Third Five-Year Review Report

for

Former Naval Construction Battalion Center Davisville
North Kingstown, Rhode Island

Naval Facilities Engineering Command
Mid-Atlantic

Contract Number N62472-03-D-0057
Contract Task Order 19

MARCH 2013

121209/P

THIRD FIVE-YEAR REVIEW REPORT

for

FORMER NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command Mid-Atlantic
9742 Maryland Avenue
Norfolk, Virginia 23511-3095

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Contract Number N62472-03-D-0057
Contract Task Order 19

MARCH 2013

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APPROVED BY:

DAVID A. BARNEY
BRAC ENVIRONMENTAL COORDINATOR
By Direction of BRAC PMO

26 MARCH 2013
DATE

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Former Naval Construction Battalion Center Davisville		
EPA ID: RI6170022036		
Region: 1	**State:** RI	**City/County:** Washington
SITE STATUS		
NPL status: Final		
Remediation status: Operating		
Multiple OUs? Yes	**Construction completion date:**	
Has site been put into reuse? Yes		
REVIEW STATUS		
Lead agency: U.S. Department of the Navy		
Author name: Prepared by Tetra Tech under contract to the Navy		
Author title:	**Author affiliation:**	
EPA's Review period: January 2008 to December 2012		
Date(s) of site inspection: Various dates.		
Type of review: Post-SARA		
Review number: 3 (Third)		
Triggering action: Second Five-Year Review – March 28, 2008		
Triggering action date *(from WasteLAN)*: 03/28/2008		
Due date *(five years after triggering action date):* 03/28/2013		

Five-Year Review Summary Form, cont'd.

Issues:

Calf Pasture Point:

There are no protectiveness issues identified in this review.

Allen Harbor Landfill:

There are no protectiveness issues identified in this review.

Five-Year Review Summary Form, cont'd.

Recommendations and Follow-up Actions:

Calf Pasture Point:

None.

Allen Harbor Landfill:

None.

Five-Year Review Summary Form, cont'd.

Protectiveness Statements:

Calf Pasture Point:

The remedy at Calf Pasture Point is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through institutional controls. These controls are effectively preventing exposure to site-related contaminants in groundwater.

Allen Harbor Landfill:

The remedy at Allen Harbor Landfill is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through remedy-related institutional controls and a state-enforced prohibition of shellfishing in Allen Harbor. These controls are effectively preventing exposure to site-related contaminants.

Other Comments:

The following are specific recommendations for Calf Pasture Point:

1. Prepare ESD to document the removal action (excavation and off-site removal) of the source area that was performed in summer to fall 2011.

2. a) Schedule a DQO meeting to discuss optimization of the LTMP and establish the objectives and scope of the LTMP.
   b) Prepare a revised UFP-SAP for Long-Term Monitoring at Site 07.

3. Schedule a DQO meeting to discuss reporting requirements for data reports and schedule for comprehensive data reviews.

The following are specific recommendations for Allen Harbor Landfill:

1. a) Schedule a DQO meeting to discuss optimization of the LTM program and establish the objectives and scope of the LTM program.
   b) Prepare a revised Work Plan/SAP for Long-Term Monitoring at Site 09.

2. Schedule a DQO meeting to discuss reporting requirements for data reports and schedule for comprehensive data reviews.

3. Prepare a Technical Memorandum based on data collected in offshore area in October 2012 and include evaluation of date through ME 40 with conclusions and recommendations for future long-term sampling.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NEW ENGLAND - REGION I
5 POST OFFICE SQUARE, SUITE 100 (OSRR 07-03)
BOSTON, MASSACHUSETTS 02109-3912

March 28, 2013

David Barney
Department of the Navy
BRAC PMO NE
4911 Broad St
Philadelphia, PA 19112-1303

Re: *Third Five-Year Review Report for Former Naval Construction Battalion Center, North Kingstown, Rhode Island*

Dear Mr. Barney:

