, or other breaches. The frequency of site inspections may be reduced after the first 5-year review period following remedy construction. Appendix A provides the inspection tasks and procedures. The soil cover will be visually inspected to ensure the following conditions are maintained at the site:

- No large trees, brush, or weeds (with deep taproots) are present on the soil cover that may penetrate the protective liner
- No evidence of burrowing mammals or other holes in the soil cover
- No erosion of the soil cover is evident
- No excessive vegetation is growing in the surface and subsurface drainage features
- No noticeable depressions or ponded water are present on the soil cover outside of the wetlands
- No noticeable sliding (slope failure) or desiccation cracks are present in the soil cover
- Neither the protective liner nor the demarcation layer is not protruding, exposed, or torn
- No signs of vandalism of the soil cover and associated components (e.g., settlement monuments and survey benchmarks)

The following subsections describe the additional inspections related to the grading, drainage, and erosion control for the soil cover.

2.3.1.1. Grading

A final survey of the soil cover will be conducted after installation to measure as-built elevations. The elevations of settlement monuments will be established during the final survey. As part of the routine inspection, settlement marker locations and elevations will be surveyed once per year. When annual settlement of 0.1 foot or less has been measured for 2 consecutive years, surveys can be scaled back to once every 5 years. The Navy will use data collected from the settlement markers to assess the amount of settlement, if any, from waste consolidation or consolidation of the underlying Bay Mud.

The soil cover will be visually inspected for evidence of damage, erosion, liner exposure, or differential settlement within the Parcel E-2 Landfill. Any differential settlement sufficient to cause surface water ponding on Parcel E-2 will be repaired as soon as possible after the observation. If the inspection identifies items to be addressed, a copy of the general site inspection checklist (Appendix A) will be forwarded to the Caretaker Site Office (CSO) for immediate action. If significant damage, erosion, or liner exposure is observed, the CSO will be contacted immediately at the telephone number on the inspection form. The CSO will notify the appropriate personnel, including the Navy Base Realignment and Closure Office in San Diego, California.

2.3.1.2. Drainage

Rainfall that does not infiltrate through the vegetative cover will run off as sheet flow to drainage swales. Rainfall that infiltrates through the vegetative cover will be transmitted via the geocomposite drainage layer to drainage swales. The drainage swales will discharge either directly to San Francisco Bay or to the freshwater wetlands (and then to the bay). Stormwater best management practices (BMPs) will be inspected during the site walk. BMPs include, but are not limited to, vegetation on the soil cover and surface drainage swales. BMPs will be inspected to ensure they are intact and functioning properly. In addition, drainage features adjacent to Parcel E-2 should be inspected for proper function and condition and any deficiencies reported to the Navy. Future development of the surrounding area could affect drainage to Parcel E-2 and should be addressed through revisions to the OMP if necessary.

2.3.1.3. Erosion Control

Vegetation established on the soil cover will be the primary means by which erosion will be controlled. The vegetated surface of the cover will (1) protect the surface of the cover from erosion by wind and water, (2) improve the stability of the cover slopes, (3) help ensure the integrity of the final cover, and (4) improve aesthetics.

The soil cover will be inspected for signs of erosion and desiccation. Corrective action may be needed if signs of soil erosion or desiccation are excessive (e.g., desiccation cracks greater than 2 inches wide or extending to the cap liner) and continual (recurring in the same area). Actions may include (1) filling in the eroded area or cracks with nonexpansive soil containing no COCs, (2) investigating the cause of erosion, (3) checking the integrity of the geosynthetic liner, and (4) regrading slopes.

Vegetation on the cover will be inspected for signs of stress, stunted growth, wilting, changes in color, and bare spots. Areas of significantly healthier or sickly growth will be noted, as well as the presence of invasive or deep-rooting species that could damage the protective liner (discussed further in Section 2.3.2). Chronic deficiencies may require selecting and planting species better adapted to the environment.

An area is considered bare if healthy vegetation is not covering the soil. Bare spots shall not exceed 2 percent of the total cover area and 30 percent of any individual 100-square-foot area. These areas must be reseeded or planted in accordance with the construction specification for seeding (provided in the RD). The seed mix for the soil cover is identified in Table 4. Seeding should be performed during the spring, fall, or winter months when evapotranspiration rates are lower. Planting during the summer should be avoided in order to minimize seed germination during the dry summer months. Once the seed germinates, it is important to maintain moist conditions because young plants are more sensitive to dry soil conditions than fully mature plants. After seeding, soil in the area will be kept wet to a depth of 1 inch by frequent watering that will be adjusted by weather conditions, until vegetation in the distressed area has reached maturity. Water will be applied at a rate recommended by the seeding suppliers, but will not be so excessive as to cause erosion, puddling, or surface runoff. Cutting or mowing vegetation must occur when it would promote a healthier stand of vegetation or when desired to prevent creation of wildlife habitat. Mowing of the site annually should be sufficient to maintain the health of the cover but the frequency may need to be altered depending on future use. Vegetation should not require irrigation once established because it is of drought-tolerant varieties. Loss of vegetation caused by lack of water is a trigger to consider establishment or reestablishment of more drought-tolerant plant species.

Burrowing animal activity can be expected on the soil cover and, if the burrows extend deep enough, such activity could be indicative of potential damage to the protective liner. Accordingly, the soil cover will be regularly inspected for evidence of burrowing animals. Specific inspection procedures for burrowing animal activity are included in Appendix A.

2.3.2. Maintenance of Soil Cover

Vegetation on the cover will be maintained in a manner to minimize soil erosion from wind and water. To protect the integrity of the protective liner, trees, shrubs, and herbaceous plants with deep taproots will be identified and removed from the cap. Previously identified invasive species at Parcel E-2 include sweet fennel (*Foeniculum vulgare*), cocklebur (*Xanthium strumarium*), black mustard (*Brassica nigra),* short-pod mustard *(Hirschfeldia incana),* wild radish (*Raphanus raphanistrum)* and cultivated radish

(*Raphanus sativus*), sour clover (*Melilotus indica*), sweet clover (*Melilotus officinalis*), cheeseweed (*Malva parviflora*), and pampas grass (*Cortaderia* sp.). Cheeseweed was found on dump piles just south of the existing landfill cover. This plant can develop very large and powerful roots and is competitive, growing and setting seed very quickly. Pampas grass is another plant of concern. It is highly invasive and can develop deep root structures. If any invasive species are found, a remedial strategy should be developed as soon as possible. Possible methods of removal are (1) spot spraying with Roundup (glyphosate) or other herbicides that do not contain any of the COCs or other chemicals of environmental concern, (2) cutting out roots, and (3) conducting a follow-up inspection to ensure the effectiveness of the removal.

If burrowing animal activity is observed, maintenance actions would include prompt repair of any damage to the soil cover (or underlying protective liner) and may involve the use of animal control measures. Appendix A describes the corrective measures and adaptive management that will be used to control burrowing animal activity, if necessary, to limit erosion of the soil cover or ensure the integrity of the protective liner. Low-impact control measures, such as the installation of raptor perches, are preferable as opposed to higher impact control measures, such as the use of poisons, to control burrowing animals at Parcel E-2.

Mowing will be performed at least once a year to reduce fire hazards on the site. Mowing events will be timed so the seeds are not harmed. If mowing occurs before the seed is mature, the vegetation will not reseed itself for the following season. Mowing will occur throughout the soil cover outside of the wetlands. Assuming good growth on the cover, the cover should be mowed during the spring. Additional mowing may be performed during the fall, if necessary, to promote a healthier stand of vegetation. If motorized mowing equipment is used, precautions should be taken so that ruts are not created on the soil cover during mowing. For instance, mowing should not be performed when the soil surface is fully saturated and mowing configurations should avoid having a tight turning radius.

2.3.3. Repair of Soil Cover

Deficiencies, damage, and failure of the final grade will be repaired and the cover restored to constructed conditions based on the as-built record drawings. Temporary repairs will be made, if necessary, until permanent repairs can be scheduled. Damage to vegetation or insufficient stands will also be repaired in a timely manner. When damage includes loss of soil cover, the cover will be repaired to the design thickness. Cracks in the final cover will be sealed with similar soil. Erosion that results from heavy rainfall will be repaired. Temporary berms, ditches, and straw mulch will be used to minimize further erosion damage until site conditions permit reestablishment of the final cover and vegetation. The seeding specification provided in the RD should be used for any additional reseeding that may be necessary during O&M because it has been selected specifically for the conditions at Parcel E-2.

If damage to the soil cover results in a breach in the demarcation layer, the site will be secured to prevent access by the public. The Navy will notify the FFA signatories and CDPH of such damage as soon as practicable, but not later than 10 days after discovery. The soil cover will be repaired and the cover restored to design conditions as soon as practicable, but no later than 60 days after the Navy becomes aware of the breach. Any repairs to the soil cover should follow the design drawings and the construction specifications in the RD.

2.4. CONSTRUCTED WETLANDS

Constructed wetlands at Parcel E-2 will be monitored and managed to promote reestablishment of native tidal wetland and seasonal freshwater wetland species. Monitoring will be performed twice per year under the RAMP for final planting and grading of the seasonal and tidal freshwater wetlands. Monitoring components in the RAMP include documenting the development of wetland hydrology, hydric soil, vegetative establishment, species richness and diversity, and surface water sampling. Corrective actions will be addressed under the OMP. Maintenance components of this OMP include identifying and repairing evidence of erosion and sedimentation, managing invasive species, and identifying disturbances (e.g., human and vehicular traffic, litter, etc.). The efficacy of the monitoring and maintenance actions at the constructed wetlands will be evaluated annually, and potential changes to these procedures may be addressed through revisions to the OMP and RAMP if necessary. The following subsections describe the planned inspection, maintenance, and repair for the constructed wetlands at Parcel E-2.

2.4.1. Inspection of Wetlands

Regular inspections will be conducted at least semiannually for the first five years to ensure proper operation of the system and to identify and address any problems that may hinder establishment of plantings. Routine maintenance activities will likely include removal of debris and monitoring of invasive species and erosion at all created and restored wetland areas after major storm events (as defined in Section 4). Additional maintenance items may be identified based on monitoring inspections conducted as part of the RAMP.

2.4.2. Maintenance of Wetlands

Maintenance tasks and their frequency are outlined below. The frequency of the maintenance tasks will be reevaluated after 5 years.

For invasive species, maintenance activities will include the following:

- Removal will be conducted at least twice per month during Years 1 and 2 of monitoring.
- Removal will be conducted at least twice annually (spring and fall events) in Years 3, 4, and 5 of monitoring.

- Removal of all invasive plant species rated by the California Invasive Plant Council as high will be performed by hand or by hand-operated power tools. A plan to manage invasive species is included as part of Appendix A. Synthetic herbicides will be used to control invasive species as a last resort, and only when appropriate nonchemical methods are deemed ineffective, upon written approval from Navy .
- If the use of synthetic herbicides is necessary, only those herbicides approved for marine and freshwater aquatic use shall be applied (e.g., Rodeo). Herbicides will be applied in accordance with state and federal laws.

Routine O&M activities will include the following:

- Inspections of culvert(s) or other outflow structure(s) installed for freshwater outflow from the freshwater wetland area on a monthly basis during the wet season and at least quarterly during the remainder of the year. During and after storm events, the status of the culvert(s) and/or outlet structure(s) will be evaluated. Any corrective actions will be implemented, as weather permits.
- Removal of solids and floatable debris that may block flows.
- Mechanical or manual removal of nuisance and feral animal species.
- Adaptive management of any erosion of restored or created wetland areas after major storm events (as defined in Section 4).

2.4.3. Corrective Measures and Adaptive Management

As measured during each monitoring event and reported annually, attainment of performance standards and other data will guide the need for implementation of adaptive management actions. As needed, these actions will include corrective measures required resulting from the following:

- Erosion in tidal wetlands (placement of larger boulders or other material as wave attenuation).
- Plant mortality (replanting or species selection changes).
- Need to control Norway and/or Black rats and other predatory rodents (trapping program and avian/larger terrestrial mammal predation).
- Bird predation by invasive mammals (control measures to be coordinated with the appropriate resource agency).
- Colonization by nonnative, invasive species (maintenance removal).
- Slow recruitment and natural colonization of native vegetation (augmentation with new plantings).

Appendix A includes a supporting document that describes the corrective measures and adaptive management of invasive plant and animal species for the constructed wetlands. Any repairs to the wetlands should follow the design drawings and the construction specifications provided in the RD.

2.5. SHORELINE REVETMENT

The revetment protects the shoreline from eroding into San Francisco Bay and protects the edge of the soil cover in upland portions of Parcel E-2. The soil cover and protective liner will be installed in accordance with design drawings and construction specifications provided in the RD. The following subsections describe the planned inspection, maintenance, and repair for the shoreline revetment at Parcel E-2.

2.5.1. Inspection of Revetment

The revetment will be inspected quarterly for the first year and semiannually thereafter and will include observations for settlement, vandalism, and displacement of the riprap. The toe of the revetment will be closely inspected at low tidal stages for any signs of undercutting. The crest of the structure should be inspected and the original elevation maintained. Final survey of the revetment will be conducted after installation to measure as-built elevations. The elevations of settlement monuments will be established during the final survey. As part of the routine inspection, settlement marker locations and elevations will be surveyed once per year. When annual settlement of 0.1 foot or less has been measured for 2 consecutive years, surveys can be scaled back to once every 5 years. The Navy will use data collected from the settlement markers to assess the amount of settlement, if any, from consolidation of the underlying Bay Mud. The filter fabric underlying the structure should not be exposed; and, if exposed, would trigger the need for repair.

2.5.2. Maintenance of Revetment

The revetment is not expected to require major maintenance. Trash should be cleared from the face of the revetment and disposed of properly. Nuisance vegetation along the revetment is not expected to be a significant issue but should be removed if present.

2.5.3. Repair of Revetment

Any missing stones on the revetment face should be promptly replaced with similar size stones. Gaps caused by settlement should be filled with appropriately sized rocks. Areas of undercutting at the toe of the structure should be monitored and repaired when the integrity of the structure could be compromised. The toe should be submerged in sediment and recorded and monitored if not. Similar consideration should be given to the ends or the flanks of the structure.

Areas where damage to the revetment results in a breach of the filter layer will be secured to prevent access by the public. The Navy will notify the FFA signatories and CDPH of such damage as soon as practicable, but not later than 10 days after discovery. The revetment will be repaired to design conditions as soon as practicable, but no later than 60 days after the Navy becomes aware of the breach. Any repairs to the revetment should follow the design drawings and construction specifications provided in the RD.

2.6. LANDFILL GAS AND GROUNDWATER MONITORING NETWORK

The constructed remedy will include a network of LFG probes and groundwater wells that will be regularly monitored to demonstrate compliance with the remedial action objectives and comply with the substantive provisions of pertinent ARARs. The LFG monitoring probes and groundwater monitoring wells will be inspected during all sampling events and semiannually for damage. Damage to the locks, wells, and well labels could result from vandalism or weathering. The LFG monitoring probes and groundwater monitoring wells will be inspected for signs of damage, unusual wear, rust and corrosion, vandalism, unauthorized entry and/or use, settlement, and the presence of standing water. Groundwater monitoring wells will be inspected for accumulation of silt and sand by measuring the total depth during sampling and comparing these depths with previous or original depths. The probes and wells will be visually inspected for signs of grout or concrete stress or failure, and watertight locking caps will be inspected for cracked or torn rubber seals.

Any damage that may limit the effectiveness of the LFG and groundwater monitoring network will be repaired or the well will be replaced in a timely manner. Repairs to or replacement of worn parts will be performed as needed. Removal of rust and painting of corroded surfaces will be conducted as necessary. If locks have rusted and do not function properly, they will be replaced. All maintenance of the LFG monitoring probes and groundwater monitoring wells will be documented in a field logbook or on maintenance forms. Evidence of vandalism, unauthorized use, or settlement will be photographed and documented in field notes. Repair work will be performed in accordance with the construction specifications provided in the RD.

The long-term monitoring requirements for Parcel E-2 are described in a separate document, the RAMP, which is also a component of the RD.

2.7. LANDFILL GAS CONTROL SYSTEM

The constructed remedy will include control systems for extracting and treating LFG. As described in Section 1.4.4, the Navy will perform an LFG survey to support the design of the LFG control systems, and fieldwork is planned for summer 2013. Accordingly, the Draft OMP does not include details regarding O&M of the LFG control systems; however, this information will be provided in the Draft Final OMP.

2.8. GROUNDWATER CONTROL FEATURES

As noted in Section 1.4.4, the remedy includes long-term monitoring of groundwater control features to demonstrate compliance with the remedial action objectives and comply with the substantive provisions of pertinent ARARs. Flow of contaminated groundwater into San Francisco Bay will be limited by installing an upgradient below-ground barrier and French drain along the western boundary (Figure 3). This barrier and drain would divert groundwater flow from the landfill to the new freshwater wetland. In

addition, a nearshore slurry wall will be installed near the shoreline to keep contaminants from flowing into San Francisco Bay at concentrations greater than the corresponding water quality criteria for aquatic organisms. The alignment of the nearshore slurry will include a series of leachate monitoring and extraction wells along the upgradient side of the barrier, approximately every 50 feet. A corresponding series of piezometers will be located along the downgradient side of the nearshore slurry wall. Figure 4 shows the groundwater control features. Monitoring and potential extraction of leachate will be conducted under the RAMP. The inspection, maintenance, and repair procedures for the upgradient French drain, and the monitoring and extraction wells associated with the slurry walls are addressed under this OMP.

The leachate monitoring and extraction wells and piezometers will be inspected during all sampling events and semiannually for damage. Damage to the locks, leachate monitoring and extraction wells and piezometers, and labels could result from vandalism or weathering. Leachate monitoring wells and piezometers will be inspected for accumulation of silt and sand by measuring the total depth during sampling and comparing these depths with previous or original depths. The leachate monitoring wells and piezometers will be visually inspected for signs of grout or concrete stress or failure, and watertight locking caps will be inspected for cracked or torn rubber seals. Any damage that may limit the effectiveness of the leachate monitoring and extraction wells will be repaired or the well will be replaced in a timely manner. If locks have rusted and do not function properly, they will be replaced. All maintenance of the leachate monitoring wells and piezometers will be documented in a field logbook or on maintenance forms.

The French drain will be inspected quarterly in conjunction with the general site inspections. Particular attention will be paid to outflow from the drain during the spring inspection. The primary goal of this inspection will be to establish that flow is emerging from the drain, and that the drain is functioning properly and clear of sediments and debris.

2.9. RADIOLOGICAL CONSIDERATIONS

Some maintenance activities (e.g., major repair work to the soil cover or revetment or replacement of a groundwater monitoring well) within the ARIC for radionuclides may require excavation of native soil that was not screened for radioactivity during construction of the soil cover. Activities that involve movement of soil from below the demarcation layer or the revetment to the surface will follow the soil screening, handling, health and safety, and disposal procedures described in a task-specific work plan, which will be prepared and provided to the regulatory agencies for review. Excavation below the demarcation layer will be prohibited until such time that concurrence from the FFA signatories and CDPH is received on the work plan. Procedures for excavation below the demarcation layer and revetment must also follow the requirements in the LUC RD.

Section 3. Reporting

An annual inspection report will be prepared to summarize the inspections for each year; this report will be forwarded for review and approval by the FFA signatories and CDPH. The annual inspection report will include, at a minimum, results of the inspections and a summary of all repair and maintenance activities conducted. The report will be certified by a professional engineer registered in California. Annual inspection reports will support the ongoing 5-year review reports that will be prepared under CERCLA. The wetlands portion of the monitoring reports may also include the results of functional, condition, or other assessments used to provide quantitative or qualitative measures of the functions provided by the compensatory mitigation at Parcel E-2.

Statutory 5-year reviews pursuant to CERCLA Section 121 and the National Oil and Hazardous Substances Pollution Contingency Plan will be conducted because the selected remedy will leave contamination in place at Parcel E-2 above levels that allow for unrestricted use and unlimited exposure. Five-year reviews for Parcel E-2 will follow the ongoing schedule of 5-year reviews established for other remedies in place at HPNS.

Additional reporting may be necessary following significant repair of the soil cover or revetment and following inspections triggered by an earthquake or other natural event. Additional reporting requirements and procedures should be assessed following the selection of an O&M contractor.

Section 4. Emergency Response Plan

This section describes the emergency response plan for Parcel E-2 if potential emergencies, failure, or breakdown of the components of the remedy occur. As stated in Section 2, the Navy will be responsible for inspection, maintenance, and repair until Parcel E-2 is transferred to the Successor Agency, and that entity will be responsible after transfer. The post-construction OMP and its emergency response plan will be maintained with the active O&M contractor at all times.

4.1. POTENTIAL EMERGENCIES

Although the Navy and future owners will take action to reduce the potential for emergencies, it is possible for events to occur at Parcel E-2 that cannot be prevented. This plan provides response procedures for the following emergencies:

- Earthquakes
- Floods or major storms
- Fire

Equipment and materials required to mitigate the emergency may include portable berms, absorbency media or blankets, loaders and backhoes, clean fill soil, waste receptacles, caution tape, sandbags, erosion control blankets or media, bulldozers, compactors, sand, chain-link fencing, bailing wire, and straw bales. These equipment and materials are commonly available commercial items. The Navy will ensure that their O&M contractor has these items available on an immediate basis when needed through prompt delivery or storage.

The following subsections describe the emergency response procedures to be implemented if an earthquake, flood or major storm, or fire should occur at Parcel E-2.

4.1.1. Earthquakes

The San Francisco Bay area has a high potential for earthquakes because it is located on the tectonic boundary between the Pacific and North American plates. A significant earthquake is defined as 7.0 magnitude or higher centered within 40 miles of the site, 6.0 magnitude or higher within 10 miles of the site, or 4.0 magnitude or higher within 1 mile of the site. If a significant earthquake occurs, qualified personnel will visually inspect the constructed remedy for signs of damage within 24 hours of the seismic event, or as soon as it is safe to do so. Any damage will be promptly repaired to ensure the integrity of the remedy. If the soil cover and protective liner have sustained extensive damage, corrective actions will

be implemented to ensure that potential contaminants are contained and human health is protected. Post-earthquake site inspection records will be submitted to the FFA signatories, California Department of Resources Recycling and Recovery (CalRecycle), and CDPH (if damage occurs within the radiological ARIC), as stated in Table 5.

Following a significant earthquake, the soil cover and protective liner will also be inspected for lateral shifting of debris toward San Francisco Bay and damage to the shoreline revetment. Settlement markers will be resurveyed to assess any horizontal or vertical movement of the cap. The revetment area will be inspected for significant shifting of soil or slope failure cracks. A summary of damages and repairs will be submitted to the FFA signatories, CalRecycle, and CDPH (if damage occurs within the radiological ARIC), as stated in Table 5.

4.1.2. Floods or Major Storms

If a flood or major storm occurs, the Navy will dispatch a team within 24 hours of the event to inspect the constructed remedy to ensure its integrity. Appendix A includes an emergency response inspection checklist. A major storm is defined in this plan as 4.17 inches of precipitation or more over a 24-hour period (24-hour, 25-year storm). Any damage will be promptly repaired to ensure the integrity of the remedy. A summary of damages and repairs will be submitted to the FFA signatories, CalRecycle, and CDPH (if damage occurs within the radiological ARIC), as stated in Table 5.

4.1.3. Fire

If a surface fire occurs near Parcel E-2, the local fire department will be notified. The Navy will share applicable site-specific information with local fire officials. In addition, the Navy will dispatch a landfill fire specialist to assist in any fire emergency response. If a breach in the soil cover and protective liner is observed during a fire, other firefighting methods (such as using foam or smothering with dirt) will be considered and used, as appropriate. Following the incident, the Navy will thoroughly inspect the soil cover and protective liner using the emergency response checklist included in Appendix A to ensure that the integrity of the synthetic layers has not been compromised. If there is fire damage, the Navy will implement corrective actions to ensure that potential contaminants are contained and human health is protected. The corrective actions will include reestablishment of vegetation over any burned areas (in accordance with the procedures described in Section 2.3.3). A summary of damages and repairs will be submitted to the FFA signatories, CalRecycle, and CDPH (if damage occurs within the radiological ARIC), as stated in Table 5.