This office is in receipt of the *"Third Five-Year Review Report for Former Naval Construction Battalion Center, North Kingstown, Rhode Island"* dated March 2013. EPA reviewed the report for compliance with the Comprehensive Five-Year Review Guidance (OSWER No. 9355.7-03B-P dated June 2001), Recommended Evaluation of Institutional Controls: Supplement to the Comprehensive Five-Year Review Guidance (OSWER 9355.7-18 dated September 2011), Clarifying the Use of Protectiveness Determinations for CERCLA Five-Year Reviews (OSWER 9200.2-111 dated September 2012), and Assessing Protectiveness at Sites for Vapor Intrusion: Supplement to the Comprehensive Five-Year Review Guidance (OSWER 9200.2-84 dated November 2012). The report addresses nine operable units (OUs) at the Site and establishes protectiveness statements for two of those OUs, OU 1- Allen Harbor Landfill and OU 8- Calf Pasture Point. The protectiveness statements are required because those two remedies have hazardous substances, pollutants or contaminants remaining within the operable unit.

Upon review of this report, EPA concurs with the protectiveness statements for each of the two operable units. The protectiveness statements establish that the remedies are protective of human health and the environment. We should note that EPA reports annually to Congress on sites that have completed the five-year review and on the protectiveness of the remedies.

Although there are no major issues or recommendations that affect protectiveness, the Navy will conduct follow-up actions to address several minor concerns. For example, the Navy will revise its long-term monitoring plans to ensure that the extent of contamination in all media is monitored optimally and will appropriately document a recent removal action performed at OU8-Calf Pasture Point.

EPA has determined that this Site meets the Site-Wide Human Exposure Environmental Indicator which means there are no current human exposure pathways at the site. However,

EPA has insufficient data to determine the status of the Contaminated Ground Water Migration Environmental Indicator because there are two OUs with groundwater contamination that do not have a final remedy decision. The OU9 remedy decision is expected this fiscal year and the OU7 remedy decision is expected in fiscal year 2015.

Land use controls, including shellfishing bans, played a key role in EPA's determination that both OU 1 and OU 8 are currently protective. The Navy must ensure that those institutional controls remain effective until such time that they are no longer necessary.

The 2013 Five-Year Review, the third comprehensive Five-Year Review completed at the Former Naval Construction Battalion Center, was triggered by the second comprehensive Five-Year Review completed in 2008. Consistent with Section 121(c) of CERCLA, the next Five-Year Review must be finalized on or before March 28, 2018.

If you have any questions with regard to this letter, please contact Christine Williams at (617) 918-1384 or Bryan Olson at (617) 918-1365.

Sincerely,

James T. Owens III, Director
Office of Site Remediation and Restoration

cc: Christine Williams
Richard Gottlieb, RIDEM
Johnathan Reiner, ToNK
Steven King, QDC
Jeff Dale, Navy RPM

RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
235 Promenade Street, Providence, RI 02908-5767 TDD 401-222-4462

3 April 2013

Mr. Jeffrey Dale, RPM
BRAC PMO Northeast
4911 South Broad Street
Bldg. 679, PNBC
Philadelphia, PA 19112

RE: Third Five-Year Review Report
Naval Construction Battalion Center
Davisville, Rhode Island
Submitted 28 March 2013, Dated 28 March 2013

Dear Mr. Dale:

The Rhode Island Department of Environmental Management, Office of Waste Management (RIDEM) has reviewed the above referenced document and responses to our 18 March 2013 comments have been satisfactorily addressed. RIDEM concurs that currently the remedies in place at Naval Construction Battalion Center in North Kingstown, Rhode Island are protective of human health and the environment. Based on our understanding of the sites RIDEM does look forward to discussing with the Navy and USEPA the possible need for sediment project action limits at NCBC Site 07 (Calf Pasture Point).

RIDEM would like to thank you for the opportunity to comment on this document and looks forward to working with the Navy and USEPA. If you have any questions or require additional information please call me at (401) 222-2797 ext. 7138 or email me at richard.gottlieb@dem.ri.gov.