4.2. EMERGENCY RESPONSE PROCEDURES

Table 5 provides recommended responses for the above situations and occurrences. This plan is intended to address contingencies that are reasonably foreseeable, but will be amended when appropriate as follows:

- Whenever a failure or release occurs and the O&M contractor did not account for an appropriate response.
- Whenever the use of the site changes in ways that are not addressed in the existing O&M contract.
- If the local enforcement agency notifies the Navy in writing that the current emergency response plan is inadequate.

Section 5. References

Agency for Toxic Substances and Disease Registry, 2001. "Health Consultation Summary, Hunters Point Shipyard, Parcel E Landfill Fire, San Francisco, California." January.

Department of the Navy (Navy), 2012. "Final Record of Decision for Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." November 26.

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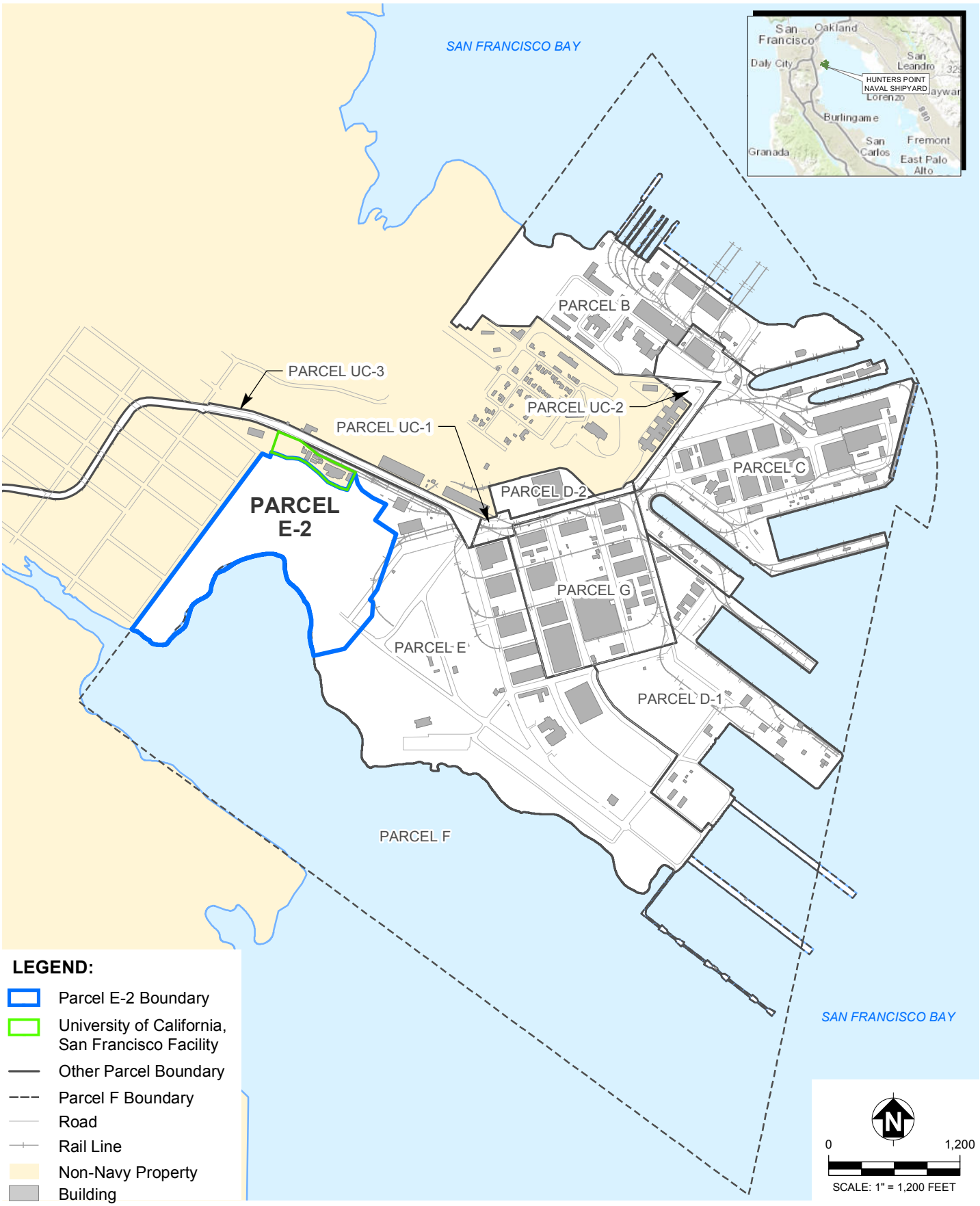
Innovative Technical Solutions, Inc., 2013. "Draft Work Plan, Landfill Gas Survey at Parcel E-2, Hunters Point Naval Shipyard, San Francisco, California." February 21.

Naval Energy and Environmental Support Activity (NEESA), 1984. "Initial Assessment Study, Hunters Point Naval Shipyard (Disestablished), San Francisco, California." NEESA 13-O59. October.

Tetra Tech EM Inc. (TtEMI), 2003. "Final Operation and Maintenance Plan, IR-01/21, Industrial Landfill, Parcel E, Hunters Point Shipyard, San Francisco, California." May 30.

TtEMI, 2004. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

Figures



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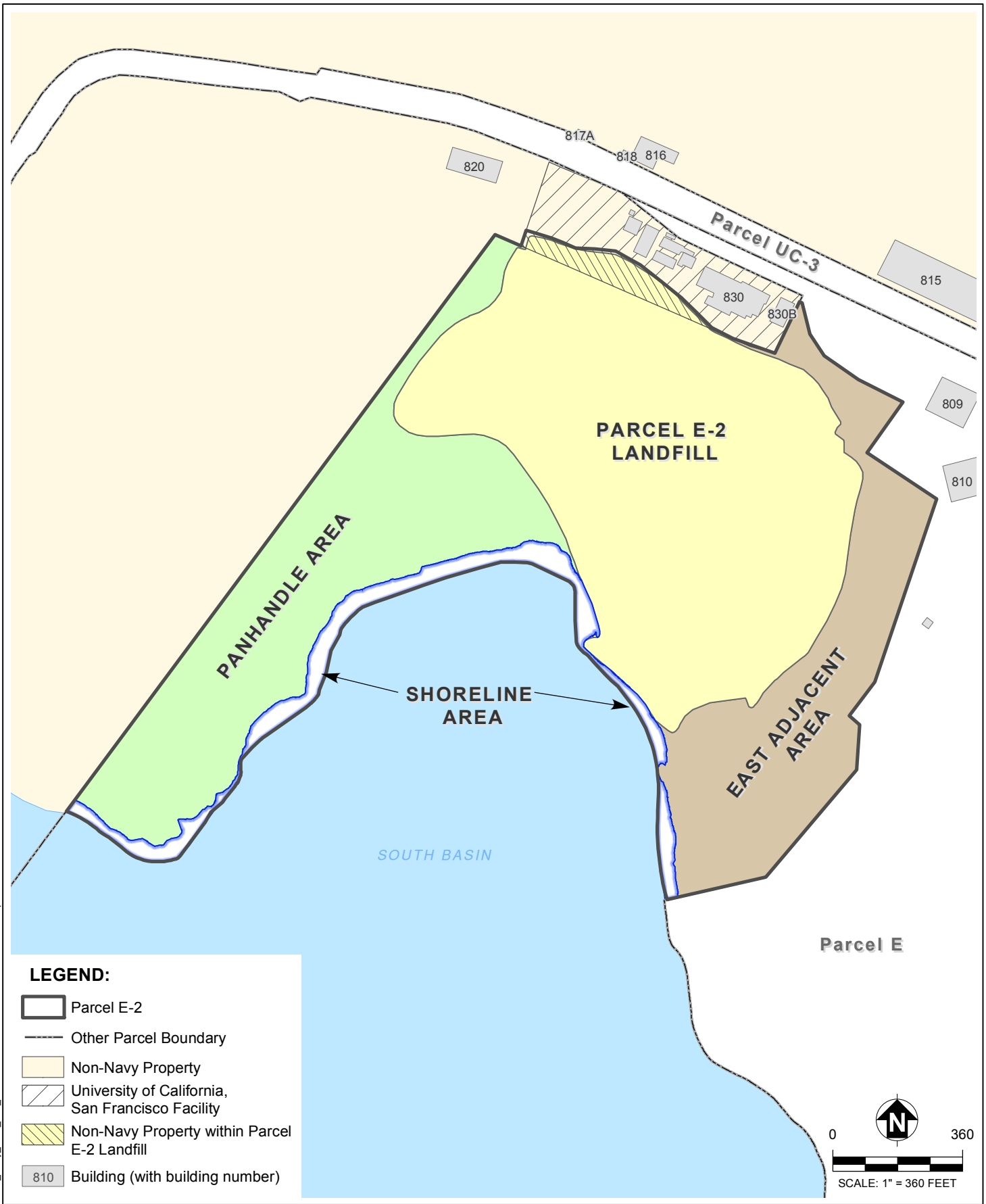
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 1



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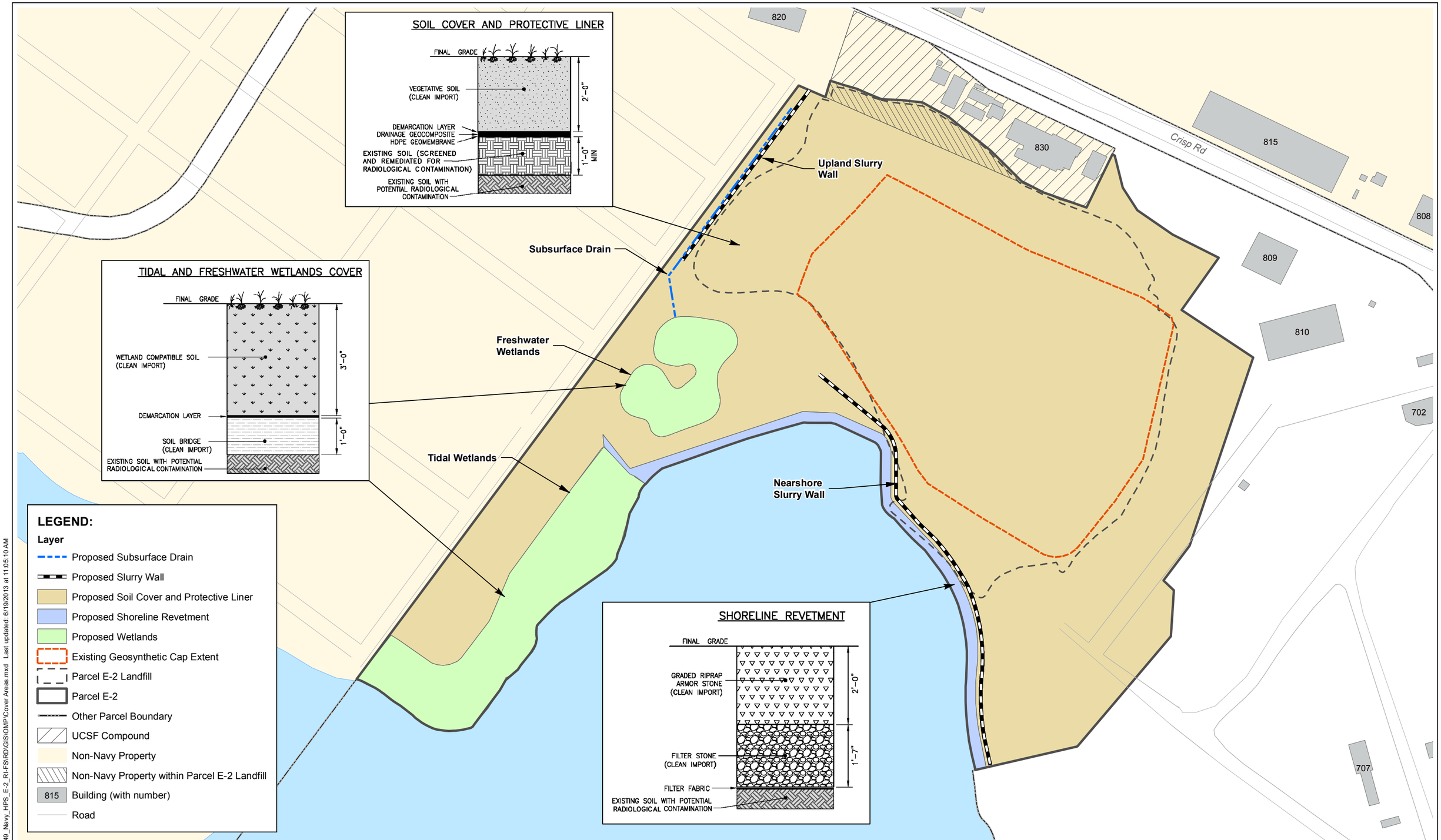
ERRG Engineering/Remediation Resources Group, Inc. 115 Sansome Street, Suite 200 San Francisco, California 94104 (415) 395-9974	CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	PARCEL E-2 AREAS			
	LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: DB 02/20/13	PROJECT NO. 25-049	FIG NO. 2



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SCALE: 1" = 240 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT: DEPARTMENT OF THE NAVY, BRAC PMO WEST	COVER FEATURES FOR PARCEL E-2			
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: JS 02/20/13	PROJECT NO. 25-049	FIG NO. 3

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SCALE: 1" = 240 FEET

ERRG Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104
(415) 395-9974

CLIENT:			
DEPARTMENT OF THE NAVY, BRAC PMO WEST	LANDFILL GAS MONITORING AND CONTROL SYSTEM		
LOCATION: HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA	DRAWN BY: JJC 02/20/13	CHECKED BY: JS 02/20/13	PROJECT NO. 25-049	FIG NO. 4

Tables

Table 1. Required Content for Closure and Maintenance

Citation	Required Information	Location in Design Package
Title 27 Cal. Code Regs. § 21800(c) (for closure plans)	Closure cost estimate	NA
	Location maps indicating property boundaries; general location of the landfill; and the existing, permitted, and proposed final limits of waste placement, entry roads, and structures	DBR Figures and Design Drawings
	Location map of the current monitoring and control systems, including systems related to leachate control, drainage and erosion control, and landfill gas monitoring and control	DBR Figures and Design Drawings
	Description of proposed post-closure land uses	DBR Section 2.6
	Estimate of the maximum extent of the landfill that will require closure	DBR Sections 3.2, 3.3, and 3.4
	Estimate of the closure date	NA
	Preliminary description of closure activities related to site security and structure removal	DBR Section 3.2
	Preliminary description of closure activities related to final cover and grading	DBR Section 3.5
	Preliminary description of closure activities related to construction quality assurance methods	DBR Appendix D
	Preliminary description of closure activities related to drainage and erosion control systems	DBR Sections 3.5.4
	Preliminary description of closure activities related to landfill gas monitoring and control systems	DBR Section 3.8, RAMP Section
	Preliminary description of closure activities related to leachate monitoring and control measures	DBR Sections 3.5.3 and 3.8, RAMP Section
	Preliminary schedules for implementation of closure activities	NA
Title 27 Cal. Code Regs. § 21830 (for maintenance plans)	Emergency response plan	OMP Section 4
	Persons or companies responsible for each aspect of post-closure maintenance, and their addresses and telephone numbers	OMP Table 2
	Description of the planned uses of the property during the post-closure maintenance period	DBR Section 1.1
	As-built description of the current monitoring and control systems at the landfill, including a detailed description of any proposed changes to be implemented as part of closure	DBR Section 3.8

Table 1. Required Content for Closure and Maintenance *(continued)*

Citation	Required Information	Location in Design Package
Title 27 Cal. Code Regs. § 21830 (for maintenance plans)	Detailed description of the methods, procedures, and processes that will be used to maintain, monitor, and inspect the closed landfill during the post-closure maintenance period	OMP Section 2 and Appendix A
	Operations and maintenance plan for the landfill gas control system	OMP Section 2.5
	Summary of the requirements for reporting the results of monitoring and collection	RAMP Section 5
	Post-closure maintenance cost estimates	NA

Notes:

Cal. Code Regs. = California Code of Regulations

DBR = Design Basis Report

OMP = Operations and Maintenance

RAMP = Remedial Action Monitoring Plan

§ = Section

NA = Not available, information has not been developed for the site

Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment

Design Requirement	Citation[a]	Element to Address Basis of Design Criteria
Federal ARARs for Containment		
Resource Conservation and Recovery Act (Title 42 USC, ch. 82, §§ 6901–6991[i])[b]		
The final cover will prevent the downward entry of water into the closed landfill throughout a period of at least 100 years.	Cal. Code Regs. tit. 22, § 66264.310(a)(1)	Design includes an OMP and an engineering cost estimate relevant to the preparation of the post-closure OMP, providing: ▪ Emergency response action information ▪ Descriptions of the proposed monitoring and control systems at the landfill ▪ Detailed descriptions of the methods, procedures, and processes that will be used to maintain, monitor, and inspect the closed landfill during the post-closure maintenance period ▪ O&M information for the LFG control and abatement system. ▪ A summary of the requirements for reporting monitoring results
Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events throughout the post-closure period.	Cal. Code Regs. tit. 22, § 66264.310(b)(1)	Design includes a post-closure OMP with detailed descriptions of the methods, procedures, and processes that will be used to maintain, monitor, and inspect the closed landfill during the post-closure maintenance period.
Protect and maintain surveyed benchmarks throughout the post-closure period.	Cal. Code Regs. tit. 22, § 66264.310(b)(5)	Design includes a post-closure OMP that details procedures for the required maintenance of the surveyed benchmarks.

Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment *(continued)*

Design Requirement	Citation[a]	Element to Address Basis of Design Criteria
State ARARs for Containment		
State Water Resources Control Board/California Department of Resources Recycling and Recovery		
Diversion and drainage facilities will be designed, constructed, and maintained to accommodate the anticipated volume of precipitation and peak flows. In addition, erosion and related damage of the final cover due to drainage must be prevented throughout the post-closure maintenance period.	Cal. Code Regs. tit. 27, § 20365(c) and (d) and § 21090(c)(4)	Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the Vegetative Establishment Plan within the OMP.
The post-closure maintenance period will extend as long as the wastes pose a threat to water quality. The landfill will be maintained and monitored for a period of not less than 30 years after closure of the entire solid waste landfill.	Cal. Code Regs. tit. 27, § 20950(a) and § 21180(a)	Design includes an OMP and an engineering cost estimate relevant to the preparation of the post-closure OMP, providing: ▪ Emergency response action information ▪ Descriptions of the proposed monitoring and control systems at the landfill ▪ Detailed descriptions of the methods, procedures, and processes that will be used to maintain, monitor, and inspect the closed landfill during the post-closure maintenance period ▪ O&M information for the LFG control and abatement system ▪ A summary of the requirements for reporting monitoring results
The final cover of closed landfills will be designed, graded, and maintained to prevent ponding and to prevent site erosion caused by high runoff velocities. Slopes should be at least 3 percent.	Cal. Code Regs. tit. 27, § 21090(b)(1)	Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the Vegetative Establishment Plan within the OMP.

Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment *(continued)*

Design Requirement	Citation[a]	Element to Address Basis of Design Criteria
State ARARs for Containment		
State Water Resources Control Board/California Department of Resources Recycling and Recovery *(continued)*		
Potential emergency conditions that may exceed the design of the site and could endanger the public health or the environment must be anticipated.	Cal. Code Regs. tit. 27, § 21130	The Navy will comply with the substantive portions of this requirement. Design includes an OMP and an engineering cost estimate relevant to the preparation of the post-closure OMP, providing emergency response information.
Requires that all points of access be restricted except at permitted entry points, and that the monitoring, control, and recovery systems be protected from unauthorized access.	Cal. Code Regs. tit. 27, § 21135 (f) and (g)	The Navy will comply with the substantive portions of this requirement. Design includes a site perimeter fence to restrict unauthorized access.
The drainage and erosion control system will be designed and maintained to (1) ensure integrity of post-closure land uses, roads, and structures; (2) prevent public contact with waste and leachate; (3) ensure the integrity of gas monitoring and control systems; (4) prevent safety hazards; and (5) prevent exposure of waste.	Cal. Code Regs. tit. 27, § 21150(a)	Design includes an OMP and an engineering cost estimate relevant to the preparation of the post-closure OMP. Finished cover designed to accommodate vegetation for erosion control. Cover will be seeded with native species mixture established by the Vegetative Establishment Plan within the OMP.
Sets forth requirements for final closure plan contents.	Cal. Code Regs. tit. 27, § 21800(c)	Design of the post-closure OMP takes into consideration the substantive portions of Cal. Code Regs. in developing the final closure plan, as described in Table 1.
Provides the content requirements for post-closure maintenance plans for solid waste disposal sites.	Cal. Code Regs. tit. 27, § 21830	Design of the post-closure OMP takes into consideration the substantive portions of Cal. Code Regs. in developing the final closure plan as described in Table 1.

Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment *(continued)*

Design Requirement	Citation[a]	Element to Address Basis of Design Criteria
State ARARs for Containment		
State Water Resources Control Board/California Department of Resources Recycling and Recovery *(continued)*		
Subsection (a) requires proposed post-closure land uses be designed and maintained to protect health and safety; prevent contact with waste, LFG, and leachate; and prevent gas explosions. Subsection (b) specifies that the site closure design shall show one or more proposed uses of the closed site or show development that is compatible with open space. Subsection (c) specifies that approval is required if proposed post-closure land uses involve structures within 1,000 feet of the disposal area, structures on top of waste, modification of the low-permeability layer, or irrigation over waste. Subsections (d) through (g) set forth conditions for construction of onsite structures.	Cal. Code Regs. tit. 27, § 21190(a), (b), (d), (e), (f), and (g)	The substantive portions of Subsections (a), (b), (d), (e), (f), and (g) are relevant and appropriate. Even though no waste was discharged after July 18, 1997, this section is relevant and appropriate because it is a closure/post-closure requirement in Cal. Code Regs. tit. 27, Division 2, Subchapter 5, Article 2, which applies to "disposal sites that did not complete closure prior to November 18, 1990, in accordance with all applicable requirements" (Cal. Code Regs. tit. 27, § 21100). Subsection (c) specifies nonsubstantive requirements, and is therefore not an ARAR. The substantive provisions of Subsection (g) are relevant and appropriate for future construction within the Parcel E-2 boundary, including the portion of the Parcel E-2 Landfill that extends onto UCSF property, because Parcel E-2 may be affected by subsurface gas emanating from the Parcel E-2 Landfill. However, these provisions are not relevant and appropriate to future offsite construction beyond the Parcel E-2 boundary because these areas are not affected by subsurface gas emanating from the Parcel E-2 Landfill. The Navy will implement institutional controls, which are legal and administrative mechanisms for the continued protection of human health and the environment. The institutional controls for Parcel E-2 will restrict the development, land use, and activities on Parcel E-2 property as described in the LUC RD. These institutional controls will be maintained until concentrations of hazardous substances in soil and groundwater are at such levels to allow for unrestricted use and exposure. Implementation of Parcel E-2 institutional controls are discussed in the OMP and RAMP and include requirements for monitoring and inspections and reporting to ensure compliance with land use or activity restrictions.

Table 2. ARARs for Landfill and Wetland Soil Covers and Revetment *(continued)*

Notes:

a = Only the substantive provisions of the requirements cited in this table are ARARs.

b = Statutes and policies and their citations are provided as headings to identify general categories of ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that the Navy accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only substantive requirements of specific citations are considered ARARs.

ARARs = applicable or relevant and appropriate requirements

Cal. Code Regs. = California Code of Regulations

ch. = Chapter

LFG = landfill gas

LUC RD = Land Use Control Remedial Design

Navy = Department of the Navy

O&M = operation and maintenance

OMP = Operation and Maintenance Plan

RAMP = Remedial Action Monitoring Plan

tit. = Title

UCSF = University of California San Francisco

USC = United States Code

§ = Section

Table 3. Operation and Maintenance Oversight Personnel

General O&M Item	Qualifications
Maintain Updated OMP	Authorized Navy Representative
Financial Responsibility	Authorized Navy Representative
Bookkeeping	Authorized Navy Representative
Institutional Controls	
Site Security	Navy and O&M Contractor
Signs and Gates	O&M Contractor
Site Access	O&M Contractor
Land Use	Authorized Navy Representative
Final Cover	
Vegetative Cover	CPESC, QSP, or Civil PE (O&M Contractor)
Final Grading	CPESC, QSP, or Civil PE (O&M Contractor)
Demarcation Layer	PG or Civil PE (O&M Contractor)
Methane Monitoring Probes	PG or Civil PE (O&M Contractor)
Groundwater Monitoring Wells	PG or Civil PE (O&M Contractor)
Drainage	CPESC, QSP, or Civil PE (O&M Contractor)
Maintenance Path	CPESC, QSP, or Civil PE (O&M Contractor)
Revetment	
Armoring Material	Civil PE (O&M Contractor)
Filter Layer	PG or Civil P.E. (O&M Contractor)
Final Grading	CPESC, QSP, or Civil PE (O&M Contractor)
Scour and Erosion Impacts	CPESC, QSP, or Civil PE (O&M Contractor)
Wetland	
Vegetation	Civil PE or Wetland Professional (O&M Contractor)
Soil	Civil PE or Wetland Professional (O&M Contractor)
Hydrology	Civil PE or Wetland Professional (O&M Contractor)
Emergency Response	O&M Contractor
Wildlife	Biologist with California Species of Special Concern proficiency

Notes:
CPESC = Certified Professional in Erosion and Sediment Control
O&M = operation and maintenance
OMP = Operation and Maintenance Plan
PE = Professional Engineer
PG = Professional Geologist
QSP = Qualified SWPPP (Stormwater Pollution Prevention Plan) Practitioner

Table 4. Seed Mix

Scientific Name	Common Name	Pounds/Acre
Bromus carinatus	California Brome	25
Hordeum brachyantherum	Meadow Barley	10
Vulpia microstachys	Small Fescue	6
Trifolium willdenovii	Tomcat Clover	4
Eschscholzia californica	California Poppy	1.5

Table 5. Emergency Responses

Occurrence	Threat Posed	Response
Earthquake, including liquefaction	▪ Health and safety hazards ▪ Damage to monitoring systems ▪ Slope failure ▪ Damage to cover or its components	1. Immediately conduct visual inspection of area to assess damage and potential impact. 2. If safety hazards are present, immediately cordon off area. 3. If damage to monitoring systems has occurred, contact maintenance contractor to facilitate repairs. 4. Resurvey the area and increase the frequency of inspection and maintenance of final cover, drainage system, vegetative cover, and final grading to quarterly for a period of 1 year. 5. If slope failure, surface cracking, or similar damage occurs, contact the contracted geotechnical consultant, as appropriate, to evaluate problem areas within 48 hours of notice. If necessary, perform a geotechnical investigation of failure to develop a corrective action plan. 6. For damage or potential damage to other components that affect site integrity, security, or safety, arrange immediate temporary repairs (if necessary) and arrange repair or restoration within 2 weeks (weather and conditions permitting) to design conditions in accordance with construction specifications. 7. Notify FFA signatories, CalRecycle, and CDPH. **Required Equipment:** erosion control blankets or media, bulldozer, loader, compactor, sand, clean fill, and cordon tape.
Flood or Major Storm	▪ Excessive erosion of surface ▪ Slope failure ▪ Health and safety hazards ▪ Damage to cover or its components	1. Immediately conduct visual inspection of area to assess damage and potential impact. 2. If safety hazard is present, immediately cordon off the affected area. 3. If slope failure occurs, contact contracted geotechnical consultant, as appropriate, to evaluate the problem area with 48 hours. If necessary, conduct a geotechnical investigation of the failure to develop a corrective action plan. 4. For damage or potential damage to components that affect site integrity, security, or safety, arrange repair or restoration within 2 weeks (weather and conditions permitting) to design conditions and in accordance with construction specifications. 5. Investigate preventive measures. 6. Notify FFA signatories, CalRecycle, and CDPH. **Required Equipment:** erosion control blankets or media, bulldozer, loader, compactor, sand, clean fill, and cordon tape.

Table 5. Emergency Responses *(continued)*

Occurrence	Threat Posed	Response
Fire	▪ Health and safety hazards ▪ Damage to monitoring systems ▪ Damage to cover or its components	1. Notify San Francisco Fire Department and Navy representative. 2. Immediately conduct visual inspection of area to assess damage and potential impact. 3. Immediately cordon off affected area. 4. For damage or potential damage to other components that affect site integrity, security, or safety, arrange immediate temporary repairs (if necessary) and arrange repair or restoration within 2 weeks (weather and conditions permitting) to design conditions and in accordance with construction specifications. 5. Notify FFA signatories, CalRecycle, and CDPH. **Required Equipment:** erosion control blankets or media, silt fencing, straw bales, sandbags, bulldozer, loader, compactor, sand, clean fill, and cordon tape.

Notes:

CalRecycle = California Department of Resources Recycling and Recovery

CDPH = California Department of Public Health

DTSC = Department of Toxic Substances Control

EPA = U.S. Environmental Protection Agency

ROICC = Resident Officer in Charge of Construction

Water Board = San Francisco Bay Regional Water Quality Control Board

Appendix A. Inspection and Repair Procedures, Checklists, and Frequency

- Inspection and Repair Procedures for Operations and Maintenance at Parcel E-2
- General Inspection Checklist
- Emergency Inspection Checklist

Inspection and Repair Procedures for Operations and Maintenance of the Parcel E-2 Remedy

Section 1. Inspection and Repair Procedures

The site will be visited quarterly for the first 5 years and semiannually thereafter—or as necessary based on the results of the inspections. Some items will not be inspected during every site visit—for instance, subsurface geosynthetic materials. Tables A-1 and A-2 list the inspection frequencies. At a minimum, the following materials should be brought to the site for each site visit and this list should be adapted over time based on previous inspections conducted by the operation and maintenance (O&M) contractor:

- Camera
- Operations and Maintenance Plan (OMP)
- Land Use Control Remedial Design Report
- Appropriate documentation materials, including any inspection checklists
- Copies of appropriate maps and figures
- O&M logbook
- Telephone and contact list
- Common items requiring replacement (e.g., locks, well caps, well seals, and similar equipment)
- Previous inspection reports and photographs of concern (as necessary)

Inspection reports summarizing the findings of the inspections should be filed promptly with the Navy following the inspection and, in cases where significant damage has been observed, the Navy should be notified as soon as possible. Appendix A1 provides the general inspection checklist.

Significant issues of vandalism and theft, especially when recurring, should be reported to police and may result in increased inspection frequency.

Basic repairs can be conducted on site at the time of inspections. The kinds of repairs may include but are not limited to replacement of signage, replacement of monitoring well locks and protective caps, filling in of small gullies caused by water erosion, and replanting of small areas. Significant repairs are those that are not defined as or considered to be similar to the basic repairs listed in the previous sentence. Significant repairs may include but are not limited to addition of revetment armoring material, filling of areas over the soil cover, and repairs associated with exposure of the demarcation layer or the revetment filter fabric. This level of repair will require specialized equipment and materials and should be conducted by an appropriate contractor in accordance with the design- and construction-related documents, including the design drawings and the construction specifications. Repairs such as these will have a potential impact on the protectiveness of the remedy and should be conducted under the

supervision of a licensed professional engineer and in accordance with a work plan approved by the Federal Facility Agreement signatories and California Department of Public Health for the area requiring institutional controls for radionuclides. The following sections list the procedures to be used during the site inspection process that should be adapted based on site conditions as they evolve over time.

1.1. GENERAL SITE CONDITIONS

- The perimeter of the site should be walked and the fence and boundary conditions inspected for signs of breaching, vandalism, and degradation. Issues should be documented in inspection summary reports, and photographs should be taken of any areas of concern and the exact location documented.
- The shoreline revetment should be inspected during low tide so the full extent of the structure can be viewed.
- The condition of any designated access points to the site should be inspected for damages.
- Any trash, debris, or other materials should be removed from the site and disposed of properly. This material also includes debris that may wash up onto the revetment and vegetation along the revetment.
- Any issues of concern should be reported to the Navy as necessary. Repairs to the fence should be scheduled with an appropriate contractor.
- Any unauthorized digging on the site should be recorded, and excavated areas should be filled and compacted as necessary.

1.2. SITE SIGNAGE

- Each sign should be inspected for integrity and vandalism. Structural issues should be dealt with appropriately during the inspection when possible or scheduled with an appropriate contractor.
- If the signs begin to degrade visually, photographs should be taken to document and monitor degradation and signs should be replaced promptly when necessary.
- Signs that are illegible at a distance of 5 feet will be cleaned or replaced.
- Any stolen signs should be replaced promptly.

1.3. SITE SECURITY FENCING

- Fences should be inspected for integrity and vandalism. Structural issues should be dealt with appropriately during the inspection when possible or scheduled with an appropriate contractor.
- Graffiti should be removed promptly.
- Any vegetation that is growing too close to the fence and may damage the fence over time should be removed.
- Holes or damaged portions of the fence should be fixed promptly to prevent access to the site.

1.4. SOIL COVER AND PROTECTIVE LINER

- The cover should be walked systematically to inspect the complete extent of the cover. Particular attention should be given to the side slopes, drainage swales, and the portion where the soil cover meets the crest of the revetment.
- The as-built drawings should serve as the basis of comparison to document changes in the cover.
- Areas where vegetation has been damaged should be documented, photographed, and monitored. The vegetative cover should naturally regenerate without additional seeding. If the damaged areas do not regenerate or are extensive, the seed mix provided in this OMP should be used when reseeding.
- The roots of any species outgrowing the predominant grasses could breach the demarcation layer (or underlying protective liner) and must be promptly removed. Prevent exposure of underlying soil beneath trees and apply herbicide as necessary.
- Mowing should be conducted when grasses are greater than 2 feet in height. Do not remove more than 1/3 of the total height within a 1-week period. Maintain a minimum grass height of 6 inches.
- Areas of settlement should be recorded. Minor settlement is not an immediate concern but should be monitored over time. Major settlement could require specialized labor and personnel for repair.
- Cracks in the soil cover should be documented and repaired with similar soil.
- Areas of erosion or soil displacement by slumping should be recorded and repaired promptly. These repairs, when minor, could be completed during the inspection. Use of appropriate contractors and equipment would be necessary for more significant repairs.
- Obstructions to the drainage swales should be removed.
- Evidence of burrowing animals on the soil cover should be noted and monitored over time. The approximate location, diameter, and vertical depth of burrows will be recorded. Pest control measures may be necessary if damage to the cover occurs (see Section 2).
- If any animal burrow or hole in the soil cover is identified, it will be will be backfilled using material removed from the hole and compacted manually using a hand tamper.
- For burrows that extend to the demarcation layer (at least 2 feet vertically below the ground surface), the following inspections should be performed:
  - Excavate and expose the demarcation layer by hand.
  - Examine the demarcation layer for damage that exposes any of the underlying geosynthetic materials (for all non-wetland areas, these layers will consist of, at minimum an high-density polyethylene [HDPE] geonet, geotextile fabric, and HDPE geomembrane; additional layers, most notably a geosynthetic clay liner, will be present in the Parcel E-2 Landfill).
  - If the demarcation layer or underlying geosynthetic materials are damaged, promptly repair the affected areas in accordance with the construction specifications and pertinent manufacturer guidelines.

  - Backfill the excavation using material removed from the hole and compact manually using a hand tamper.
  - Reseed the area using the seed mix provided in this O&M plan.

- Repairs to the soil cover should follow the procedures outlined in the design and construction documents, including the design drawings and construction specifications.

1.4.1. Demarcation Layer

- Any exposure of the demarcation layer should be documented, and the approximate location, size, and depth of the opening will be recorded.
- Damage to the soil cover and, if necessary, the demarcation layer should be promptly repaired, in accordance with the construction specifications and, for the demarcation layer, pertinent manufacturer guidelines.
- Based on the recommendation of the material manufacturer, the demarcation fabric may require periodic inspection. Any necessary inspection would require excavation above the demarcation layer to allow visual inspection of the material. The frequency is expected to be every 5 or 10 years; however, individual manufacturers have varying recommendations.

1.4.2. Protective Liner

- If the demarcation layer is found to be damaged, then the underlying geosynthetic materials will require inspection and, if necessary, repair.
- During inspection of damage to the demarcation layer, any exposed geosynthetic materials (e.g. geocomposite drainage layer, HDPE geomembrane, etc.) should be visually inspected.
- Any exposure should be documented, and the geosynthetic materials should be repaired in accordance with the construction specifications and based on procedures in the manufacturer's specifications.

1.5. CONSTRUCTED WETLANDS

- The as-built drawings should serve as the basis of comparison to document changes in the wetlands.
- Document areas with signs of vandalism.
- Areas of settlement should be recorded. Minor settlement is not an immediate concern but should be monitored over time. Major settlement could require specialized labor and personnel for repair.
- Areas of erosion or soil displacement by slumping should be recorded and repaired promptly. These repairs, when minor, could be completed during the inspection. Use of appropriate contractors and equipment would be necessary for more significant repairs.
- Inspection of culverts and other inflow and outflow structures at the freshwater wetlands should be conducted. Obstructions to the drainage structures that could block flow should be removed.

- Areas where vegetation has been damaged should be documented, photographed, and monitored. If the areas do not regenerate or are extensive, replanting should follow the wetland planting design described in the Design Basis Report.
- The wetlands and adjoining areas should be inspected for invasive plant and animal species and managed in accordance with the procedures described in Section 2.

1.6. SHORELINE REVETMENT

- The limits of the revetment should be inspected for vandalism or theft of materials and documented or replaced accordingly. The revetment should be compared to the as-built drawings.
- Any shifting of materials or settlement should be recorded. This record should be done through comparison to previous inspections. Shifting and settling is anticipated to occur and does not impact the integrity of the structure but should be monitored.
- The toe portion of the revetment should be observed during low tide so the entire extent of the structure can be properly documented. Photographs of the revetment should be taken as necessary.
- Trash or debris that may have accumulated on the revetment should be removed and disposed of properly. Excessive nuisance vegetation should be removed from the structure.
- The toe portion and the flanks of the revetment should be inspected for signs of settlement, changes in slope, and undercutting and erosion. The toe portion should be fully covered by sediment and any exposure of rocks should be recorded. Exposure of the armoring material does not jeopardize the integrity of the structure but should be monitored over time.
- Exposure of the filter fabric indicates that the revetment armoring has been displaced. This exposure should be recorded and repairs made through the addition of material. Inspect integrity and consistency of subgrade.
- Note any signs of vandalism or theft. Areas where additional revetment armoring rock may be necessary should be replaced promptly. Procedures summarized in the design and construction documents should be followed, and repairs should be made based on the as-built drawings and the construction specifications.
- The crest of the revetment should be inspected for degradation and the movement of rock.
- Any signs of wave overtopping of the revetment should be documented and monitored over time.

1.7. LANDFILL GAS MONITORING PROBES AND GROUNDWATER MONITORING WELLS

- Protective materials (casing, pads, etc.) should be inspected for integrity. Damages should be documented through photographs. Slight damages can be monitored over time but damages that may jeopardize the functionality of the probe or well should be reported and repaired promptly.
- Vandalism and theft of any materials related to the probes or wells should be repaired promptly. Repair may include replacing locks, caps, and other items or covering vandalized items with paint.

- Repair or replace rusted or otherwise nonfunctional well locks.
- The probes and wells should be inspected to ensure that they are free of obstructions. This inspection is especially important in situations where locks or well caps are missing or when there are other signs that the well has been breached. Appropriate probes can be used to check that obstructions do not exist within the well itself.
- Any issues should be recorded through photographs and written descriptions, and the probe and well locations should be recorded.
- Any repair needing immediate attention should be promptly reported to the Navy for scheduling with appropriate contractors.

1.8. LANDFILL GAS CONTROL FEATURES

The Navy will perform a landfill gas (LFG) survey to support the design of the LFG control systems, and fieldwork is planned for summer 2013. Accordingly, the Draft OMP does not include details on O&M of the LFG control systems and this information will be provided in the Draft Final OMP.

1.9. GROUNDWATER CONTROL FEATURES

- Check French drain outfall. Note whether water appears to freely exit from the outfall pipe. Note any visible blockage of water flow.
- Obstructions to water flow in the French drain should be removed.
- Check leachate monitoring and extraction wells and piezometers for signs of damage or vandalism. Inspect subsurface vaults for signs of physical damage to their integrity and locking mechanisms.
- Vandalism and theft of any materials related to the wells or piezometers should be repaired promptly. Repair may include replacing locks, caps, and other items or covering vandalized items with paint.
- Repair or replace rusted or otherwise nonfunctional well and piezometer locks.

1.10. MAINTENANCE PATH

- The maintenance path should be walked systematically to inspect the complete extent of the pathway.
- The as-built drawings should serve as the basis of comparison to document changes in the pathway.
- Note areas of excessive traffic.
- Document areas with signs of vandalism.
- Areas of settlement should be recorded. Minor settlement is not an immediate concern but should be monitored over time. Major settlement would require specialized labor and personnel for repair.

Section 2. Invasive Species Management

Colonization of the final remedy, including the soil cover and constructed wetlands, by invasive, undesirable plants and animals is a concern and will require measures be taken to prevent their establishment and ensure long-term viability of the constructed remedy. The following sections identify the invasive plant and animal species that are of primary concern, and provide preliminary information on the means by which they will be managed. The Draft Final OMP will provide more detailed information on how invasive species at Parcel E-2 will be managed.

2.1. INVASIVE PLANTS IN WETLAND AREAS

Two invasive species common to the bay region are smooth cordgrass (*Spartina alterniflora*) and broadleaf pepperweed (*Lepidium latifolium*). Once introduced, both species can dominate any environment that provides suitable conditions for establishment. Spartina alterniflora readily hybridizes with and out competes the native California (Pacific) cordgrass (*Spartina foliosa*), and threatens it with local extinction. Smooth cordgrass (*Spartina alterniflora*) and its hybrid with *Spartina foliosa* are the most widespread invasive Spartina species in the San Francisco estuary. Surveys show that the invasive Spartina hybrids are rapidly spreading in the south, central, and north bay regions. Populations appear to begin at the bay and slough edges and move into the interior of marshes as the invasion progresses. Because the invasive *Spartina alterniflora* and *Spartina foliosa* hybrid occurs at the project site, it likely will invade the restored tidal marsh areas. The Navy will control the spread and eradicate invasive species, including *Spartina alterniflora* and *Spartina foliosa* hybrid, to less than 10 percent of vegetation over a 5-year monitoring program within the project area.

Broadleaf pepperweed aggressively colonizes wetland-upland transition areas and is increasingly prevalent in saline soil and waste areas of the bay region, thus it is a sitewide concern. Broadleaf pepperweed does not survive periods of prolonged flooding during the growing season, but it can dominate wetlands from the edge of standing water to dry upland areas.

2.2. INVASIVE PLANTS IN UPLAND AREAS

Previously identified invasive species at Parcel E-2 upland areas include sweet fennel (*Foeniculum vulgare*), cocklebur (*Xanthium strumarium*), black mustard (*Brassica nigra),* short-pod mustard *(Hirschfeldia incana),* wild radish (*Raphanus raphanistrum)* and cultivated radish *(Raphanus sativus*), sour clover (*Melilotus indica*), sweet clover (*Melilotus officinalis*), cheeseweed (*Malva parviflora*), and pampas grass (*Cortaderia* sp.*)*. Cheeseweed was found on dump piles just south of the landfill cover. This plant can develop very large and powerful roots and is competitive, growing and setting seed very

quickly. Pampas grass is another plant of concern. It is highly invasive and can develop deep root structures.

2.3. MANAGEMENT OF INVASIVE PLANT SPECIES

An invasive plant species management program will be developed in the Draft Final OMP and will include the following components:

- Regular inspections will be conducted to identify and address any problems that occur from invasive recolonization that prevent the establishment of desirable plants.
- Invasive species within the project area, or close to the area, will be identified and removed either manually with equipment (e.g., backhoe) or through application of herbicides.
- Appropriate eradication methods will be determined based on the targeted species encountered and will consider integrated pest management concepts, which emphasize use of control measures with a low environmental impact (such as focused weeding or highly targeted spraying of herbicides) over measures with a high environmental impact (such as broadcast spraying of herbicides).
- Follow-up inspections to ensure the effectiveness of the removal.

2.4. INVASIVE ANIMALS IN WETLAND AREAS

Two rodents of concern are the Norway rat (*Rattus norvegicus*) and the Black rat (*Rattus rattus*), which could become established within the wetland areas by inhabiting small crevices in the shoreline revetment sections that are close to the wetlands. These species are common pests that can survive in a wide range of habitats, but are common in marshlands near buildings in urbanized areas. They nest in burrows and rock outcroppings and have caused major damage to wildlife by consuming the eggs of ground, shrub, and tree-nesting birds. Although a limited amount of information is available about their behavior in the San Francisco Bay area, Norway rats are confirmed predators of the California clapper rail (*Rallus longirostris obsoletus*), salt marsh harvest mouse (*Reithrodontomys raviventris*), and salt marsh wandering shrew (*Sorex vagrans halicoetes*). The constructed wetlands are also intended to be inhospitable to predatory mammals such as rats, feral cats, skunks, and coyotes; however, control measures may be needed if such mammals are documented preying on birds in the wetland areas.

2.5. INVASIVE ANIMALS IN UPLAND AREAS

Burrowing animals that could damage the upland soil cover include Botta's pocket gopher (*Thomomys bottae*), California mole (*Scapanus latimanus*), California ground squirrel (*Spermophilus beecheyi*), and California vole (*Microtus californicus*). The California ground squirrel was the most common mammal identified during past biological surveys of Hunters Point Naval Shipyard (HPNS) and the Candlestick Point area. Sporadic occurrences of Botta's pocket gopher and the California vole were observed during the survey, but the presence of these species was characterized as uncommon because of the urban and

industrial development that surrounds HPNS (San Francisco Redevelopment Agency, 2010)[1]. The California mole was not identified during past biological surveys of HPNS and the Candlestick Point area.

2.6. MANAGEMENT OF INVASIVE ANIMAL SPECIES

A program to manage invasive animal species will be developed in the Draft Final OMP and will include the following components:

- Regular inspections will be conducted to identify and address any problems that occur from burrowing animals that cause unacceptable erosion, prevent the establishment of surface vegetation, or damage the protective liner (which consists of multiple layers of geosynthetic materials).
- Physical methods to deter movement of burrowing animals or encourage their predation may be implemented. Example of such methods include (1) raptor perches that could be installed in suitable areas (i.e., away from wetland areas) to encourage predation of burrowing animals; (2) small crevices in the shoreline revetment close to wetland areas could be filled with concrete to limit the habitat for Norway rats; and (3) fencing adjacent to the property boundary could be modified to below-ground material (such as galvanized wire mesh) that would limit the movement of burrowing animals.
- Appropriate eradication methods will be selected based on the targeted species encountered and will consider integrated pest management concepts, which emphasize use of control measures with a low environmental impact (such as the physical methods identified above) over measures with a high environmental impact (such as application of poison).
- Follow-up inspections will be performed to ensure the effectiveness of the removal.