Sincerely,

Richard Gottlieb

Cc: M. Destefano, DEM OWM

30% post-consumer fiber

C. Williams, EPA Region 1
D. Barney, Navy BEC
S. King, RIEDC
S. Licardi, ToNK
L. Sinagoga, TTNUS

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ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCT	BRAC Cleanup Team
BGS	Below Ground Surface
BRAC	Base Realignment and Closure
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLTMP	Conceptual Long-Term Monitoring Plan
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CSFs	Cancer Slope Factors
CSM	Conceptual Site Model
CTO	Contract Task Order
CVOC	Chlorinated Volatile Organic Compound
DANC	Decontaminating Agent Non-Corrosive
DCA	Dichloroethane
DCE	Dichloroethene
DD	Decision Document
DDE	Dichlorodiphenyldichloroethylene
DGPS	Differential Global Positioning System
DI	Deionize
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DPT	Direct Push Technology
DQO	Data Quality Objective
ELUR	Environmental Land Use Restriction
EPA	Environmental Protection Agency
EPCs	Exposure Point Concentrations
ERA	Ecological Risk Assessment
ERM	Effects Range Median
ESD	Explanation of Significant Differences
FFA	Federal Facilities Agreement
FOC	Fractional Organic Carbon
FOST	Finding of Suitability to Transfer

FS	Feasibility Study
FWENC	Foster Wheeler Environmental Corporation
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IR	Installation Restoration
IRIS	Integrated Risk Information System
LTM	Long-Term Monitoring
LTMP	Long-Term Monitoring Program
LUCIP	Land Use Control Implementation Plan
MOA	Memorandum of Agreement
MCL	Maximum Contaminant Level
ME	Monitoring Event
MS	Matrix spike
MSD	Matrix spike duplicate
MSL	Mean Sea Level
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NCBC	Naval Construction Battalion Center
NCP	National Contingency Plan
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
O&M	Operations and Management
ORP	Oxidation-Reduction Potential
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PAL	Project Action Limit
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PID	Photo Ionization Detectior
PFM	Passive Flux Meter
PPT	Parts Per Thousand
PRG	Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan

RAB	Restoration Advisory Board
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RfDs	Reference Doses
RG	Remedial Goal
RI	Remedial Investigation
RIDEM	Rhode Island Department of Environmental Management
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendment and Reauthorization Act
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SVOC	Semivolatile Organic Compound
TBCs	To Be Considered
TCA	Trichloroethane
TCE	Trichloroethene (Trichloroethylene)
TPH	Total Petroleum Hydrocarbons
UCL	Upper Concentration Limit
UF	University of Florida
UFP	Uniform Federal Policy
VC	Vinyl Chloride
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
WQS	Water Quality Standard

EXECUTIVE SUMMARY

This report presents the results of the third five-year review for the former Naval Construction Battalion Center (NCBC) Davisville, located in North Kingstown, Rhode Island. The Installation Restoration (IR) Program for the former NCBC Davisville includes 13 Sites and 3 Study Areas. For two of the sites, Site 07 – Calf Pasture Point, and Site 09 – Allen Harbor Landfill, the selected remedy includes hazardous substances, pollutants, or contaminants remaining above levels that allow for unlimited use and unrestricted exposure. As such, they are subject to the statutory requirement under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to review these remedies at least once every five years, to assure that they continue to be protective of human health and the environment. Long-term monitoring (LTM) is also part of the required action at Sites 07 and 09. The triggering action for this review is the completion of the second five-year review on March 28, 2008.

At Site 07 - Calf Pasture Point, the remedy includes institutional controls (deed restrictions) and long-term monitoring of groundwater and sediment. Deed restrictions include: a prohibition on the construction of buildings for residential or commercial use; a prohibition on the construction of any building, structure, or facility without adequate ventilation, as approved by the Navy, the U.S. Environmental Protection Agency (EPA), and the Rhode Island Department of Environmental Management (RIDEM); and a prohibition on the installation of water supply wells and the use of groundwater for any purpose other than sampling or remediation. Compliance with deed restrictions is documented annually via the Land Use Control Implementation Plan (LUCIP) for NCBC Davisville.