[1] San Francisco Redevelopment Agency (SFRA), 2010. "Final Environmental Impact Report, Candlestick Point-Hunters Point Phase II." Volumes I through X. May 13.

Tables

Table A-1. Inspection Summary and Checklist (for the ARIC for Radionuclides)

Component	Inspection Item	Frequency
General Site Conditions	▪ Security of area not breached ▪ Access and roads ▪ Vandalism ▪ Fencing Intact	Quarterly
Site Signage	▪ Presence of signs ▪ Legibility of wording ▪ Vandalism ▪ Inadequacy – structural issues, age, etc.	Quarterly
Soil Cover	▪ Drainage – on and off site ▪ Prevention of erosion ▪ Vegetation ▪ Invasive deep-rooted species ▪ Vandalism or excessive traffic ▪ Burrowing animals ▪ Depressions ▪ Slope failure	Quarterly
Demarcation Layer	▪ Not exposed ▪ Degradation (investigation through excavation	Quarterly Every 5 to 10 years or as specified by the manufacturer
Protective Liner	▪ Not exposed	Quarterly
Revetment	▪ Toe scour ▪ Flank scour ▪ Changes to the bay slope/evidence of erosion ▪ Displacement or sinking of structure ▪ Structural damage ▪ Evidence of excessive overtopping by waves ▪ Trash and vegetation removal ▪ Filter fabric remains in place/ not exposed ▪ Vandalism and theft	Quarterly
Landfill Gas Monitoring Probes and Groundwater Monitoring Wells	▪ Obstructions ▪ Security ▪ Seals ▪ Damage ▪ Vandalism	During all sampling events and at least semiannually
Maintenance Path	▪ Degradation ▪ Cracks, holes, and depressions	Quarterly

Notes:

Complete inspections should be conducted following significant earthquakes (as determined based on professional judgment and site experience).

Conduct inspections following hurricane-level storm events and adjust the trigger level based on site experience.

Mowing the vegetative cover is not part of the inspection but should be completed semiannually or as needed based on future site use.

ARIC = area requiring institutional controls

Table A-2. Inspection Summary and Checklist (Area Outside ARIC for Radionuclides)

Component	Inspection Item	Frequency
General Site Conditions	▪ Security of area not breached ▪ Access and roads ▪ Vandalism ▪ Fencing Intact	At least semiannually
Site Signage	▪ Presence of signs ▪ Legibility of wording ▪ Vandalism ▪ Inadequacy – structural issues, age, etc.	At least semiannually
Soil Cover	▪ Drainage – on and off site ▪ Prevention of erosion ▪ Vegetation ▪ Vandalism or excessive traffic ▪ Burrowing pests ▪ Depressions ▪ Slope failure	Quarterly
Constructed Wetlands	▪ Prevention of erosion ▪ Drainage – on and off site ▪ Vegetation ▪ Vandalism or excessive traffic	Semiannually for first 5 years
Groundwater Control Features	▪ Obstructions ▪ Security ▪ Seals ▪ Damage ▪ Vandalism ▪ Outflow from drain	Quarterly

Notes:

Complete inspections should be conducted following significant earthquakes (as determined based on professional judgment and site experience).

Conduct inspections following hurricane-level storm events and adjust the trigger level based on site experience.

Mowing the vegetative cover is not part of the inspection but should be completed semiannually or as needed based on future site use.

ARIC = area requiring institutional controls

Appendix A1. General Inspection Checklist

GENERAL INSPECTION CHECKLIST

General Site Condition (Applies to All Areas of the Site)

1. Is the landfill adequately secured by a perimeter fence that is in good condition and shows no signs of having been trespassed?

☐Yes
☐No*

** If no, secure the perimeter fence with locks obtained from the CSO. If the fence is damaged, mark location of damage and notify the CSO for repairs.*

Comments:_____

2. Are posted signs in place and in good condition (legible)?

☐Yes
☐No*

** If no, mark location(s) of damaged or missing signs and notify the CSO for repairs or replacements.*

Comments:_____

3. Inspect condition of maintenance pathways. Are any ruts or potholes large enough to hinder vehicular traffic?

☐Yes*
☐No

** If yes, notify the CSO to assess the appropriate course of action for repair.*

Comments:_____

Soil Cover and Protective Liners

4. Does the soil on the cap appear to be disturbed to the point that the geosynthetic layers underneath could be damaged (deeper than 24 inches below cap surface) or are there areas of exposed geosynthetic liner material?

☐Yes*
☐No

** If yes, uncover the area and visually inspect the drainage net and underlying geosynthetics. If damaged, repair in accordance with manufacturer's instructions.*

Comments:_____

5. Are open holes present in the soil that may be caused by burrowing animals?

☐ Yes*
☐ No

** If yes, fill up the hole with clean soil (contains no chemicals of concern) and report to the CSO. Develop a strategy to remove the burrowing animals, and make recommendations for long-term corrective action in consultation with appropriate Navy personnel. Suggested corrective action includes installing a Molecontrol device or similar system.*

Comments:_____

6. Are there noticeable depressions or ponding of surface water on the soil cover?

☐ Yes*
☐ No

** If yes, backfill the depression with the soil type described in the construction specifications to restore grade of the cap as shown on the design drawings. Where soil erosion seems excessive and continual, corrective action may be needed (contact the CSO). In areas that require substantial earthwork, reseeding will be required (refer to checklist item No. 7)*

Comments:_____

7. Are there large (more than 2 inches wide) cracks or rills present in the soil cover?

☐ Yes*
☐ No

**If yes, notify the CSO to assess whether the cracks are due to desiccation or slope failure. Note the orientation, location, and frequency of the cracks; photograph areas of concern; and, if possible, make recommendations for corrective action.*

Comments:_____

8. Have any trees or shrubs grown on the soil cover?

☐ Yes*
☐ No

** If yes, remove the tree(s) or shrub(s).*

Comments:_____

9. If applicable, inspect all Molecontrol devices (or similar system to ward off burrowing animals). Is each device functioning properly?

☐Yes
☐No*

** If no, first replace the batteries of the inoperative device. If the Molecontrol device is still not functioning, replace the device by contacting D&D Chemical, Inc. ([800] 434-0221) or visiting http://www.ddchem.com/molecontrol.htm. Mark new devices, so they can be easily located during future inspections.*

Comments:_____

10. Are there any signs of sliding or sloughing of the soil layer that might indicate a slope failure?

☐Yes*
☐No

**If yes, note the location, photograph if possible, and make recommendations for corrective action.*

Comments:_____

Site Drainage

11. Inspect areas that channel water runoff at the site (landfill cap and adjacent areas), including ditches, slope edges, and pipe outlets. Are there signs of erosion from stormwater runoff?

☐Yes*
☐No

** If yes, notify the CSO to assess the appropriate course of action for repair.*

Comments:_____

12. Is there excessive vegetation (large stalks that would impede surface water flow) in the central gravel drainage ditch?

☐Yes*
☐No

** If yes, remove the vegetation by spraying it with herbicides that contain no chemicals of concern.*

Comments:_____

13. Are excessive debris, silt, or other harmful materials obstructing flow through the surface water runoff control system?

☐Yes*
☐No

**If yes, remove the obstruction(s). Where obstructions are continuous or recurring, make recommendations on corrective measures to address the problem.*

Comments:_____
_____
_____
_____

Vegetation

14. Are areas larger than 20 square feet of stressed or missing vegetation present at the site (both landfill cover and adjacent areas)?

☐Yes*
☐No

**If yes, reestablish vegetative growth by watering or reseeding. Seeding should take place during the season that will optimize establishment of vegetation.*

Comments:_____
_____

15. Are known areas of continual poor growth present despite reseeding efforts?

☐Yes*
☐No

**If yes, and the areas appear to be affecting the integrity of the soil cover, contact appropriate Navy personnel and make recommendations on corrective measures to address the problem. If poor growth does not seem to be caused by a lack of water, consider testing the soil for pH, heavy metals, or other potential causes. If areas adjacent to the cap have areas of continual poor growth, notify the CSO so that reseeding efforts can be made to better establish growth.*

Comments:_____
_____

16. Have invasive or deep-rooting species that may penetrate the cap deeper than 18 inches taken root on the cap soil cover?

☐Yes*
☐No

**If yes, identify the affected area and the observed plant species and develop a strategy to remove the invasive plants (permanently if possible). One recommended approach is to spot spray the species with an herbicide; this approach may take up to 4 days, depending on the extent of removal. Roots can also be cut out. Inspect the area every 2 weeks following removal to ensure that invasive species have not returned.*

Comments:_____
_____
_____

17. Is vegetation on the landfill cover dry (a possible fire hazard); and, if so, is the grass more than 6 inches high?

☐Yes*
☐No

**If yes, contact appropriate Navy personnel to complete a fire hazard evaluation. One recommended solution is to mow dry vegetation to a maximum height of 6 inches, if necessary.*

Comments:_____
_____
_____
_____
_____

Landfill Gas and Monitoring Well Network

18. Are landfill passive vents and turbines in good working order (e.g., vents are not damaged, valves are open, and turbines are free to spin from wind force)?

☐Yes
☐No*

** If no, notify the CSO to repair vents or turbines.*

Comments:_____
_____
_____

19. Inspect the gas vent gates and protection system. Are the existing cages secure and in good condition?

☐Yes
☐No*

**If no and the cages are damaged, mark the location of damage and notify Navy personnel immediately (same business day) and make recommendations for repairs.*

Comments:_____
_____
_____
_____
_____

20. Inspect the groundwater monitoring wells. Are the existing wells secure and in good condition?

☐Yes
☐No*

**If no, remove obstructions from well box and casings. If wells are damaged, mark the location of damage and notify Navy personnel immediately (same business day) and make recommendations for repairs.*

Comments:_____
_____
_____
_____

Revetment

21. Inspect the general condition of the revetment. Is there any evidence of pests, vandalisms, or excessive traffic? Are the filter fabric and filter layer properly placed? Is there any evidence of settlement or movement

☐Yes*
☐No

**If yes, notify the CSO to assess the appropriate course of action for repair.*

Comments:_____
_____
_____
_____

22. Inspect the transition from cover to revetment. Is there any evidence of wave overtopping? Is there any evidence of the cover soil overtopping into the crest??

☐Yes*
☐No

** If yes, notify the CSO to assess the appropriate course of action for repair.*

Comments:_____
_____
_____
_____

23. Inspect the toe and flank of the revetment. Is there any evidence of scour and erosion? Are there and changes in the bay slope?

☐Yes*
☐No

** If yes, notify the CSO to assess the appropriate course of action for repair.*

Comments:_____
_____
_____
_____

Groundwater Controls

1. Inspect the leachate extraction wells and piezometers. Are the existing wells secure and in good condition?

☐Yes
☐No*

**If no, remove obstructions from well box and casings. If wells are damaged, mark the location of damage and notify Navy personnel immediately (same business day) and make recommendations for repairs.*

Comments:_____
_____
_____
_____
_____

2. Are excessive debris, silt, or other harmful materials obstructing flow through the French drain?

☐Yes*
☐No

**If yes, remove the obstruction(s). Where obstructions are continuous or recurring, make recommendations on corrective measures to address the problem.*

Comments:_____
_____
_____
_____

Additional Notes (Time, temperature, wind direction, and other observations)

_____
_____
_____
_____
_____
_____
_____

_____
Name of Inspector(s)

_____
Company

_____ _____
Signature of Inspector Time and Date of Inspection

EMERGENCY RESPONSE INSPECTION CHECKLIST

This checklist should be completed in conjunction with the standard inspection checklist following any catastrophic event (e.g., unauthorized land use or vandalism, earthquakes, floods, or fires and explosions) that may adversely affect the integrity of the cap or landfill gas control system and monitoring network at Parcel E-2.

1. Are there large cracks in the soil cover that are more than 2 inches in width or extend to cap liner?

☐ Yes*
☐ No

** If yes, notify the CSO to assess whether the cracks are caused by desiccation or slope failure.*

Comments:_____
_____
_____
_____
_____

2. Are there notable depressions or ponding of surface water on the landfill cover?

☐ Yes*
☐ No

**If yes, backfill and regrade the depressions with approved soil type(s) described in the original project specifications or as approved by the CSO. Where soil erosion seems excessive and continual, make recommendations for corrective action. Reseeding will be required in areas that require substantial earthwork; reseed in accordance with design specifications or as approved by the CSO.*

Comments:_____
_____
_____
_____
_____

3. Are posted signs in place and in good condition (legible)?

☐ Yes
☐ No*

** If no, mark location(s) of damaged or missing signs and notify the CSO for repairs or replacements.*

Comments:_____
_____
_____
_____
_____

In addition, for EARTHQUAKES:

7. Do settlement markers indicate any significant horizontal or vertical movement?

☐ Yes*
☐ No

** If yes, arrange resurveying to establish magnitude of movement.*

Comments:_____
_____
_____
_____

8. Are there signs of shifting or sloughing of cover soil?

☐ Yes*
☐ No

** If yes, prevent further sloughing, if possible, by constructing temporary barrier, followed by long-term repair of the cover.*

Comments:_____
_____
_____
_____

9. Inspect the lined drainage channels. Are there any cracks or fissures along the channels?

☐ Yes*
☐ No

** If yes, patch cracked areas according to manufacturer's specifications.*

Comments:_____
_____
_____
_____

10. Inspect the revetment. Is there significant shifting of rock or loss of revetment height?

☐ Yes*
☐ No

** If yes, immediately notify the CSO to schedule revetment repair.*

Comments:_____
_____
_____
_____

In addition, for MAJOR STORMS and FLOODS:

11. Are excessive debris, silt, or other harmful materials obstructing flow through the surface water runoff control system?

☐Yes*
☐No

**If yes, remove the obstruction(s). Where obstructions are continuous or recurring, make recommendations on long-term corrective measures to address the problem.*

Comments:_____

12. Inspect areas where stormwater runoff enters the drainage channels. Are there signs of excessive erosion from stormwater runoff or other signs of damage?

☐Yes*
☐No

**If yes, determine the appropriate course of action for repair in consultation with CSO personnel. Recommend long-term corrective measures to address the problem.*

Comments:_____

In addition, for FIRES and EXPLOSIONS:

15. Is there evidence suggesting geocomposite drainage layer may have been burnt or compromised? Evidence may include large charred areas or pits on the cap surface or areas of exposed charred or melted geocomposite materials.

☐Yes*
☐No

** If yes, fully investigate and delineate the extent of damage (may require hand digging test pits to evaluate geocomposite integrity). Repair all damaged geocomposite in accordance with the manufacturer's specifications.*

Comments:_____

16. Is there evidence suggesting the integrity of the geomembrane liner may have been compromised (melted or cracked)? Evidence may include large charred areas or pits on the cap surface or areas of exposed charred or melted geomembrane materials.

☐Yes*

☐No

** If yes, fully investigate and delineate the extent of damage (may require hand digging test pits to evaluate liner integrity). Repair all damaged geomembrane in accordance with the manufacturer's specifications.*

Comments:_____

17. Are areas of burnt or missing vegetation observed on the landfill cover?

☐Yes*
☐No

**If yes, reestablish vegetative growth by watering or reseeding in accordance with design specifications or as directed by the CSO. Seeding should take place during the season that will optimize establishment of vegetation.*

Comments:_____

18. Inspect landfill gas vent pipes. Are any of the stand pipes damaged or melted?

☐Yes*
☐No

** If yes, evaluate the potential for damage to any subsurface piping (may require hand digging to visually inspect subsurface piping). Fully repair all damaged piping according to manufacturer's specification.*

Comments:_____

Additional Notes (time, temperature, and wind direction, and other observations)

Name of Inspector(s)

Company

Signature of Inspector

Time and Date of Inspection

Draft

Construction Quality Assurance Plan for Parcel E-2

Hunters Point Naval Shipyard
San Francisco, California

June 2013

Prepared for:
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Base Realignment and Closure
Program Management Office West
San Diego, California

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Draft
Construction Quality Assurance Plan for Parcel E-2
Hunters Point Naval Shipyard, San Francisco, California

Submitted by:
Engineering/Remediation Resources Group, Inc.

	June 25, 2013
Signature	Date
Doug Bielskis, P.E.	Project Manager/Engineer of Record
Name	Title

ERRG-6011-0000-0034

Table of Contents

SECTION 1. INTRODUCTION 1-1

1.1. Purpose 1-1

1.2. Construction Quality Assurance Organization 1-2

1.3. Report Organization 1-2

1.4. Terms and Definitions 1-3

SECTION 2. GENERAL REQUIREMENTS 2-1

2.1. Construction Quality Assurance Personnel and Responsibilities 2-1

2.1.1. Responsibilities of the CQA Manager 2-1

2.1.2. Responsibilities of the CQA Monitors 2-2

2.1.3. Responsibilities of the Design Engineers 2-2

2.1.4. Responsibilities of the CQC Manager 2-2

2.1.5. Appointment Letters 2-3

2.2. Meetings 2-3

2.2.1. Preconstruction Meeting 2-4

2.2.2. Progress Meeting 2-4

2.2.3. Weekly Meeting 2-5

2.2.4. Other Meetings 2-5

2.3. Control of Documents, Records, and Forms 2-5

2.3.1. Control of Construction Documents 2-5

2.3.2. Control of As-Built Information 2-6

2.3.3. Control of Forms 2-6

2.3.4. Processing Daily Reports 2-6

2.3.5. Processing Test Reports 2-6

2.3.6. Processing Project Records 2-6

2.3.7. Photographic Records 2-6

2.4. Documentation and Control of Nonconformance 2-7

2.4.1. Observation of Nonconformance 2-7

2.4.2. Determining Extent of Nonconformance 2-7

2.4.3. Documenting Nonconformance 2-7

2.4.4. Corrective Measures 2-7

2.4.5. Verification of Corrective Measures 2-7

2.5. Construction Monitoring 2-8

Table of Contents

2.6. Materials Quality Verification 2-8
2.6.1. Materials Submittals 2-8
2.6.2. Certificates of Compliance and Conformance 2-8
2.7. Equipment Control 2-9

SECTION 3. CONSTRUCTION QUALITY ASSURANCE 3-1
3.1. Construction Testing 3-1
3.2. Test Frequencies 3-1
3.2.1. Soil Sample Numbering 3-1
3.2.2. Soil Sample Tagging 3-2
3.2.3. Soil Sample Processing 3-2
3.2.4. Field Density Tests 3-2
3.2.5. Field Density Test Locations 3-3

SECTION 4. MONITORING AND TESTING REQUIREMENTS FOR EARTHWORK 4-1
4.1. Clearing and Grubbing 4-1
4.2. Screening, Excavation, and Offsite Disposal of Hot Spots 4-1
4.3. Acceptance and Backfilling Imported Fill 4-2
4.4. Stockpiling and Management of Soil 4-3
4.5. Excavation and Grading 4-3
4.6. OnSite Consolidation of Solid Waste 4-4
4.7. Placement of Foundation Layer 4-5
4.8. Preparation of Geomembrane Subgrade 4-5
4.9. Installation of Subsurface Drain Materials 4-6
4.10. Installation of Slurry Wall 4-7
4.11. Installation of Shoreline Revetment 4-7
4.12. Placement Wetland-Compatible Soil 4-8
4.13. Placement of Vegetative Layer 4-9
4.14. Placement of Service Road Materials 4-9

SECTION 5. MONITORING AND TESTING REQUIREMENTS FOR PIPING AND WELLS 5-1
5.1. Destruction of Groundwater Monitoring Wells 5-1
5.2. Installation of Landfill Gas Extraction Wells and Landfill Gas Monitoring Probes 5-2
5.3. Installation of Landfill Gas Conveyance Piping 5-2
5.3.1. Delivery, Handling, and Storage 5-3
5.3.2. Installation 5-3
5.4. Installation of Groundwater Monitoring Wells 5-3

Table of Contents

SECTION 6. MONITORING AND TESTING REQUIREMENTS FOR GEOSYNTHETIC MATERIALS 6-1

6.1. Installation of Geogrid Reinforcement and Geotechnical Filter Fabric 6-2

6.1.1. Delivery 6-2

6.1.2. Conformance Testing 6-3

6.1.3. Geotextile Installation 6-3

6.1.4. Repairs 6-4

6.1.5. Anchor Trench 6-4

6.1.6. Acceptance 6-5

6.2. Installation of Geosynthetic Clay Liner 6-5

6.2.1. Delivery 6-5

6.2.2. Conformance Testing 6-6

6.2.3. GCL Installation 6-6

6.2.4. Repairs 6-8

6.2.5. Anchor Trench 6-8

6.2.6. Acceptance 6-8

6.3. Installation of Geomembrane 6-9

6.3.1. Delivery 6-9

6.3.2. Conformance Testing 6-9

6.3.3. Geomembrane Installation 6-10

6.3.4. Construction Testing 6-13

6.3.5. Repairs 6-14

6.3.6. Wrinkles 6-15

6.3.7. Folded Material 6-15

6.3.8. Anchor Trench 6-15

6.3.9. Acceptance 6-16

6.3.10. Installer Experience and Qualifications 6-16

6.4. Installation of Geocomposite Drainage Layer and Demarcation Layer 6-16

6.4.1. Delivery 6-17

6.4.2. Conformance Testing 6-18

6.4.3. Geocomposite Installation 6-18

6.4.4. Repairs 6-19

Table of Contents

SECTION 7. MONITORING AND TESTING REQUIREMENTS FOR RUNOFF CONTROL FEATURES 7-1

7.1. Installation of Surface Water and Stormwater Controls 7-1

7.2. Installation of Temporary Erosion and Sediment Control 7-1

SECTION 8. DOCUMENTATION 8-1

8.1. Daily Record-Keeping 8-1

8.1.1. Daily Record of Construction Progress 8-1

8.1.2. Acceptance Certificates 8-2

8.1.3. Inspection Reports and Logs 8-2

8.1.4. Test Data Sheets 8-2

8.1.5. Nonconformance Reports 8-3

8.2. Photographs 8-3

8.3. Design and Specification Changes 8-3

8.4. Construction Quality Assurance Summary Report 8-4

8.5. Final Construction Report 8-4

SECTION 9. REFERENCES 9-1

List of Tables

Table 1. Testing Frequencies for Earthwork Construction of Covers[1]
Table 2. Testing Frequencies for Construction of Geotechnical Filter Fabric, Geonet, and Geotextile
Table 3. Testing Frequencies for Construction of Geosynthetic Clay Liner
Table 4. Testing Frequencies for Construction of Geomembrane

Acronyms and Abbreviations

ASTM	ASTM International
CQA	construction quality assurance
CQC	construction quality control
DBR	Design Basis Report
Navy	Department of the Navy
ERRG	Engineering/Remediation Resources Group, Inc.
GCL	geosynthetic clay liner
HDPE	high-density polyethylene
LFG	landfill gas
mm	millimeter
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RA	remedial action
RD	remedial design
Shaw	Shaw Environmental, Inc.

Section 1. Introduction

Engineering/Remediation Resources Group, Inc. (ERRG) has prepared this Construction Quality Assurance (CQA) Plan for the remedy detailed in the remedial design (RD) at Parcel E-2, Hunters Point Naval Shipyard in San Francisco, California. Parcel E-2 consists of 47.4 acres and a closed industrial landfill (referred to as the "Parcel E-2 Landfill") and surrounding adjacent areas that contain isolated or noncontiguous pockets of buried solid waste. This plan, which was prepared on behalf of the Department of the Navy (Navy), describes the necessary quality assurance (QA) procedures that are to be undertaken during the closure activities planned as part of selected remedy.

1.1. PURPOSE

This CQA Plan is to be used by the CQA organization during construction of the selected remedy at Parcel E-2 to ensure that appropriate quality control (QC) and QA procedures are followed during construction.

The CQA Plan is a guidance document that contains general and specific work element requirements to be used to monitor construction. General requirements include organization and responsibilities of CQA personnel, documentation control, and reporting procedures. The following specific work elements require construction quality control (CQC) and CQA:

- Earthwork
  - Clearing and grubbing
  - Screening, excavation, and offsite disposal of isolated hot spots
  - Acceptance and backfilling of imported fill
  - Stockpiling and management of soil
  - Excavation and grading (to achieve subgrade elevations)
  - Onsite consolidation of solid waste
  - Placement of foundation layer
  - Preparation of geomembrane subgrade
  - Installation of subsurface drain materials
  - Installation of slurry wall
  - Installation of shoreline revetment
  - Placement of wetlands-compatible soil layer
  - Placement of vegetative layer
  - Placement of service road materials

- Piping and Wells
  - Destruction of groundwater monitoring wells
  - Installation of landfill gas (LFG) extraction wells and LFG monitoring probes
  - Installation of LFG conveyance piping (including conversion of existing LFG barrier trench vents and risers)
  - Installation of groundwater monitoring wells
- Geosynthetic Materials
  - Installation of geogrid reinforcement and geotechnical filter fabric (for slope abutting the shoreline)
  - Installation of geosynthetic clay liner (GCL)
  - Installation of geomembrane
  - Installation of geocomposite drainage layer and demarcation layer
- Runoff Control Features
  - Installation of surface water and stormwater controls
  - Installation of temporary erosion and sediment controls

The CQC Organization will prepare a final construction completion report following completion of construction. The report will include information generated through the CQC program and will document the extent to which construction was performed in accordance with this plan and the intent of the RD.

The CQA Organization will prepare a CQA summary report documenting the CQA tasks performed at Parcel E-2 during construction.

1.2. CONSTRUCTION QUALITY ASSURANCE ORGANIZATION

The CQA organization has the primary responsibility of implementing and managing the CQA program described in this plan and will document that CQC was performed in compliance with the CQC plan, and that construction was performed in compliance with the design and contract documents. Section 2.1 presents the specific responsibilities for the CQA Organization's site personnel.

1.3. REPORT ORGANIZATION

This CQA Plan is organized as follows:

- Section 1. Introduction: summarizes the purpose of the CQA Plan; the CQA organization; and provides terms, including their definitions, used throughout the plan.
- Section 2. General Requirements: provides an overview of the CQC and CQA program, including CQC and CQA personnel and responsibilities, meetings, document control, documentation of nonconformances, construction monitoring, verification of materials quality, and equipment control.

- Section 3. Construction Quality Assurance: describes the construction testing and test frequencies.
- Section 4. Earthwork Monitoring and Testing Requirements: summarizes the CQC and CQA requirements for the specific work elements discussed in Section 1.1.
- Section 5. Piping and Wells Monitoring and Testing Requirements: summarizes the CQC and CQA requirements for the specific work elements discussed in Section 1.1.
- Section 6. Geosynthetic Materials Monitoring and Testing Requirements: describes the CQC and CQA requirements for the different geosynthetic materials (see Section 1.1), as well as the requirements for delivery, conformance testing, installation, repair, and acceptance.
- Section 7. Runoff Control Features Monitoring and Testing Requirements: describes the CQC and CQA requirements for the components of surface water drainage controls (including concrete) for specific work elements discussed in Section 1.1.
- Section 8. Documentation, provides general requirements for CQC project documentation: including recordkeeping, photographs, design and construction specification changes, the CQA summary report, and the final construction report.
- Section 9. References: lists the documents and other supporting information that was used to prepare this plan.

All parties involved in construction activities should be thoroughly familiar with this plan, the design drawings, and the project specifications.

1.4. TERMS AND DEFINITIONS

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

Construction Manager. The individual responsible for providing overall construction management for the project. The construction manager is the primary contact on the project site.

Construction Drawings. The official plans, profiles, typical cross sections, elevations, and details, as well as their amendments and supplemental drawings, that show the locations, character, dimensions, and details of the work to be performed. Construction drawings are also referred to as "plans."

Construction Quality Assurance (CQA). Those actions that ensure a contractor's CQC measures are working effectively, and that the end product complies with the QC requirements established by the contract. CQA also includes verifying that the contractor is performing QC requirements of the CQC Plan and project specifications. An independent engineering firm that is not affiliated with the construction contractor will complete CQA.

Construction Quality Control (CQC). CQC encompasses all actions that measure and regulate the characteristics of an item or service to determine conformance with contractual and regulatory requirements.

The RA Contractor, at a minimum, conducts CQC. Performance of selected CQC functions may be delegated to subcontractors, but remain the responsibility of the RA Contractor. The RA Contractor will be responsible for CQC oversight.

Project Specifications. The qualitative requirements for products, materials, and workmanship upon which the design is based.

Contract Documents. The official set of documents issued by the contracting entity. This set of documents includes bidding requirements, contract forms, contract conditions, contract specifications, addenda, and contract modifications.

Contract Specifications. Administrative requirements for project performance upon which the contract is based.

RA Contractor. The firm, partnership, or corporation, or any combination, private, municipal, or public, who, as an independent contractor, has entered into a contract to complete the project.

CQA Manager. Authorized representative of the CQA Organization and professional engineer registered in the state of California. The CQA Manager is responsible for certifying that construction was performed in accordance with the intent of the contract documents and design.

CQA Monitors. Authorized representative of the CQA organization, responsible for observing and documenting activities related to CQA during construction.

CQC Manager. Onsite authorized representative of the CQC Organization responsible for preparing and maintaining QC documentation, in addition to the QC plans and inspection system. The CQC Manager is responsible for ensuring that all specified inspections and tests are performed, and that all field and laboratory data are reviewed and approved or disapproved.

Design Engineers. The individuals or firms responsible for design and preparation of the design drawings and project specifications; also referred to as “designers” or “engineers.”

Navy. Department of the Navy, the implementing party for this project.

Nonconformance. A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of nonconformance include, but are not limited to, physical defects, test failures, and inadequate documentation.

Procedure. A document that specifies or describes how an activity is to be performed.

Program Manager. The individual responsible for administering the contract and coordinating with the Project Manager, CQC Manager, and CQA Manager.

Project Documents. This set of documents includes contractor submittals, construction drawings, record drawings, project specifications, shop drawings, CQC and CQA plans, an Accident Prevention Plan (including a Site Safety and Health Plan), Environmental Management Plan, Stormwater Pollution Prevention Plan, and project schedule.

Project Manager. Representative of the RA Contractor with overall responsibility for work performed under assigned task(s). The Project Manager provides project direction and interpretation of scope of work, as well as verification and approval of quantities and work completion.

Record Drawings. Drawings recording the constructed dimensions, details, and coordinates of the project; also referred to as "as-builts."

Subcontractor. The person or persons, firm, partnership, corporation, or any combination, or any combination private, municipal, or public, who as an independent contractor has entered into a contract with the RA Contractor.

Surveyor. A licensed surveyor in the state of California responsible for checking locations and elevations of the completed work. The surveyor is also responsible for producing stamped as-built drawings for inclusion in the final construction report.

Testing. Verification that an item meets specified requirements by subjecting that item to a set of physical, chemical, environmental, or operating conditions.

Testing Laboratory. A laboratory capable of conducting the tests required by this CQA Plan and within the project specifications.

Section 2. General Requirements

2.1. CONSTRUCTION QUALITY ASSURANCE PERSONNEL AND RESPONSIBILITIES

This section discusses the roles and primary responsibilities of key project CQA and CQC personnel, including the CQA Manager, CQA Monitors, Design Engineers, and the CQC Manager.

2.1.1. Responsibilities of the CQA Manager

The CQA Manager administers the CQA program. The CQA Manager has authority to identify deficiencies and implement corrective action measures to the CQA program. The CQA Manager has the following key responsibilities:

- Reviewing Engineer Manual 1110-1-4011 (U.S. Army Corps of Engineers, 1999) and the CQA Plan.
- Reviewing the design plans, project specifications, and any proposed changes to plans and specifications.
- Attending project meetings, including the Post-Award Kickoff Meeting, Partnering Meeting, Preconstruction Meeting, Design Development Meeting, and Coordination and Mutual Understanding Meeting.
- Reviewing and recommending approval or disapproval of CQC data, submittals, and reports requiring Navy review for compliance with the project CQC and CQA Plan.
- Acting as an auditor to verify and document proper and complete implementation of the CQC and CQA programs.
- Reviewing RA Contractor personnel qualifications to verify conformance with the contract and project specifications.
- Attending weekly CQA/CQC meetings with the CQC Manager, RA Contractor Superintendent, and the Navy representative.
- Educating CQA Monitors about onsite-specific CQA requirements and procedures.
- Assigning CQA Monitors to observe all activities requiring monitoring.
- Reviewing warranty submittals to verify they comply with the specified warranty requirements.
- Reviewing as-built surveys and drawings.
- Reviewing and recommending approval or denial of the final construction completion report.

The CQA Manager reports directly to the Navy.

2.1.2. Responsibilities of the CQA Monitors

The CQA Monitors implement the CQA program under the direction of the CQA Manager. The CQA Monitors perform all construction monitoring and construction materials testing requested by the CQA Manager. The CQA Monitors report directly to the CQA Manager. The CQA Monitors have the following key responsibilities:

- Preparing and maintaining required reports, files, and logs, including Daily CQA Reports, a testing plan and log, a rework log, and a submittal log.
- Verifying that the RA Contractor is following this CQA Plan and the approved CQC Plan.
- Verifying construction is performed in accordance with the plans and the project specifications.
- Overseeing any activities that could result in damage to installed remedy components.
- Stopping any segment of work that does not comply with the approved plans and project specifications.
- Directing removal and replacement of any defective work.
- Confirming calibrations of CQA and CQC testing equipment are correctly performed and recorded.
- Confirming that CQA and CQC tests are properly performed and recorded and the results meet specified requirements.
- Overseeing the collection, marking, packaging, and shipping of CQA conformance samples.

2.1.3. Responsibilities of the Design Engineers

The Design Engineers represent their organizations and are responsible for site engineering services related to their design. Those services include reviewing RA Contractor submittals, resolving technical issues related to construction, providing interpretation of the construction drawings and project specifications, and approving substantial design modifications and technical revisions, if necessary.

2.1.4. Responsibilities of the CQC Manager

The CQC Manager implements the CQC program under the direction of the Program Manager. Key responsibilities of the CQC Manager include:

- Reviewing and approving the CQC Plan and any proposed amendments to the plan and reviewing QC sections of contract specifications.
- Attending project meetings, including the Post-Award Kickoff Meeting, Partnering Meeting, Preconstruction Meeting, Design Development Meeting, and Coordination and Mutual Understanding Meeting.
- Conducting weekly QA/QC meetings with the CQA Manager, RA Contractor Superintendent, and the Navy representative.

- Performing submittal review and approval.
- Overseeing the quality of all construction, construction monitoring, and construction materials testing.
- Performing the three phases of control.
- Identifying deficiencies and implementing corrective action measures in accordance with the requirements of the CQC Plan.
- Maintaining all documentation and test data summaries related to construction, construction monitoring, and construction materials testing.
- Providing QC certifications and documentation required in the contract.
- Managing and coordinating the three phases of control and documentation performed by the testing laboratory personnel and any other inspection and testing personnel required by the contract.

The CQC Manager has the authority to stop work at any sign of noncompliance. If potential concerns are identified during execution of the fieldwork, the CQC Manager will consult with the CQA Manager who may authorize work to continue upon review. The CQC Manager will communicate QC inspection and testing results directly with the Construction Manager and coordinate with the Construction Manager to implement corrective actions, if needed.

2.1.5. Appointment Letters

The CQA Manager will be granted authority to stop work and to implement and manage the three phases of control. If any QA specialists are necessary, once they have been selected, the CQA Manager will issue a Letter of Direction outlining their duties, authorities, and responsibilities.

2.2. MEETINGS

Prior to and during the design phase of this project, the Navy, Construction Manager, Project Manager, CQA Manager, and CQC Manager will attend the following meetings to facilitate coordination between the different entities:

- Post-Award Kickoff Meeting
- Partnering Meeting
- Coordination and Mutual Understanding Meeting
- Design Development Meeting

Close coordination between the Navy, Construction Manager, Project Manager, CQA Manager, and CQC Manager is essential to facilitate construction and to clearly define construction goals and activities. To meet this objective, preconstruction, progress, weekly, and other meetings will be held. The Navy or

designee, unless otherwise specified, will document resolutions and action items from the meetings and forward the documentation to all meeting attendees.

2.2.1. Preconstruction Meeting

Following bid award, the Navy, Construction Manager, Project Manager, CQA Manager, CQC Manager, and others as designated by the CQA Organization will attend a preconstruction meeting. The purpose of the meeting will be to:

- Review construction drawings, project specifications, CQA and CQC plans, work area security, safety and health procedures, and related issues.
- Provide all attendees with relevant project documents.
- Review responsibilities of each attendee.
- Define lines of communication and authority.
- Establish reporting and documenting procedures.
- Review procedures for handling submittals.
- Review testing equipment and procedures.
- Review procedures for field directives and changes to scope, schedule, and budget.
- Establish testing protocols and procedures for correcting and documenting construction or nonconformance.
- Establish weekly or other regular meetings schedule.
- Discuss work areas, laydown areas, and related items (this task typically includes conducting a site visit as part of the meeting).
- Review the project schedule and critical path items.

The CQC Organization will prepare handouts for all attendees and document the meeting. The CQA Organization will review copies of the minutes.

2.2.2. Progress Meeting

Informal progress meetings will be held each morning before the start of work. At a minimum, the CQC Manager and Construction Manager will attend the meeting. The purpose of the meeting is to:

- Discuss problems and resolutions.
- Review test data.
- Discuss the RA Contractor's personnel and equipment assignments for the day.
- Review the previous day's activities and accomplishments.

- Resolve any outstanding problems or disputes.
- Any action items will be documented on the daily report by the CQC Manager.

2.2.3. Weekly Meeting

Weekly meetings will be held either at the site or by conference call. The CQC Manager, CQA Manager, and Construction Manager will attend the weekly meetings, with additional support from the Navy and other project team personnel, as needed. The meetings will be held to:

- Review the minutes of the previous meeting; review the schedule and status of work, including work or testing accomplished since the last meeting; rework items identified since the last meeting; and rework items completed since the last meeting.
- Review the status of submittals, including submittals reviewed and approved since the last meeting and submittals required in the future.
- Review work to be accomplished in the next 2 weeks and documentation required (e.g., establish completion dates for rework items, discuss construction methods and approach to be used to provide construction quality and identify potential problems, discuss status of offsite work or testing, identify documentation required, and resolve QC and production problems).
- Address items that may require revising the QC plan (e.g., changes in CQC Organization personnel and in procedures).

2.2.4. Other Meetings

As required, other meetings will be held to discuss problems or nonconformance. These meetings will be attended by parties as directed by the CQA Manager. If the problem requires a design modification and subsequent change order, the design engineering firm should also be present. The meeting will be documented.

2.3. CONTROL OF DOCUMENTS, RECORDS, AND FORMS

2.3.1. Control of Construction Documents

The Project Manager will control contract documents, including project specifications, construction drawings, and change orders. The Project Manager will maintain one or more copies of the most current set of construction documents for use by the CQA and CQC Organizations. Upon issuance of new copies or revisions, the Project Manager will notify the CQA and CQC Organizations of the revisions, provide revised contract documents, and order the recall of all unrevised copies of the contract documents. The Project Manager will also provide the latest revised set of contract documents to the CQA and CQC Organizations.

2.3.2. Control of As-Built Information

The CQC Manager will control as-built information generated by the RA Contractor. During the progress of work, the CQC Manager obtains and initials all as-built information provided by the RA Contractor, surveyors, or others and compiles all as-built data. The CQA Manager will review record drawings resulting from the topographic surveys performed by the registered land surveyor. At the completion of the project, this information is used in preparing final drawings for the final construction report. The set of as-built mark-ups of design drawings must be maintained on site and be clearly marked as such.

2.3.3. Control of Forms

The CQC Manager will control daily report forms, test report forms, and other project forms and maintain a master of each form for reproduction. Upon issuance of a new form, the CQC Manager will recall and remove all superseded copies along with the master and provide new copies for use. The CQA Manager will approve substantive updates to project forms.

2.3.4. Processing Daily Reports

The CQC Manager will write a daily record of work progress, submit the daily reports to the Navy, and maintain daily reports at the site. The CQA Manager will review daily reports for legibility, clarity, traceability, and completeness. The CQA Manager must sign off on the review before the CQC Manager submits the daily reports to the Navy.

2.3.5. Processing Test Reports

The CQC Organization will complete a test report whenever testing is performed. Prior to submittal to the Navy, the CQA Manager will review the test reports for mathematical accuracy; conformance to test requirements and to project specifications; and clarity, legibility, traceability, and completeness. The CQA Manager will document the review by a signature and the CQC Organization will submit test reports to the Navy. Test reports are to be maintained on site in an organized manner.

2.3.6. Processing Project Records

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all of the blanks provided on the form, followed by the signature of the individual completing the form. All project records must be maintained at the site.

2.3.7. Photographic Records

The CQA Monitors will take photographs of construction progress, nonconformance, corrective actions, etc. provide a supplemental and visual record. The photographs will be identified by number, location, time, date, photographer, as well as a brief description or caption. The CQC Manager will append hard copies of the captioned photographs to the daily reports and provided to the CQA Manager on a weekly

basis. The CQC Organization will provide the digital files for the photographs (on compact disc) to the CQA Manager upon completion of the project.

2.4. DOCUMENTATION AND CONTROL OF NONCONFORMANCE

2.4.1. Observation of Nonconformance

Whenever a nonconformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQC Manager will notify the Construction Manager and the CQA Manager.

2.4.2. Determining Extent of Nonconformance

Whenever a nonconformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQC Manager and their organization will determine the extent of the nonconformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate. The CQA Manager will review all nonconformance assessments made by the CQC Organization.

2.4.3. Documenting Nonconformance

The CQC Organization must document all nonconformance in writing on the daily records, logs, and elsewhere, as appropriate. The documentation must occur immediately upon determining the extent of the nonconformance. For those nonconformances that are considered serious or complex in nature or that require an engineering evaluation, the CQC Organization will prepare and issue a nonconformance report to the CQA Manager, the Construction Manager, and the Project Manager.

2.4.4. Corrective Measures

For a simple or routine nonconformance, corrective measures will be determined by specification direction or, if none exists, the CQC Manager, Construction Manager, and Project Manager will discuss standard construction methods to correct the deficiency. For nonconformance reports that require an engineering evaluation, the Design Engineers must determine corrective measures. The CQC Manager will forward a copy of the nonconformance report, with the Design Engineer's corrective measure determination, to the CQA Manager for informational purposes and to the Construction Manager for implementation of the corrective action.

2.4.5. Verification of Corrective Measures

Upon notification by the Construction Manager that a corrective measure is complete, the CQC Manager will verify its completion and report the results of the corrective actions to the CQA Manager. The verification must be accomplished by observations or retesting and documented photographically. The CQC Manager will provide written documentation of the corrective measures on daily reports, logs, and

forms, and, if applicable, a nonconformance report. The Project Manager will review and verify the corrective measure. The Design Engineer will review and verify completion of corrective action measures that require an engineering evaluation.

2.5. CONSTRUCTION MONITORING

Before construction begins, the CQA Manager will establish a list of monitoring priorities for the CQC Organization. The list will include the various construction activities and the monitoring priority of those activities. The monitoring priorities may change during construction based on RA Contractor performance and Navy request. The CQA Manager must approve any changes in the monitoring priorities.

2.6. MATERIALS QUALITY VERIFICATION

The CQC Organization may identify material sources, and samples from those materials may be tested to evaluate whether the material meets the project specifications for specific work elements. Definitions and requirements of materials are provided in the project specifications appended in this RD. Test samples will be obtained in accordance with applicable ASTM International (ASTM) standards. The CQC Organization will maintain and store archive samples and results of the test samples at the project site. The CQC Organization will establish and maintain a materials quality verification list. The list will include material sources, sample locations, testing requirements, test results, and verification action items. The CQA Manager will review the list as it is updated. The CQA Manager may, through onsite CQA Monitors, obtain and test samples or certificates of compliance and conformance to verify the results of the CQC Organization's analyses.

2.6.1. Materials Submittals

When sample submittals are required, the RA Contractor will make them available to both the CQC and CQA Organizations. The CQA Manager is responsible for review and acceptance material submittals from the CQC Organization, if those submittals are designated as requiring government approval in the project specifications. The CQA Organization may use material submittals (submitted by the CQC Organization) to establish the acceptability of materials. The CQC Organization will submit submittals not requiring government approval to the CQA Manager for informational purposes.

2.6.2. Certificates of Compliance and Conformance

The CQA Manager may use certificates of compliance and conformance (submitted by the CQC Organization or obtained by the CQA Monitor) to establish the acceptability of materials. The certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. The certificate may be used for acceptance of a product before or instead of testing, if allowed by the project specifications.

2.7. EQUIPMENT CONTROL

Before the start of construction, the CQC Manager will complete a list of all measuring, sampling, and testing equipment to be used at the site. As new equipment becomes available during the course of the project, it must be added to the list. When more than one type of equipment is available, a unique number will be affixed to each piece to maintain its identity. The equipment list is maintained in the project files and contains the following information:

- Type of equipment
- Serial number or identifying number
- Date item received at site
- Use of the equipment
- Date removed from service

Before using a piece of testing equipment, the CQC Organization must calibrate and establish its accuracy. Types of equipment requiring calibration include nuclear gauges, sand cone devices, sand to be used in sand cones, and scales. The calibration procedures and frequencies must be in accordance with manufacturer's instructions or ASTM standards. Whenever the equipment is suspect or is producing questionable results, the CQC Manager must remove the equipment from service immediately and recalibrate.

The CQA Manager will review equipment maintenance and calibration records periodically to verify that the CQC Organization is conforming to the operations and maintenance protocols for the testing equipment.

Section 3. Construction Quality Assurance

This section describes CQC procedures for construction operations and the CQA monitoring required to verify the proper implementation of the CQC program. The scope of items with related CQC and CQA requirements includes the following specific work elements listed in Section 1.1.

3.1. CONSTRUCTION TESTING

The project specifications in the RD identify all required CQC testing methods and procedures.

3.2. TEST FREQUENCIES

Tables 1 through 4 establish the test frequencies for CQC of earthwork and geosynthetic materials. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any retests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency. The CQA Organization's role partly consists of monitoring the frequency and quality of testing conducted by the CQC Organization, as described in this CQA Plan.

3.2.1. Soil Sample Numbering

The CQC Organization maintains soil sample numbers in a master log maintained at the site. Sample numbers begin with (001) and proceed upward. No sample number can be repeated, and retests of a failing sample are given the original number with a letter suffix (e.g., retests for a failing sample 021 would be 021A, 021B, etc.). The master log of test samples includes the following information:

- Sample number
- Test(s) to be performed
- Date sampled
- Monitor obtaining sample
- Location sampled
- Location to testing (site vs. off site)
- Date sample sent off site
- Date test results received
- Site testing monitor

- Date testing completed at site
- Test results and remarks

The CQA Manager will periodically review the master log of test samples to verify that sample collection and testing are being performed in accordance with the project specifications.

3.2.2. Soil Sample Tagging

The CQC Organization is responsible for maintaining sample identification for all soil samples while on site, from time of sampling through completion of testing. The CQC Organization must place a sample tag on the soil sample container immediately upon sampling. The tag must remain with the soil sample throughout processing. The tag contains the following information:

- Sample number
- Material type
- Project name and project number
- Sampling monitor
- Date sampled
- Test(s) to be performed

The CQA Monitors will periodically inspect sample tags to verify that they conform to the format specified above.

3.2.3. Soil Sample Processing

The CQC Organization is responsible for the timely processing of soil test samples. The CQC Manager determines which samples are tested on site and which are tested off site. The CQC Manager bases this determination on labor available, equipment available, complexity of test, and time available for results. For expediency, samples to be tested off site should be shipped the same day as they are collected.

The CQA Manager will periodically assess the timeliness and expediency of the CQC Organization's soil sample processing. The CQA Manager will make recommendations to the CQC Manager regarding soil sample processing deficiencies, if any are discovered.

3.2.4. Field Density Tests

The CQC Organization is responsible for maintaining test numbers and results for field density tests performed by the nuclear moisture density method (ASTM D6938 [ASTM, 2010f]). All other testing is identified through the sample number (Section 3.2.1). The CQA Monitors maintain field logbooks that identify soil segments, data tested, person performing the test, and sequential test number. The CQA

Monitors will periodically inspect field logbooks to verify that field test documentation conforms to the requirements described in this CQA Plan. The CQA Monitors will also observe density testing procedures and, if deemed necessary, may commission independent simultaneous testing to verify the quality of the CQC Organization's testing program.

Each soil segment will have a series of numbers as listed below.

Soil Segment	Test Number Series
Solid Waste	1000–1999
Foundation Layer	2000–2999
Drainage Layer	3000–3999
Cover Layer/Vegetative Layer	4000–4999
General Fill	5000–5999

No test number can be repeated for a given soil segment, and retests of failing tests must be given a letter suffix along with the original test number (e.g., retests for a failing Test 1201 would be 1201A, 1201B, etc.). Test data and results must be filled out on the field-density test form.

3.2.5. Field Density Test Locations

The intention of the CQC program is to provide confidence that the earthwork materials and work conform to the project specifications. To meet this intent, the CQC Organization will perform density tests of soil products used during construction. Density tests must performed at various elevations and uniformly dispersed throughout the entire plan dimensions of the fill. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, the CQC Manager will plot density test locations on a drawing to verify that no significant areas are untested.

The CQA Organization will provide confidence that the CQC Organization is adequately evaluating and testing the earthwork materials and work to confirm that the project specifications are being met. To achieve this, the CQA Organization will monitor the distribution of field-density test locations to confirm that the coverage of the testing meets the requirements identified in the project specifications.

Section 4. Monitoring and Testing Requirements for Earthwork

This section summarizes CQC monitoring and testing requirements for earthwork. The CQA Organization will verify that the following monitoring and testing requirements are being fulfilled by the CQC Organization.

4.1. CLEARING AND GRUBBING

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for clearing and grubbing. Determine and note corrective action items if applicable.
- Verify that erosion and sediment control silt fences, straw bale barriers, and other measures are securely in place prior to initiating clearing and grubbing operations in any area.
- Verify that existing plant life designated to remain is protected against damage during construction.
- Consult with a biologist to ensure that noxious weeds are not spread through the clearing and grubbing process.
- Verify that clearing in areas required for site access and execution of the work is complete.
- Verify that vegetation, roots, and highly organic soil within marked areas are removed to a minimum depth of 6 inches (150 millimeters [mm]) below the existing ground surface.
- Verify that all stumps, tree and shrubbery roots, buried logs and any other harmful material is removed to a minimum of 3 feet (900 mm) below the existing ground surface.
- Verify that all stumps and plant life are placed in the site recycling yard.
- Verify that stockpile subgrades are surveyed prior to stockpiling.

It has been estimated that approximately 10 percent of the material removed during clearing and grubbing (0 to 1 foot below ground surface) may contain hot spots requiring offsite disposal (ERRG and Shaw Environmental, Inc. [Shaw], 2011).

4.2. SCREENING, EXCAVATION, AND OFFSITE DISPOSAL OF HOT SPOTS

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan for proposed methods for the screening, excavation, and offsite disposal of hot spots. Identify and note any corrective action items, if applicable.
- Verify all equipment used for screening and detection is in proper working order.
- Verify all excavated material, except large debris, is screened using beta and gamma detectors to identify radioactive materials exceeding the remediation goals (ERRG and Shaw, 2011).
- Verify all radiological surveying and sampling is conducted in a manner consistent with the "Multi-Agency Radiation Survey and Site Investigation Manual, NUREG-1575, Revision 1 guidance" (U.S. Department of Defense, 2000) and project-specific work instructions that have been approved by the Radiological Affairs Support Office.
- Verify all large debris is segregated and screened separately for possible radioactivity (ERRG and Shaw, 2011).
- Radioactive material and identified radioactive mixed waste will be properly stored on site until disposal by a certified waste broker through the Navy's Low-level Radioactive Waste Disposal Program (ERRG and Shaw, 2011).

4.3. ACCEPTANCE AND BACKFILLING IMPORTED FILL

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for imported fill material testing and acceptance criteria and backfilling. Determine and note corrective action items if applicable.
- Imported fill must meet soil classification criteria outlined in the project specifications (Section 31 00 00, Earthwork).
- Perform visual and manual soil classifications (ASTM D2487 [ASTM, 2011a] and D2488 [ASTM, 2009a]) to verify that the material source is suitable for backfilling. Verify that the material is free of organic and oversized materials. Perform classifications continually during import of backfill materials.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content of backfill materials. Perform tests at the testing frequencies specified in Table 1. If the excavation is too deep to allow for testing personnel to enter safely, then the RA Contractor will develop and implement (subject to approval) an alternative testing protocol at the ground surface. The alternative testing protocol should demonstrate that a specified compaction effort (i.e., a specified number of passes from a given piece of heavy equipment) will be adequate to achieve the relative compaction identified in the project specifications.
- Verify backfill testing will include collection of samples for analysis of the site-specific chemicals of concern and radionuclides of concern, and other contaminants based on the nature of the fill source.

- Verify chemical testing of imported fill is performed in accordance with the DTSC "Information Advisory, for Clean Imported Fill Material" (DTSC, 2001).
- Verify that backfill materials are placed and compacted in 12-inch maximum loose lifts. If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.

4.4. STOCKPILING AND MANAGEMENT OF SOIL

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for stockpiling and management of soil. Determine and note corrective action items if applicable.
- Verify stockpile locations; stockpile dimensions; haul routes; material segregation procedures; and erosion, sediment, and drainage control measures. Determine and note corrective action items, if applicable.
- Verify that stockpile locations have been cleared, grubbed, and stripped in accordance with Section 4.1 of this CQA Plan and the project specifications.
- Identify and verify material classifications for excavated soil to be consolidated on site, in accordance with ASTM D2487 (ASTM, 2011a) and ASTM D2488 (ASTM, 2009a), as necessary, to support field density testing during placement of consolidated material. Work closely with the RA Contractor's QC personnel to classify materials using the rapid field tests described in ASTM D2488 (ASTM, 2009a).
- Verify that stockpiles are constructed with slopes no steeper than 2:1 (horizontal to vertical), and that the top surface maintains a minimum 5 percent grade. Verify slopes and grades using hand-held levels and inclinometers, range poles, and measuring tapes.

4.5. EXCAVATION AND GRADING

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for excavations. Determine and note corrective action items if applicable.
- Verify that dewatering systems, if any, are operational, and that the static groundwater level is sufficiently drawn down to allow excavations to proceed.
- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Verify that the RA Contractor has notified the Underground Service Alert to identify and locate underground utilities.
- Verify that excavated materials are segregated into proper stockpiles and placement areas.
- Coordinate with RA Contractor to perform radiological screening of excavation subgrade.

- Coordinate with the RA Contractor to perform excavation verification surveys upon completion of excavating operations. Verify completion of corrective action measures, as determined by verification surveys.
- Sandblast waste encountered during excavation activities will be handled in accordance with Navy-approved work instruction specifically written to govern material with possible radioactivity (ERRG and Shaw, 2011).

The RA Contractor will excavate and dispose offsite hot spots (Tiers 1 through 5; see Section 3.2 of Design Basis Report [DBR]) and will collect confirmation samples for analysis to verify that residual chemical concentrations are less than the hot spot goals. Upon confirmation of sampling results, the excavations will be backfilled with clean imported soil in accordance with final grading (ERRG and Shaw, 2011) and consistent with the procedures described in Section 4.3. Material excavated as a part of the overall grading will be incorporated into the landfill under the new cap extension (ERRG and Shaw, 2011).

4.6. ONSITE CONSOLIDATION OF SOLID WASTE

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for placement of the solid waste. Determine and note corrective action items if applicable.
- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Visually inspect waste to be relocated prior to placement and verify that only inert construction debris (such as concrete, wood, and metal) are consolidated on site. Any oversized construction debris that cannot be compacted will be resized prior to consolidation or disposed of at an appropriately permitted recycling or disposal facility. Work closely with the RA Contractor to classify waste containing hazardous materials that may not be appropriate for onsite consolidation and may require disposal at an appropriately permitted offsite facility.
- Verify that solid waste materials are placed and compacted in 8-inch-thick loose lifts. If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.
- Field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.
- Coordinate with the RA Contractor to perform verification surveys at the completion of waste placement operations. Verify completion of corrective action measures, as determined by verification surveys. Verification surveys will also be used to determine the limits of waste for future applications.

4.7. PLACEMENT OF FOUNDATION LAYER

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for placement of the foundation layer. Determine and note corrective action items if applicable.
- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2487 [ASTM, 2011a] and D2488 [ASTM, 2009a]) to verify that the material source is suitable for the foundation layer. Verify that the material is free of organic and oversized materials. Perform classifications continually during excavation of borrow materials.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content of earth fill materials. Perform tests at the testing frequencies specified in Table 1.
- Verify that foundation materials are placed and compacted in 8-inch maximum loose lifts. If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.
- Perform nuclear gauge density and moisture tests (ASTM D6938 [ASTM, 2010f]) to verify that each lift is compacted as required by the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Verify that soil materials that are too wet for proper compaction per the specifications are properly aerated and processed to bring the moisture content of the material into the acceptable range of the optimum moisture content.
- Verify that soil that is too dry for proper compaction per the specifications is properly moisture conditioned and processed to bring the moisture content into the acceptable range of the optimum moisture content.
- Verify that desiccated lifts are properly repaired or removed before placing subsequent lifts.
- Verify that the final foundation layer surface is free of sharp objects or rocks larger than 0.5 inch protruding at the surface that may damage the geomembrane.
- During placement of the foundation layer, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.
- Coordinate with the RA Contractor to perform verification surveys at the completion of foundation layer operations. Verify completion of corrective action measures, as determined by verification surveys. Verification surveys will also be used to determine the limits of foundation layer for measurement and payment applications.

4.8. PREPARATION OF GEOMEMBRANE SUBGRADE

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for the preparation of the geomembrane subgrade. Determine and note corrective action items if applicable.
- Verify that material source is suitable for the subgrade, is free of organic and oversized materials, and meets the grading requirements of the project specifications.
- Verify that grade control construction staking is performed prior to work.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content of subgrade materials.
- Verify that the top of the subgrade is compacted as required by the project specifications with nuclear gauge density and moisture tests (ASTM D6938 [ASTM, 2010f]). Perform tests at the testing frequencies specified in Table 1.
- Verify that angular or sharp rocks and other debris that could damage the geomembrane are removed from the surface of the subgrade. Verify that the subgrade is free of irregularities and is rolled smooth using a steel drum prior to geosynthetic placement.
- Verify that the final surface provides continuous and intimate contact with the overlying geosynthetic.
- Coordinate with the RA Contractor to perform subgrade verification surveys upon completion of the subgrade preparation. Verify completion of corrective action measures, as determined by the verification surveys. Verification surveys will also be used to determine the limits of the subgrade preparation for measurement and payment applications.

4.9. INSTALLATION OF SUBSURFACE DRAIN MATERIALS

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for excavation and installation of drainage materials for a subsurface drain. Determine and note corrective action items if applicable.
- Perform sieve analysis (ASTM D422 [ASTM, 2007a]) to verify that granular drainage materials for the subsurface drain comply with material gradation requirements of the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Complete visual inspections of 4-inch perforated high-density polyethylene (HDPE) pipe for use in the subsurface drain to ensure material quality and conformance with RA Contractor's approved work plan and design drawings.
- Verify that grade control construction staking is performed prior to work.
- Monitor placement of the drainage material to verify that underlying geosynthetic materials are not damaged during placement operations. Mark damaged geosynthetic materials and verify that damage is repaired.
- Verify and record material depth during placement of the drainage material by against grade control stakes.

- Coordinate with the RA Contractor to perform verification surveys of the primary and secondary cap drainage collection layers upon completion of placement operations. Verify completion of corrective action measures, as determined by the verification surveys. Verification surveys will also be used to determine the limits of the primary and secondary collection layer for measurement and payment applications. Submit copy of verification to the Construction Manager.

4.10. INSTALLATION OF SLURRY WALL

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for excavation and installation of backfill materials for a slurry wall. Determine and note corrective action items if applicable.
- Perform sieve analysis (ASTM D422 [ASTM, 2007a]) to verify that slurry wall materials for the subsurface drain comply with material requirements of the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Verify that grade control construction staking is performed prior to work.
- Verify and record material depth during placement of the slurry wall against grade control stakes.
- Coordinate with the RA Contractor to perform verification surveys of the base and finished elevations and final alignment of the slurry wall upon completion of placement operations. Verify completion of corrective action measures, as determined by the verification surveys. Verification surveys will also be used to determine the limits of the slurry backfill for measurement and payment applications. Submit copy of verification to the Construction Manager.

4.11. INSTALLATION OF SHORELINE REVETMENT

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for placement of the shoreline protection materials. Determine and note corrective action items if applicable.
- Verify that crushed rock and graded riprap materials for the revetment comply with material size distribution and gradation requirements of the project specifications.
- Verify that grade control construction staking is performed prior to work.
- Monitor placement of the crushed rock layer and graded riprap to verify that underlying geosynthetic materials are not damaged during placement operations. Mark damaged geosynthetic materials and verify that damage is repaired.

- Verify and record material depth during placement of the crushed rock and graded riprap against grade control stakes.
- Coordinate with the RA Contractor to perform verification surveys of the crushed rock and graded riprap layers upon completion of placement operations. Verify completion of corrective action measures, as determined by the verification surveys. Verification surveys will also be used to determine the limits of the crushed rock and riprap for measurement and payment applications. Submit copy of verification to the Construction Manager.

4.12. PLACEMENT WETLAND-COMPATIBLE SOIL

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for placement of wetland-compatible soil. Determine and note corrective action items if applicable.
- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2487 [ASTM, 2011a] and ASTM D2488 [ASTM, 2009a]) to verify that the material source is suitable for the wetlands layer. Verify that the material is free of oversized materials. Perform classifications continually during excavation of borrow materials.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content of wetlands soils. Perform tests at the testing frequencies specified in Table 1.
- Verify that wetlands soil is placed and compacted in 12-inch-thick loose lifts. If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.
- Perform nuclear gauge density and moisture tests (ASTM D6938 [ASTM, 2010f]) to verify that each lift is compacted as required by the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Verify that desiccated lifts are properly repaired or removed before placing subsequent lifts.
- Verify that final cover layer surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment runoff.
- During placement of the wetlands soil layer, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.
- Coordinate with the RA Contractor to perform verification surveys at the completion of wetlands soil placement operations. Verify completion of corrective action measures, as determined by verification surveys. Verification surveys will also be used to determine the limits of cover soil for measurement and payment applications.

4.13. PLACEMENT OF VEGETATIVE LAYER

The CQC Organization will perform the following:

- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2487 [ASTM, 2011a] and ASTM D2488 [ASTM, 2009a]) to verify that the material source is suitable for the vegetative layer. Verify that the material is free of organic and oversized materials. Perform classifications continually during excavation of borrow materials.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content of earthfill materials. Perform tests at the testing frequencies specified in Table 1.
- Verify that earthfill materials are placed and compacted in 8-inch-thick loose lifts. If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.
- Perform nuclear gauge density and moisture tests (ASTM D6938 [ASTM, 2010f]) to verify that each lift is compacted as required by the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Verify that soil materials that are too wet for proper compaction per the specifications are properly aerated and processed to bring the moisture content of the material into the acceptable range of the optimum moisture content.
- Verify that soil that is too dry for proper compaction per the specifications is properly moisture conditioned and processed to bring the moisture content into the acceptable range of the optimum moisture content.
- Verify that desiccated soil is properly repaired or removed before placing subsequent lifts.
- Verify that final vegetative layer surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment runoff.
- During placement of the vegetative layer, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.
- Coordinate with the RA Contractor to perform verification surveys at the completion of vegetative layer operations. Verify completion of corrective action measures as determined by verification surveys. Verification surveys will also be used to determine the limits of earth fills for measurement and payment applications.

4.14. PLACEMENT OF SERVICE ROAD MATERIALS

The CQC Organization will perform the following:

- Verify that construction staking is performed before work, and that survey benchmarks with elevations are secured outside the work area.
- Perform moisture and density relationship testing (ASTM D1557 [ASTM, 2012a]) to determine the maximum dry density and optimum moisture content for road materials.
- If a sheepsfoot compactor is not used, verify that the top of each compacted lift is scarified before placing the subsequent lift.
- Perform nuclear gauge density and moisture tests (ASTM D6938 [ASTM, 2010f]) to verify that each lift is compacted as required by the project specifications. Perform tests at the testing frequencies specified in Table 1.
- Verify that soil materials that are too wet for proper compaction per the specifications are properly aerated and processed to bring the moisture content of the material into the acceptable range of the optimum moisture content.
- Verify that soil that is too dry for proper compaction per the specifications is properly moisture conditioned and processed to bring the moisture content into the acceptable range of the optimum moisture content.
- Verify that desiccated lifts are properly repaired or removed before placing subsequent lifts.
- Verify that final road surfaces are free of ruts, gouges, and other features that might contribute to erosion or undermine the roadway.
- Coordinate with the RA Contractor to perform verification surveys at the final road. Verify completion of corrective action measures, as determined by verification surveys.

Section 5. Monitoring and Testing Requirements for Piping and Wells

The following sections list CQC monitoring and testing requirements for select portions of the LFG system and groundwater monitoring wells. The complete design of the LFG system will not be completed until the Draft Final RD. Accordingly, the Draft Final CQA Plan will include a complete list of CQC monitoring and testing requirements for the LFG system. The CQA Organization will verify that the following monitoring and testing requirements are being fulfilled by the CQC Organization.

5.1. DESTRUCTION OF GROUNDWATER MONITORING WELLS

Groundwater monitoring wells not required for future monitoring, as specified in the RAMP, will be destroyed in accordance with City and County of San Francisco and State of California regulations. If necessary, groundwater monitoring wells will be destroyed and replaced if protecting the well adversely affects construction. The DBR, specifically Table 5, identifies which existing groundwater monitoring wells at or adjacent to Parcel E-2 will be destroyed.

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods for well abandonment. Ensure compliance with City and County of San Francisco and State of California regulations, including all relevant sections of (1) California Water Code Division 7, Chapter 10; (2) California Health and Safety Code Division 104, Part 9.5; (3) California Water Well Standards Bulletins 74-81 and 74-90; and (4) the standards specified by the San Francisco County Department of Environmental Management. Determine and note corrective action items if applicable.
- Verify abandonment is by over-drilling, removing all casing and filter pack, and grouting with an appropriate sealing material.
- Verify that wells are sounded immediately prior to destruction to ensure they are free of obstructions.
- Verify removal of all material (e.g., annular seal, casing, screen, filter pack, etc.) within the original borehole.
- Verify complete backfilling of borehole with impervious sealing material. Acceptable sealing materials include neat cement, sand-cement grout, or concrete.
- Verify placement of sealing material by tremie pipe or equivalent method in one continuous operation.

5.2. INSTALLATION OF LANDFILL GAS EXTRACTION WELLS AND LANDFILL GAS MONITORING PROBES

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods to install LFG vertical extraction wells, head pipes, and central collection system. Determine and note corrective action items if applicable.
- Verify depth of screen intervals for LFG extraction wells and monitoring probes.
- Complete visual inspections of slotted polyvinyl chloride (PVC) (for use in screen intervals of LFG extraction wells and monitoring probes) and solid PVC pipe (for portion of LFG extraction wells and monitoring probes above the screen) to ensure material quality, dimensions, and conformance with RA Contractor's approved work plan.
- Complete visual inspections of gravel or sand pack material for all LFG extraction wells, header pipes, and central collection system to ensure conformance with RA Contractor's approved work plan.
- For LFG extraction wells and monitoring probes installed within the low-permeability liner footprint, review product data (shop drawings) and shop test results for geomembrane penetrations and penetration details to verify conformance with specifications and ensure no leaks. Verify installation and testing of geomembrane seams, as discussed in Section 6.3, Installation of Geomembrane.
- Verify installation of LFG extraction wells and monitoring probes in accordance with RA Contractor's approved work plan.

5.3. INSTALLATION OF LANDFILL GAS CONVEYANCE PIPING

Conveyance piping refers to the lateral piping and main header piping that transport the LFG flow from the extraction components to the treatment facility. The primary components of LFG extraction consist of the vertical wells discussed in Section 5.2. In addition, the existing LFG control system, which consists of an HDPE barrier wall and horizontal LFG collection trench (with five vertical trench vents terminating aboveground and three vertical trench risers terminating at the ground surface) that will be connected to the LFG conveyance piping. Two of the five existing trench vents and all four trench risers will be sealed because they are not needed for the active LFG collection system. The remaining three trench vents will be modified to connect with the horizontal LFG conveyance piping. LFG conveyance pipes will be constructed and buried in trenches in the vegetative soil above the geomembrane layer of the final cap. The LFG pipes will be constructed of HDPE.

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods to install LFG conveyance piping. Determine and note corrective action items if applicable.
- Construction must be conducted in accordance with the design drawings and project specifications. To monitor compliance the CQC Organization will (1) review the contractor's quality control submittals, (2) monitor construction testing, and (3) monitor installations.
- All construction testing will be conducted in accordance with the project specifications.

5.3.1. Delivery, Handling, and Storage

The CQC Organization will perform the following:

- Verify that chains, end hooks, cable slings, or any other devices that may scar the pipe are not used to handle pipe. Wide nylon web slings are recommended to handle the pipe.
- Verify that the pipe is not damaged during handling operations and that damaged pipe is separated from accepted pipe.
- Verify that pipe out-of-roundness will not occur due to excessive stacking heights when the pipe is stored at the site.
- Verify that the pipe is not damaged by sharp rocks or excessive abrasion when the pipe is pulled into place during fusion welding and installation operations.
- Complete visual inspections of HDPE pipe to ensure material quality, dimensions, and conformance with RA Contractor's approved work plan.

5.3.2. Installation

The CQC Organization will perform the following before installation of the piping:

- Verify that the piping, fittings, and flanged couplings comply with product requirements of the project specifications.
- Verify that certified fusion welding operators will be performing the welding.
- Verify fusion welding techniques and procedures are in accordance with project specifications and the RA Contractor's approved work plan.

5.4. INSTALLATION OF GROUNDWATER MONITORING WELLS

Existing groundwater monitoring wells will be protected throughout construction if they are to be incorporated into the post-remedial action monitoring program. If relocation of a well is required, the well will be installed as close to the original location as feasible and will have the same construction (inside diameter, depth, and screen interval) as the original well.

The CQC Organization will perform the following:

- Review the RA Contractor's approved work plan of proposed methods to install groundwater monitoring wells. Determine and note corrective action items if applicable.
- Verify depth of screen intervals for groundwater monitoring wells.
- Complete visual inspections of slotted PVC and solid PVC pipe to ensure material quality, dimensions, and conformance with RA Contractor's approved work plan and project specifications.
- Complete visual inspections of sand pack material for all groundwater monitoring wells to ensure conformance with RA Contractor's approved work plan.
- Verify borehole is bored, drilled, or augered as close to vertical as possible and ensure conformance with RA Contractor's approved work plan.
- Verify the depth and volume of the borehole, including the over-drilling if applicable, is calculated and the appropriate materials procured prior to drilling activities to ensure conformance with RA Contractor's approved work plan.

Section 6. Monitoring and Testing Requirements for Geosynthetic Materials

The objectives of the geosynthetic materials CQC program are to (1) ensure that proper construction techniques and procedures are used and (2) ensure that the project is completed in accordance with the design drawings and project specifications. The intents of the CQA program are to (1) verify that the CQC Organization is monitoring the installation of geosynthetic materials in accordance with the project specifications, (2) identify and define problems that may occur during installation, and (3) verify that these problems are corrected before construction is complete.

CQC for the installation of geosynthetic materials will be performed to verify that geosynthetic materials are installed in accordance with the design. Construction must be conducted in accordance with the design drawings and project specifications. To monitor compliance, the CQC Organization will (1) review the RA Contractor's QC submittals, (2) perform material conformance testing, (3) monitor construction testing, and (4) monitor installations. Conformance testing refers to activities that take place before installation of geosynthetic materials. Construction testing includes activities that occur during installation of geosynthetic materials. All CQC testing will be conducted in accordance with this CQA Plan, the project CQC Plan, and the design drawings and project specifications. If a discrepancy exists in the testing requirements, the document that requires the most stringent testing will govern.

This section describes CQC procedures for the installation of geosynthetic components. The following types of geosynthetic materials will be used for this project:

- Geogrid reinforcement and geotechnical filter fabric (for slopes abutting the shoreline)
- GCL
- 60-mil thick HDPE geomembrane
- Geocomposite drainage layer (includes nonwoven geotextile and HDPE geonet) and demarcation layer (includes nonwoven geotextile and magnetic marking tape)

The CQA Organization will verify that the following monitoring and testing requirements are being fulfilled by the CQC Organization.

6.1. INSTALLATION OF GEOGRID REINFORCEMENT AND GEOTECHNICAL FILTER FABRIC

As described in the DBR, two layers of Tencate Miragrid® 22XT geogrid (or equivalent reinforcement with a combined long-term design tensile strength of 20,500 pounds per foot) will be installed to ensure the stability of the shoreline slopes adjacent to the Parcel E-2 Landfill. The geogrid layers will be placed on the shoreline slope directly below the revetment material and will extend horizontally to an appropriate anchor point under the protective liner. The geogrid layers will be installed in segments (perpendicular to the shoreline) in the following sequence:

1. Excavate material along the shoreline slope and upland area requiring reinforcement
2. Install two geogrid layers (one directly on top of the other)
3. Place and compact soil within the upland area to properly anchor the geogrid layers
4. Install revetment material

This general construction sequence is important because the short-term slope stability analyses (see Appendix E of the DBR) identified a potential slope failure if the geogrid layers are not installed and anchored before placement of the revetment material. The revetment material will include a geotechnical filter fabric that will be installed between the armor rock and the underlying soil to ensure that the revetment is supported. The geotechnical filter fabric will run under the entire length of the revetment and will be tied into the armor layer at both the toe and the crest. Securing the filter fabric into the revetment will secure the material in place even if the revetment material settles over time.

6.1.1. Delivery

During delivery of the geogrid reinforcement and geotechnical filter fabric, the CQC Organization will:

- Verify that the geogrid reinforcement and geotechnical filter fabric are packaged in opaque, waterproof protective coverings.
- Verify that equipment used to unload the rolls will not damage the geotextile.
- Verify that care is used to unload the rolls.
- Verify that all manufacturing documentation required by the project specifications has been received.
- Verify that each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions.
- Verify that the geogrid reinforcement and geotechnical filter fabric are stored in accordance with the project specifications and are protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.

- Verify that the geosynthetic materials receipt log form has been completed for all geogrid reinforcement and geotechnical filter fabric materials received. Any damaged rolls may be rejected. Verify that rejected material is removed from the site or stored at a location separate from accepted rolls. Geogrid reinforcement and geotechnical filter fabric rolls that do not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

6.1.2. Conformance Testing

Testing Frequency. The CQC Organization will obtain geogrid reinforcement and geotechnical filter fabric conformance test samples for every 200,000 square feet and a minimum of one per batch or lot of geogrid reinforcement and geotechnical filter fabric material delivered to the site. The CQC Organization will collect samples of the material at the site, or an independent third party will collect samples at the manufacturing plant under the direction of the CQC Organization. The CQC Organization will forward the samples to the testing laboratory for the conformance tests listed in Table 2.

The CQC Manager will review all test results and report any nonconformance to the Construction Manager and the CQA Manager.

Sampling Procedure. Samples will be collected from across the entire roll width and will be 3 feet long. Samplers must mark the manufacturer's roll identification number, as well as the machine direction, on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

6.1.3. Geotextile Installation

Surface Preparation. Before installation of the geotextile, the CQC Organization will:

- Verify that all lines and grades have been verified by the RA Contractor.
- Verify that the subgrade has been prepared in accordance with the earthwork section of the project specifications; and that, if placed over a geomembrane, the geomembrane installation and all associated documentation have been completed.
- Verify that soil or geomembrane surfaces do not contain protrusions that could damage the geotextile.
- Verify that no excessively soft areas exist in the soil surface that could damage the geogrid reinforcement and geotechnical filter fabric.
- Verify that all construction stakes have been removed.

Geogrid Reinforcement and Geotechnical Filter Fabric Placement and Seaming. During placement and seaming of geogrid reinforcement and geotechnical filter fabric, the CQC Organization will:

- Observe the geogrid reinforcement and geotechnical filter fabric as they are deployed and record all defects and defect corrective actions (e.g., panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the project specifications.
- Verify that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Verify that crews working on the geogrid reinforcement and geotechnical filter fabric do not smoke, wear shoes that could damage the geogrid reinforcement and geotechnical filter fabric, or engage in activities that could damage the geogrid reinforcement and geotechnical filter fabric.
- Verify that the geogrid reinforcement and geotechnical filter fabric are securely anchored in an anchor trench and are temporarily anchored to prevent movement by the wind.
- Verify that adjacent panels are overlapped and seamed in accordance with the project specifications.
- Verify that the geogrid reinforcement and geotechnical filter fabric were not exposed to direct sunlight for more than 5 days.
- Examine the geogrid reinforcement and geotechnical filter fabric after installation to ensure that no potentially harmful foreign objects are present.

The CQC Manager must inform both the CQA Monitor and Construction Manager if the above conditions are not met.

6.1.4. Repairs

Repair procedures include:

- Patching – used to repair large holes, tears, and small defective areas.
- Removal – used to replace large defective areas where the preceding method is not appropriate.

6.1.5. Anchor Trench

The CQC Organization will:

- Verify that termination points of the geogrid reinforcement and geotechnical filter fabric within the anchor trench are correct.
- Verify that loose soil or objectionable materials such as geosynthetic scraps and miscellaneous debris are removed from the anchor trench prior to placement of geotextile.
- Verify that the anchor trench is dewatered (pumped out) if standing water is present in the bottom of the trench.

- Verify that the geogrid reinforcement and geotechnical filter fabric are temporarily anchored in the anchor trench until all geosynthetic layers are installed and accepted as shown on the construction drawings.
- Verify that the anchor trench is backfilled with approved soil placed at the specified moisture content and density, and that compaction work within the anchor trench does not damage the geosynthetic materials.

6.1.6. Acceptance

The RA Contractor retains all ownership and responsibility for the geogrid reinforcement and geotechnical filter fabric until acceptance by the Navy. After panels are placed, seamed, and repairs made, the CQC Manager and RA Contractor will inspect the completed installation. The RA Contractor will repair any damage or defect found during this inspection. The installation will not be accepted until it meets the requirements of both parties. In addition, the CQC Manager will recommend acceptance of the geogrid reinforcement and geotechnical filter fabric by the CQA Manager only when the following activities have been completed:

- All required laboratory tests have been completed and reviewed.
- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required contractor-supplied documentation has been received and reviewed.
- All as-built record drawings have been completed and verified by the CQC Manager to show the true panel dimensions, the locations of all seams, trenches, and repairs

6.2. INSTALLATION OF GEOSYNTHETIC CLAY LINER

The multilayer geosynthetic liner for the Parcel E-2 Landfill will include a GCL, comprising bentonite clay, underlying the HDPE geomembrane. The inclusion of the GCL in the multilayer geosynthetic liner provides extra protection and enhances LFG control within the Parcel E-2 Landfill. Bentonite, when hydrated, will swell into the defect in the overlying geomembrane to impede infiltration. The interaction between the two components of the composite low-permeability layer creates a self-sealing system that is extremely impermeable to infiltration. In addition, the self-sealing properties of the composite low-permeability layer will control LFG emissions in a variety of site conditions.

6.2.1. Delivery

During delivery of GCL material, the CQC Organization will:

- Verify that GCL are packaged in opaque, waterproof-protective coverings.
- Verify that equipment used to unload the rolls will not damage the GCL.

- Verify that care is used to unload the rolls.
- Verify that all manufacturing documentation required by the project specifications has been received.
- Verify that each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions.
- Verify that the GCL is stored in accordance with the project specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Verify that the geosynthetic materials receipt log form has been completed for all GCL materials received.

Any damaged rolls may be rejected. Verify that rejected material is removed from the site or stored at a location separate from accepted rolls. GCL rolls that do not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

6.2.2. Conformance Testing

Testing Frequency. The CQC Organization will obtain conformance test samples for every 200,000 square feet of GCL delivered to the site as summarized in Table 3. The CQC Organization will collect samples of the material at the site, or an independent third party will collect samples at the manufacturing plant under the direction of the CQC Manager. The CQA Organization will forward the samples to the testing laboratory for the following conformance tests:

- Bentonite Mass per Unit Area (ASTM D5993 [ASTM, 2009e])
- Fluid Loss (ASTM D5891 [ASTM, 2009d])
- Permeability (ASTM D5084 [ASTM, 2010c])
- Geotextile Mass per Unit Area (ASTM D5261 [ASTM, 2010d])
- Peel Strength (ASTM D6496, [ASTM, 2009g] or ASTM D4632 [ASTM, 2008c])

The CQC Manager will review all test results and report any nonconformance to the CQA Manager and the Navy.

Sampling Procedure. Samples will be collected across the entire roll width and will be 3 feet long. Samplers must mark the manufacturer's roll identification number, as well as the machine direction, on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

6.2.3. GCL Installation

Surface Preparation. Before GCL installation, the CQC Organization will:

- Verify that all lines and grades have been verified by the RA Contractor.
- Verify that the underlying subgrade has been prepared in accordance with the project specifications, and that it has been certified by the RA Contractor.
- Verify that soil surfaces do not contain protrusions that could damage the GCL.
- Verify that no excessively soft areas exist in the soil surface that could damage the GCL.
- Verify that all construction stakes have been removed.
- Verify weather conditions are acceptable for placement of the GCL, and that the subgrade has not been damaged by inclement weather.
- Verify that GCL will not be installed on excessively moist subgrade or on standing water.
- Verify that all aspects of surface preparation have been performed according to the project specifications.

GCL Placement and Seaming. During GCL placement, the CQC Organization will:

- Verify that GCL will be installed in a way that prevents hydration of the GCL prior to completion of construction of the liner system.
- Observe the GCL as it is deployed and record all defects and corrective actions. Verify that corrective actions for defects are performed in accordance with the project specifications.
- Verify that equipment used does not damage the GCL by handling, equipment transit, leakage of hydrocarbons, or other means.
- Verify that the GCL is placed with the correct side facing up.
- Verify that seams are oriented parallel to the line of maximum slope, and that overlaps that occur on slopes are constructed with the upslope roll shingled over the down-slope roll.
- Verify that adjacent panels are overlapped and seamed in accordance with the project specifications.
- Examine the seams to ensure that the subgrade soil is not inadvertently pushed up between the seam overlaps.
- Verify that crews working on the GCL do not smoke, wear shoes that could damage the GCL, or engage in activities that could damage the GCL.
- Verify that the GCL is securely anchored to prevent movement by the wind.
- Examine the GCL after installation to ensure that no potentially harmful foreign objects are present.

The CQC Manager must inform both the CQA Manager and RA Contractor if the above conditions are not met.

6.2.4. Repairs

Damaged GCL will require patching to repair large holes, tears, and small defective areas. The RA Contractor will perform repairs per the project specifications.

6.2.5. Anchor Trench

The CQC Organization will:

- Verify that the anchor trench is excavated to the lines and grades shown on the construction drawings prior to placement of GCL.
- Verify that corners of the anchor trench are slightly rounded to avoid sharp bends in the geosynthetic materials.
- Verify that termination points of the GCL within the anchor trench are correct.
- Verify that loose soil or objectionable materials, such as geosynthetic scraps and miscellaneous debris, are removed from the anchor trench prior to placement of GCL.
- Verify that the anchor trench is dewatered (pumped out) if standing water is present in the bottom of the trench.
- Verify that the GCL is temporarily anchored in the anchor trench until all geosynthetic layers are installed as shown on the construction drawings.

6.2.6. Acceptance

The geosynthetic materials subcontractor retains all ownership and responsibility for the GCL until acceptance by Navy. After panels are placed, seamed, and repairs made, CQC Manager and the geosynthetic materials subcontractor will inspect the completed installation. The geosynthetic materials subcontractor will repair any damage or defect found during the inspection. The installation will not be accepted until it meets the requirements of both parties. In addition, the CQC Manager will recommend acceptance of the GCL by the CQA Manager only when the following activities have been completed:

- All required laboratory tests have been completed and reviewed.
- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required contractor-supplied documentation has been received and reviewed.
- All as-built record drawings have been completed and verified by the CQC Manager to show the true panel dimensions and the locations of all seams, trenches, and repairs.

6.3. INSTALLATION OF GEOMEMBRANE

An HDPE geomembrane at least 60-mil (0.06 inch) thick will be installed in non-wetlands portions of the Panhandle and East Adjacent Areas. The HDPE geomembrane will be connected to the multilayer geosynthetic liner for the Parcel E-2 Landfill, and will form a continuous low-permeability layer that minimizes water seeping into the contaminated material, thereby reducing the potential for contamination to leach to underlying groundwater.

6.3.1. Delivery

Upon delivery of geomembrane, the CQC Organization will:

- Verify that equipment used to unload the rolls will not damage the geomembrane.
- Verify that care is used to unload the rolls.
- Verify that all manufacturing documentation required by the project specifications has been received.
- Inspect the geomembrane rolls for damage during shipping and handling. Identify damaged materials and verify that damaged materials are set aside.
- Verify that each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions.
- Verify that the geomembrane is stored in accordance with the project specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Verify that the geosynthetic materials receipt log form has been completed for all geomembrane materials received.

Damaged geomembrane may be rejected. If rejected, verify that the material is removed from the site or stored at a location, separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location, until all documentation has been received, reviewed, and accepted.

6.3.2. Conformance Testing

Testing Frequency. One geomembrane sample will be collected for testing at the frequencies listed in Table 4. The CQC Organization will collect samples of the material at the site, or an independent third party will collect samples at the manufacturing plant under the direction of the CQC Organization. The CQC organization will forward the samples to an independent testing laboratory for the following conformance tests:

- Specific Gravity (ASTM D792 Method A [ASTM, 2008a])
- Tensile Properties (ASTM D638 [ASTM, 2010a])
- Puncture Resistance (ASTM D4833 [ASTM, 2007c])
- Carbon Black Content (ASTM D4218 [ASTM, 2008b])
- Carbon Black Dispersion (ASTM D5596 [ASTM, 2009c])
- Thickness (ASTM D5994 [ASTM,2010e])
- Interface Shear Strength (ASTM D5321 [ASTM, 2012e])
- Environmental Stress Crack (ASTM D5397 [ASTM, 2012f])

Sampling Procedure. Samples will be collected across the entire roll width. Samples may be cut for shipping purposes, but a minimum of 5 square feet must be sent to the testing laboratory. Samplers must mark the machine direction and the manufacturer's roll identification number on the sample (each piece). Samplers will also assign a conformance test number to the sample and mark the sample with that number.

6.3.3. Geomembrane Installation

Surface Preparation. The soil surface must be prepared in accordance with the project specifications. Before installation of the geomembrane, the CQC Manager and geosynthetic materials subcontractor will inspect the subgrade. The CQA Organization must verify the following:

- All lines and grades for soil surface have been verified by the RA Contractor.
- The soil surface has been rolled and compacted to be free of surface irregularities, loose soil, and protrusions.
- The soil surface does not contain stones or other objects that could damage the geomembrane.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- No excessively soft areas exist.
- The soil surface is not saturated, and no standing water is present.
- The soil surface has not desiccated.
- All construction stakes have been removed, and no debris, rocks, or any other objects are in or on the soil surface.
- The geosynthetic materials subcontractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Before installing any of the geomembrane, the geosynthetic materials subcontractor must submit drawings in accordance with the project specifications. The drawings will show the

proposed layout of the panels, including panel identification numbers, field seams, and any other details that do not conform to the construction drawings.

The CQC Manager will maintain an up-to-date panel layout drawing that shows the following: (1) roll numbers, (2) panel numbers, (3) seam numbers, (4) test locations, (5) repair locations, and (6) nondestructive testing information.

During placement of the panel, the CQC Organization will:

- Record panel numbers and dimensions on the panel and seam log.
- Observe the panel surface as it is deployed and record all panel defects and defect corrective actions (e.g., panel rejected, patch installed, extrudate placed over the defect, etc.) on the repair sheet. Verify that corrective actions are made in accordance with the project specifications.
- Verify that equipment used during deployment operations does not damage the geomembrane. Verify that equipment used on the geomembrane does not leak hydrocarbons onto the geomembrane or that corrective measures are taken to prevent leakage.
- Verify that the surface beneath the geomembrane has not deteriorated since previous acceptance. Verify that no stones, construction debris, or other items are beneath the geomembrane that could damage the geomembrane.
- Verify that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.
- Record weather conditions, including temperature, wind speed and direction, and humidity. Verify that the geomembrane is not deployed in the presence of excess moisture (e.g., fog, dew, mist, etc.). In addition, verify that the geomembrane is not placed when the ambient temperature is below 40°F, higher than 104°F, or when standing water or frost is on the ground.
- Verify that crews working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the geomembrane.
- Verify that methods used to deploy the geomembrane minimize wrinkles, and that panels are anchored to prevent movement by the wind. Verify that the geosynthetic materials subcontractor corrects any damage resulting to or from windblown geomembrane.
- Verify that no more panels are deployed than can be seamed on the same day.

The CQC Manager must inform both the RA Contractor and the CQA Manager if any of the above conditions are not met.

Field Seaming. Before the start of geomembrane welding and during welding operations, each welding apparatus will be tested by the geosynthetic materials subcontractor in accordance with the project specifications to verify that the equipment is functioning properly. One trial weld will be taken before the start of work and one at mid-shift. The CQC Manager will observe all welding operations and verify that

the geosynthetic materials subcontractor quantitatively tests each trial weld for peel adhesion and bonded seam strength (ASTM D6392 [ASTM, 2012g]). The CQC Manager will record the results of the peel and shear tests on the trial weld form. If at any time the CQC Manager judges that welding apparatus is not functioning properly, a trial weld must be performed. Another trial weld must be performed if wide changes in temperature (~30 °F), humidity, or wind speed occur. The trial weld must be allowed to cool to ambient temperature before it is tested.

During geomembrane welding operations, the CQA Organization will:

- Verify that the geosynthetic materials subcontractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Verify that equipment used for welding will not damage the geomembrane.
- Verify that extrusion welding apparatuses are purged before beginning a weld, so that all heat-degraded extrudate is removed from the nozzle of the welder.
- Verify that seam grinding is completed less than 1 hour before seam welding and the upper sheet is beveled (extrusion welding only).
- Verify that the ends of extrusion welds that are more than 5 minutes old are ground to expose new material before restarting a weld.
- Verify that contact surfaces of the panels are clean and free of dust, grease, dirt, debris, and moisture before welding.
- Verify that welds are free of dust, rocks, and other debris.
- Verify that cross seams are ground to a smooth incline before welding (fusion welding only).
- Verify that all seams are overlapped a minimum of 3 inches (75 mm) or in accordance with manufacturer's recommendations, whichever is more stringent.
- Verify that solvents or adhesives are not present in the seam area.
- Verify that procedures used to temporarily hold the panels together do not damage the panels and do not preclude CQC testing.
- Verify that strips of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, are placed below the geomembrane. These strips may be as long as the seam itself or shorter and moved with the seaming equipment. If necessary, a firm material such as a flat board or similar hard surface may be placed directly under the weld overlap to achieve firm support.
- Verify that panels are being welded in accordance with the engineering plans and project specifications.
- Verify that no free moisture is in the weld area.
- Measure surface temperature of the panels every 2 hours.

6.3.4. Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive geomembrane testing is to detect discontinuities or holes in the seams. Nondestructive geomembrane tests include vacuum and air pressure testing. Nondestructive testing must be performed over the entire length of the seam in compliance with the project specifications.

It is the geosynthetic materials subcontractor's responsibility to perform all nondestructive testing as part of the QC program. The CQC Organization's responsibility is to observe and document that the geosynthetic materials subcontractor's QC testing complies with the project specifications and to document seam defects and repairs.

During nondestructive testing, the CQC Organization will:

- Review project specifications regarding test procedures.
- Verify that equipment operators are fully trained and qualified to perform their work.
- Verify that test equipment meets the project specifications.
- Verify the entire length of each seam is tested in accordance with the project specifications.
- Observe all continuity testing and record results on the panel and seam log and the panel layout drawing.
- Verify that all testing is completed in accordance with the project specifications.
- Identify any failed areas by marking the area with a waterproof marker compatible with the geomembrane, inform the geosynthetic materials subcontractor of any required repairs, and record the repair on the panel and seam log.
- Verify that all repairs are completed and tested in accordance with the project specifications.
- Record all completed and tested repairs on a repair sheet and the panel layout drawing.

Destructive Seam Sampling Procedures and Field Testing. Destructive seam samples will be collected at intervals of at least one test per 500 lineal feet of geomembrane seams. However, additional samples will be collected if the CQC Manager suspects that a seam does not meet the construction specification requirements. Reasons for collecting additional samples may include, but are not limited to:

- Wrinkling in seam area
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap

- Adverse weather conditions
- Failing tests

The CQC Manager selects the locations from where seam samples will be cut for destructive laboratory testing, as follows:

- A minimum of one test per 500 feet of seam length, which is an average frequency for the entire installation; individual samples may be collected at greater or lesser intervals. The testing frequency will be increased if welding operations are conducted in temperatures below 40°F. The Project Manager and CQA Manager will agree upon the increase.
- The Project Manager and CQC Manager will agree to a maximum frequency at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, the CQA Manager may increase this frequency. Samples collected as the result of failed tests do not count toward the total number of required tests.

The CQC Manager will not inform the geosynthetic materials subcontractor in advance of selecting the destructive sample locations.

The geosynthetic materials subcontractor will remove specimens and samples at locations identified by the CQC Manager and field test the specimens for peel and shear before the samples are shipped off site for laboratory testing. During sampling procedures, the CQC Manager will:

- Observe sample cutting.
- Mark each specimen and sample with an identifying number that contains the seam number, destructive sample test number, welder, and date and time welded.
- Record sample locations on the panel layout drawing and panel seam logs
- Record the sample locations, weather conditions, and reasons samples were collected (e.g., random sample, visual appearance, result of a previous failure, etc.) in the destructive seam test form.

All seam specimens will be collected and tested per the project specifications. Results of field testing will be recorded on the destructive seam tests form, and the panel and seam log and seam samples will be archived in accordance with the project specifications.

6.3.5. Repairs

Portions of geomembrane panels and seams that contain (1) a flaw, (2) a destructive test, or (3) nondestructive test cuts of holes must be repaired in accordance with the project specifications. The CQC Organization must locate and record all repairs on the repair sheet and panel layout drawing. The following repair techniques are acceptable:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.
- Abrading and Rewelding – used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 2 inches in diameter.
- Spot Welding – used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
- Capping – used to repair failed welds or to cover seams where welds cannot be nondestructively tested.
- Removal – used to replace area with large defects where preceding methods are not appropriate. Also used to remove excess material (e.g., wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures outlined in the project specifications will be followed during all geomembrane repairs.

6.3.6. Wrinkles

During placement of materials over the geomembrane, temperature changes or creep may cause wrinkles to develop in the geomembrane. Any wrinkles that can fold over must be repaired either by cutting out excess material or, if possible, by allowing the geomembrane to contract by reducing the temperature. In no case can material be placed over the geomembrane, which could result in the geomembrane folding. The CQC Organization must monitor geomembrane for wrinkles and notify the CQA Monitor and Construction Manager if wrinkles are being covered by soil. The CQC Manager is then responsible for documenting corrective action to remove the wrinkles.

6.3.7. Folded Material

All folded geomembrane must be removed.

6.3.8. Anchor Trench

The CQC Organization will:

- Verify that termination points of the geomembrane within the anchor trench are correct.
- Verify that loose soil or objectionable materials, such as geosynthetic scraps and miscellaneous debris, are removed from the anchor trench prior to placement of geomembrane.
- Verify that the anchor trench is dewatered (pumped out) if standing water is present in the bottom of the trench.

- Verify that the geomembrane is temporarily anchored in the anchor trench until seaming is complete and all geosynthetic layers are installed as shown on the construction drawings.
- Ensure that expansion and contraction of the geomembrane is accounted for in the liner placement, and that the anchor trench is filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

6.3.9. Acceptance

The geosynthetic materials subcontractor retains all ownership and responsibility for the geomembrane until acceptance by the Navy. If the geosynthetic materials subcontractor is responsible for placing the cover over the geomembrane, the geosynthetic materials subcontractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the CQC Manager and geosynthetic materials subcontractor will inspect the completed installation. The geosynthetic materials subcontractor will repair any damage or defect found during the inspection. The installation will not be accepted until it meets the requirements of both parties. In addition, the CQC Manager will recommend acceptance of the geomembrane by the CQA Manager only when the following activities have been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable, and all required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- All as-built record drawings have been completed and verified by the CQC Manager to show the true panel dimensions, the locations of all seams, trenches, pipes, appurtenances, and repairs.

6.3.10. Installer Experience and Qualifications

Proper layout, seaming, and testing of the geomembrane requires skill and experience. As such, the integrity of the geomembrane is dependent upon the installers. To ensure a minimum level of experience and expertise, qualification standards are established in the project specifications. The CQC Manager will ensure that the geosynthetic materials subcontractor, geosynthetic materials subcontractor superintendent, master seamer, and all other seaming personnel meet the experience requirements outlined in the project specifications.

6.4. INSTALLATION OF GEOCOMPOSITE DRAINAGE LAYER AND DEMARCATION LAYER

A geocomposite drainage layer will be installed over the geomembrane and will consist of the following layers:

- A nonwoven polypropylene geotextile fabric placed over the HDPE geomembrane (to cushion it from the overlying geonet).
- A geonet comprising two bonded overlapping HDPE strands to transmit infiltrated water to drainage features at the top of the cap.
- Another layer of geotextile fabric to prevent soil from clogging the underlying geonet (this fabric layer may also serve as the demarcation layer that is described below).

In areas that are radiologically impacted, a demarcation layer will be installed at the bottom of the soil cover to mark the presence of remaining radiologically hazardous substances at depth. The demarcation layer will consist of an orange-colored geotextile fabric and marking tape to ensure proper identification of the bottom of the soil cap. The marking tape will be printed with a warning message indicating the presence of contaminated soil beneath the demarcation layer. The marking tape will be placed in a 10-foot grid on top of the fabric. The marking tape will be of a material suitable to be detectable by electromagnetic geophysical equipment. The following sections discuss the monitoring and testing requirements during installation of the geocomposite drainage layer and demarcation layer (referred to collectively as geocomposite materials).

6.4.1. Delivery

During delivery of geocomposite material, the CQC Organization will:

- Verify that equipment used to unload the rolls will not damage the geocomposite.
- Verify that care is used to unload the rolls.
- Verify that all documentation required by the project specifications has been received.
- Verify that each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions. Log this information on the geosynthetic receipt form.
- Verify that the geosynthetic receipt form is completed.
- Verify that materials are stored in a location that will protect the rolls from exposure to ultraviolet light, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or harmful conditions.

Any damaged rolls may be rejected. Verify that rejected material is removed from the site or stored at a location separate from accepted rolls. Geocomposite rolls that do not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

6.4.2. Conformance Testing

Testing Frequency. The CQC Organization will obtain geocomposite drainage layer conformance test samples for every 100,000 square feet of material and a minimum of one per batch or lot delivered to the site. The CQC Organization will collect samples of the material at the site, or an independent third party will collect samples at the manufacturing plant under the direction of the CQC Manager. The geotextile component will be tested as discussed in Section 6.1.2. The CQA Organization will forward the samples to the testing laboratory for the following conformance tests:

- Thickness (ASTM D5199 [ASTM, 2012d])
- Density (ASTM D1505 [ASTM, 2010b])
- Tensile strength (ASTM D5035 [ASTM, 2011c])
- Carbon black content (ASTM D1603 [ASTM, 2012b])

The CQC Manager will review all test results and report any nonconformance to the CQA Manager and the Construction Manager.

Sampling Procedure. Samples will be collected across the entire roll width and will be 3 feet long. Samplers must mark the manufacturer's roll identification number, as well as the machine direction, on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

6.4.3. Geocomposite Installation

Surface Preparation. Before geocomposite installation, the CQC Organization will:

- Verify that all lines and grades have been verified by the RA Contractor.
- Verify that the underlying geomembrane has been prepared in accordance with the project specifications, and that all associated documentation has been completed.
- Verify that soil or geomembrane surfaces do not contain protrusions that could damage the geocomposite.
- Verify that no excessively soft areas exist in the soil surface that could damage the geocomposite.
- Verify that all construction stakes have been removed.
- Verify that all aspects of surface preparation have been performed according to the project specifications.

Geocomposite Placement and Seaming. During geocomposite placement, the CQC Organization will:

- Observe the geocomposite as it is deployed and record all defects and defect corrective actions (e.g., panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the project specifications.
- Verify that equipment used does not damage the geocomposite by handling, equipment transit, leakage of hydrocarbons, or other means.
- Verify that crews working on the geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite.
- Verify that the geocomposite is securely anchored to prevent movement by the wind.
- Verify that adjacent panels are overlapped and seamed in accordance with the project specifications.
- Examine the geocomposite after installation to ensure that no potentially harmful foreign objects are present.

The CQC Manager must inform both the CQA Manager and RA Contractor if the above conditions are not met.

6.4.4. Repairs

Repair procedures include:

- Patching – used to repair large holes, tears, and small defective areas.
- Removal – used to replace large defective areas where the preceding method is not appropriate.

Repair procedures will be performed per project specifications.

Section 7. Monitoring and Testing Requirements for Runoff Control Features

This section summarizes CQC monitoring and testing requirements for installation of the surface water and stormwater control systems and temporary erosion and sediment controls. The CQA Organization will verify that the following monitoring and testing requirements are being fulfilled by the CQC Organization.

7.1. INSTALLATION OF SURFACE WATER AND STORMWATER CONTROLS

The CQC Organization will verify that all drainage ditches are graded and sloped in accordance with the project specifications and drawings.

7.2. INSTALLATION OF TEMPORARY EROSION AND SEDIMENT CONTROL

The CQC Organization will:

- Verify that the RA Contractor has prepared Navy-approved erosion and sediment control plans. Secure and review a copy of the plans to verify that the RA Contractor is implementing practices and procedures described therein. Verify that all erosion and sediment control facilities are approved by the Navy before beginning site earthwork.
- Verify that all temporary erosion and sediment control facilities (e.g., sediment basin, straw bale barriers, erosion control wattles, and silt fences) are in place and operational prior to construction. Note additional erosion control opportunities and inform the Construction Manager.
- Verify that disturbed ground surfaces are stabilized at the end of each workday. Verify that ground surfaces are immediately roughened by dozer track-walking upon reaching final grade. Verify that the dozer track imprints are perpendicular to the slope.
- Verify that permanent soil stabilization and erosion and sediment controls are implemented upon reaching final grade.
- Verify that silt fence materials comply with product requirements of the project specifications.
- Verify that silt fence lines are at a constant elevation for each continuous length of fence.
- Verify that a trench is excavated along the silt fence line, if required by the project specifications.
- Verify that fence posts are evenly spaced and securely driven into the ground along the downslope side of the excavated trench.
- Verify that the filter fabric and wire mesh support are securely fastened together and to the fence post.

- Verify that the filter fabric and wire mesh ends are joined by overlapping a minimum of 6 inches.
- Verify that the filter fabric extends into the trench a minimum of 4 inches.
- Verify that the trench is backfilled with soil.
- Verify that erosion control wattles comply with the product requirements of the project specifications.
- Verify that the erosion control wattles are placed along the contour, perpendicular to the slope.
- Verify that the wattles are set into the trench a minimum of 2 inches, with no gap between the soil and bottom of wattle.
- Verify that wooden stakes have been used to fasten the wattles to soil at 4-foot intervals.

Section 8. Documentation

The CQA Plan depends on thorough monitoring and documentation of all construction activities. Therefore, the CQA Organization will document that all QA requirements have been addressed and satisfied. Documentation will consist of daily record-keeping, weekly progress reports, photographs, design and specification changes, and a final construction report. The CQA Manager will review all CQC documentation to verify that the quality standards identified in the project specifications are being met.

8.1. DAILY RECORD-KEEPING

At a minimum, CQA Monitor's daily records will consist of a daily record of construction progress, acceptance certificates, inspection reports and logs, test data sheets, and nonconformance reports, as needed. The CQA Monitor will submit daily records to the CQA Manager for review on a weekly basis.

8.1.1. Daily Record of Construction Progress

The daily field report will summarize ongoing construction activities and the CQA activities performed. The CQA Monitor will prepare the daily field reports. At a minimum, the report will include the following:

- Date, project name, project number, and location
- A unique number for cross-referencing and document control
- Weather data
- A description of all ongoing construction for the day in the area of the CQA Monitor's responsibility, including any concerns noted
- An inventory of equipment used by the RA Contractor
- Items of discussion and names of parties involved in discussions
- A summary of the CQA activities performed
- A description of placement activities for all soil, and notes of any visual changes in earthwork materials
- A summary of CQA and CQC tests performed, test methods used, and test results, including corrective actions taken for all construction material tests that do not comply with the project specifications
- A summary of results for CQA lift thickness, density, and moisture content measurements

- A summary of geosynthetic materials received and placed, including locations, panel numbers, seams completed, test results, repairs, and methods of repairs
- A list of nonconformance and corrective actions taken to repair damage (include nonconformance report, see Section 8.1.5)
- A list of items requiring Navy attention
- Follow-up information on previously reported problems or deficiencies
- A record of significant discussions with Navy, CQC personnel, contractors, regulators and others
- Signature of CQA Monitor

8.1.2. Acceptance Certificates

The following form will be used to document the acceptance of the subgrade by the CQA Monitor prior to installation of the geosynthetic materials:

- **Certificate of Subgrade Acceptance** – A certificate of subgrade acceptance will be signed each day GCL materials or geomembrane are placed. The installer and CQA Engineer will sign each certificate prior to installation of the GCL or geomembrane. The area being accepted must be described on the certificate.

8.1.3. Inspection Reports and Logs

The following forms will be used to document the geosynthetic materials received at the site and to document deployment and seaming as the geosynthetic materials are incorporated into the project:

- **Receiving Inspection Report** – Receiving inspection reports shall be completed for incoming geosynthetic materials and other materials. An example receiving report is provided for the delivery of geosynthetic materials and should be completed by the CQA Monitors.
- **Geomembrane Panel Deployment Log** – This log shall be used to record geomembrane panel numbers as they are placed in the field and to cross-reference assigned panel numbers with roll numbers. The weather conditions, time, and temperature at placement shall be recorded on the log. Measured dimensions of the geomembrane shall also be recorded on the log.
- **Geomembrane Seam Log** – Each seam constructed shall be recorded on a geomembrane seam log.

8.1.4. Test Data Sheets

Test data sheets should include the following information, as is appropriate for the form being used:

- Date, project name, and location
- A unique number for cross-referencing and document control
- Weather data, as applicable

- A reduced scale site plan showing sample and test locations
- Test equipment calibrations, if applicable
- A summary of test results identified as passing; failing; or, if a test fails, retest
- Completed calculations
- Signature of the CQA Monitor

The following testing data sheets will be used to document the QA testing at the site:

- **Geomembrane Trial Seam Data Sheet** – Test results for each trial seam will be recorded on the Geomembrane Trial Seam Data Sheet.
- **Nondestructive and Destructive Geomembrane Seam Testing Data Sheets** – These data sheets will be used to record test results for all nondestructive and destructive geomembrane seam tests.
- **Field Moisture and Density Test Result Data Sheet** – All CQA moisture content and density tests will be recorded on this data sheet.
- **Test Report** – This data sheet will be used to record all other CQA test results for which a specific data sheet does not exist.

8.1.5. Nonconformance Reports

If a nonconformance occurs, a nonconformance verification report form will be included with the daily report. Procedures for implementing and resolving any nonconformities to the contract are outlined in Section 2.4 of this CQA Plan.

8.2. PHOTOGRAPHS

The CQC Organization will photograph construction activities. Photographs will include any significant problems encountered and corrective actions, as well as document the progress of construction. The photographs will be identified by number, location, time, date, and photographer. The photographer should document the subject or the photograph, either on the back of the picture or in a photograph log. Hard copies of the captioned photographs will be appended to the daily reports by the CQC Manager and provided to the CQA Manager on a weekly basis. The CQC Manager also provides digital files for the photographs (on compact disc) will be provided to the CQA Manager upon completion of the project.

8.3. DESIGN AND SPECIFICATION CHANGES

Design and specification changes may be required during construction. Design and specification changes will only be made with written agreement of the Design Engineer, Navy, and the RA Contractor. These changes will be made by change order to the contract. When change orders are issued, they will be prepared

by the Program Manager. The Program Manager will distribute change orders for signature and execution to the required parties.

8.4. CONSTRUCTION QUALITY ASSURANCE SUMMARY REPORT

At the completion of work, the CQA Manager will provide a final report on CQA activities performed at the site. The CQA Summary Report will include, at a minimum, the following information:

- A brief description of the project, including type of facility, name of site, location, altitude, name of owner, design engineer, general contractor, and all major subcontractors.
- A detailed description of the cover and lining systems, including surface area, cross sections, and a summary of all materials used.
- A chronological summary of construction activities.
- Photographic documentation, including photographs of the site at different phases of construction, photographs of construction details, and photographs of all CQA operations.
- A general record of activities, such as dates of performance of CQA operations, number and names of CQA Monitors, and number and names of geosynthetic installer's personnel.
- QA sampling and testing locations.
- Copies of all CQA data sheets and records completed during construction of the remedy.
- All CQA field and laboratory test results, as well as a tabulated summary of the results.
- A discussion of special problems encountered and their solutions.
- A discussion of significant changes from the design and project specifications.
- QA as-built survey records.
- CQA record drawings, which include the geomembrane panel's layout and all survey conformance data.
- A summary statement, sealed and signed by the CQA Manager, documenting that CQA was conducted in accordance with the CQA Plan and, based on visual observations and data generated in accordance with the CQA Plan, the remedy and related features shown on the construction drawings were constructed in accordance with design drawings and project specifications, except as properly authorized and documented in the CQA Summary Report.

8.5. FINAL CONSTRUCTION REPORT

At the completion of the project, the CQC Manager and the Project Manager will prepare and submit a final construction report to the CQA Manager and the Navy. This report will document that the work has been performed in compliance with the construction drawings and project specifications.

At a minimum, the report will contain:

- A summary of all construction activities.
- A summary of all laboratory and field test results.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A list of changes from the construction drawings and project specifications and the justifications for these changes.
- As-built record drawings.
- A statement of compliance with the construction contract documents and design intent signed and stamped by the CQC Manager, a professional engineer registered in the state of California.

The as-built record drawings will accurately locate the constructed location of all work items, including the location of piping, anchor trenches, etc. The RA Contractor will prepare all surveying and base maps required for development of the record drawings. The CQC Manager must review and verify that the as-builts are correct. As-built record drawings will be included in the final construction report. The CQA Manager will review the final construction report, including the as-built drawings, on behalf of the Navy.

Section 9. References

ASTM International, 2007a. "ASTM D422 Standard Test Method for Particle-Size Analysis of Soils."

ASTM International, 2007b. "ASTM D4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus."

ASTM International, 2007c. "ASTM D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products."

ASTM International, 2008a. "ASTM D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement."

ASTM International, 2008b. "ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique."

ASTM International, 2008c. "ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles."

ASTM International, 2009a. "ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)."

ASTM International, 2009b. "ASTM D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity."

ASTM International, 2009c. "ASTM D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics."

ASTM International, 2009d. "ASTM D5891 Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners."

ASTM International, 2009e. "ASTM D5993 Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners."

ASTM International, 2009f. "ASTM D6241 Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe."

ASTM International, 2009g. "ASTM D6496 Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners."

ASTM International, 2010a. "ASTM D638 Standard Test Method for Tensile Properties of Plastics."

ASTM International, 2010b. "ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique."

ASTM International, 2010c. "ASTM D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter."

ASTM International, 2010d. "ASTM D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles."

ASTM International, 2010e. "ASTM D5994 Standard Test Method for Measuring Core Thickness of Textured Geomembrane."

ASTM International, 2010f. "ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

ASTM International, 2011a. "ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)."

ASTM International, 2011b. "ASTM D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles."

ASTM International, 2011c. "ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)."

ASTM International, 2012a. "ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort, Method C."

ASTM International, 2012b. "ASTM D1603 Standard Test Method for Carbon Black Content in Olefin Plastics."

ASTM International, 2012c. "ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile."

ASTM International, 2012d. "ASTM D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics."

ASTM International, 2012e. "ASTM D5321 Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear."

ASTM International, 2012f. "ASTM D5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test."

ASTM International, 2012g. "ASTM D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods."

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Tables

Table 1. Testing Frequencies for Earthwork Construction of Covers[1]

Test Method	Frequency
Nuclear Gauge Density and Moisture (ASTM D6938)	One per 10,000 square feet per lift
Compaction Curves (ASTM D1557)	Every 5,000 cubic yards
Identification of Soils (Unified Soil Classification System) (ASTM D2487)	Every 5,000 cubic yards or one per change in material, whichever occurs first
Description and Identification of Soils (Visual-Manual Procedure) (ASTM D2488)	Continual during excavation of borrow materials, as needed to identify change in material
Oven Moisture Content (ASTM D2216)	As necessary to check nuclear method
Surveying	50-foot grid and at all grade breaks

Additional Testing Frequencies for Earthwork Construction

Material	Testing Requirement	Reference	Criteria
Top Lift of Foundation Soil	Sieve Analysis	ASTM D422	1 sieve analysis per 5,000 cy
First Lift of Vegetative Soil	Sieve Analysis	ASTM D422	1 sieve analysis per 5,000 cy

Notes:

1 = These tests will be performed at stated frequencies and at each material or source change.

2 = For general fill in trenches, the frequency shall be one test per 100 linear feet of trench.

ASTM = ASTM International

cy = cubic yards

Table 2. Testing Frequencies for Construction of Geotechnical Filter Fabric, Geonet, and Geotextile

Test Method	QC Testing Frequency	QA Testing Frequency
Conformance Testing[1]		
Grab Strength (ASTM D4632)	1 per 200,000 ft^2	1 per 500,000 ft^2
Puncture Resistance (ASTM D6241)	1 per 200,000 ft^2	1 per 500,000 ft^2
Tear Strength (ASTM D4533)	1 per 200,000 ft^2	1 per 500,000 ft^2
Permittivity (for filter geotextile only) (ASTM D4491)	1 per 200,000 ft^2	1 per 500,000 ft^2
Apparent Opening Size (filter geotextile only) (ASTM D4751)	1 per 200,000 ft^2	1 per 500,000 ft^2
Mass per Unit Area (ASTM D5261)	1 per 200,000 ft^2	1 per 500,000 ft^2
Ultraviolet Resistance at 500 Hours (ASTM D4355)	1 per 200,000 ft^2	1 per 500,000 ft^2

Notes:

1 = Conformance testing to be performed on samples collected for QC and QA. Manufacturer testing requirements and frequencies are listed in the project specifications (Appendix C to the Design Basis Report).

ASTM = ASTM International

ft^2 = square feet

QA = quality assurance

QC = quality control

Table 3. Testing Frequencies for Construction of Geosynthetic Clay Liner

Test Method	QC Testing Frequency	QA Testing Frequency
Conformance Testing[1]		
Bentonite Mass per Unit Area (ASTM D5993)	1 per 200,000 ft^2	1 per 500,000 ft^2
Fluid Loss (ASTM D5891)	1 per 200,000 ft^2	1 per 500,000 ft^2
Permeability (ASTM D5084)	1 per 200,000 ft^2	1 per 500,000 ft^2
Geotextile Mass per Unit Area (ASTM D5261)	1 per 200,000 ft^2	1 per 500,000 ft^2
Peel Strength (ASTM D6496 or ASTM D4632)	1 per 200,000 ft^2	1 per 500,000 ft^2

Notes:

1. Conformance testing to be performed on samples collected for QC and QA. Manufacturer testing requirements and frequencies are listed in the project specifications (Appendix C to the Design Basis Report).

ASTM = ASTM International

ft^2 = square feet

QA = quality assurance

QC = quality control

Table 4. Testing Frequencies for Construction of Geomembrane

Test Method	QC Testing Frequency	QA Testing Frequency
Conformance Testing[1]		
Specific Gravity (ASTM D792 Method A)	1 per 200,000 ft^2	1 per 500,000 ft^2
Tensile Properties (ASTM D638)	1 per 20,000 ft^2	1 per 500,000 ft^2
Puncture Resistance (ASTM D4833)	1 per 45,000 ft^2	1 per 500,000 ft^2
Carbon Black Content (ASTM D4218)	1 per 20,000 ft^2	1 per 500,000 ft^2
Carbon Black Dispersion (ASTM D5596)	1 per 45,000 ft^2	1 per 500,000 ft^2
Thickness (ASTM D5994)	1 per roll	1 per 10 rolls
Density (ASTM D1505)	1 per 100,000 ft^2	1 per 100,000 ft^2
Interface Shear Strength (ASTM D5321)	1 per 90,000 ft^2	1 per 500,000 ft^2
Environmental Stress Crack (ASTM D5397)	1 per 400,000 ft^2	1 per 500,000 ft^2
Field Seaming Trial Welds		
Peel Adhesion – Fusion and Extrusion (ASTM D6392)	2 per day	Observation at the discretion of the CQA Manager
Shear Strength – Fusion and Extrusion (ASTM D6392)	2 per day	Observation at the discretion of the CQA Manager
Nondestructive Seam Testing		
Vacuum Testing (ASTM D5641)	Continuous Observation	Continuous Observation
Air Pressure Testing (ASTM D5820)	Continuous Observation	Continuous Observation
Destructive Seam Testing		
Destructive Testing (ASTM D6392)	1 per 500 feet of seam length	1 per 5,000 feet of seam length

Notes:

1. Conformance testing to be performed on samples collected for QC and QA. Manufacturer testing requirements and frequencies are listed in the project specifications (Appendix C to the Design Basis Report).

ASTM = ASTM International

ft^2 = square feet

QA = quality assurance

QC = quality control