As of this review, 16 long-term monitoring events have been completed at Calf Pasture Point. In addition to long-term monitoring, several site-wide investigative activities have been completed in order to validate (and update as necessary) the conceptual site model (including contaminant transport). Additionally, the buried chemical containers (the primary source of groundwater contamination at Site 07) were successfully located and removed in 2011. The environmental data are used to evaluate the groundwater plume (primarily along the primary groundwater flow-paths) and verify the absence of unacceptable risks along the site shoreline.

Based on the data review and technical assessment performed for this five-year review, the remedy at Calf Pasture Point is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through institutional controls that prevent exposure to contaminants in site groundwater. Supplemental risk assessment and monitoring program optimization will continue to be utilized during the LTM program to verify the protectiveness of the remedy and to ensure that reasonable potential exposure pathways are being adequately monitored. Re-evaluation and

optimization of the current LTM program are included in the action items determined during this five-year review.

At Allen Harbor Landfill, the remedy includes: a multimedia cap (including a passive gas venting system); stone shoreline revetment; an offshore breakwater structure; the construction of an inter-tidal wetland; institutional controls (deed restrictions); and long-term monitoring of groundwater, sediment, shellfish, and landfill gas. Deed restrictions include: a land use restriction, limiting the site to park and recreational uses only; a prohibition on the installation of water supply wells and the use of groundwater for any purpose other than sampling or remediation; and restrictions on the types of activities permitted at the site, such as a prohibition on digging, use of motorized vehicles, or any other activity that may damage the remedy components or otherwise allow exposure to hazardous materials contained under the landfill cap. Compliance with deed restrictions is documented annually via the LUCIP. As of this five-year review, 40 LTM events have been completed at Allen Harbor Landfill. Long-term monitoring data are used to evaluate the stability of the groundwater plume and verify the absence of unacceptable risks at potential exposure points along the landfill shoreline.

Based on the data review and technical assessment performed for this five-year review, the remedy at Allen Harbor Landfill is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through remedy-related institutional controls and a state-enforced prohibition on shellfishing in Allen Harbor. These controls are effectively preventing exposure to site-related contaminants. In order to verify that the remedy continues to be protective, changes to the LTM program are warranted. Re-evaluation and optimization of the current LTM program are included in the action items for this five-year review.

1.0 INTRODUCTION

Under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-03-D-0057, Contract Task Order (CTO) No. 19, Tetra Tech, Inc. (Tetra Tech) was contracted to prepare the third Five-Year Review Report for the former Naval Construction Battalion Center (NCBC) Davisville in North Kingstown, Rhode Island.

1.1 OVERVIEW OF THE FIVE-YEAR REVIEW PROCESS

The purpose of the five-year review is to determine whether the remedy at a site (or sites) is protective of human health and the environment. The methods, findings, and conclusions of the five-year review for the former NCBC Davisville are documented in this Five-Year Review Report. In addition, this report presents issues identified during the review and provides recommendations to address them.

The following is a summary of the requirements for five-year reviews:

- The statutory requirement for five-year review was added to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as part of the Superfund Amendments and Reauthorization Act of 1986 (SARA). A five-year review is required when both of the following conditions are met, whether the site is on the National Priorities List (NPL) or not:

  1) Upon completion of the remedial actions at a site, hazardous substances, pollutants, or contaminants remain above levels that allow for unlimited use and unrestricted exposure. For example, if a site is restricted to industrial use because hazardous substances, pollutants, or contaminants remain above levels that allow for unlimited use and unrestricted exposure, five-year reviews must be conducted.

  2) The Record of Decision (ROD) or Decision Document (DD) for the site was signed on or after October 17, 1986 (the effective date of SARA).

- CERCLA §121(c), as amended, states:

  If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in

accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

- The National Contingency Plan (NCP), 40 C.F.R. Part 300.430(f)(4)(ii), states:

  If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited, and unrestricted exposure, the lead agency shall review such action no less often than every five years after initiation of the selected remedial action.

This is the third five-year review for the former NCBC Davisville. The triggering action for this statutory review is the completion of the second five-year review on March 28, 2008.

This Five-Year Review Report has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) *Comprehensive Five-Year Review Guidance*, dated June 2001 (EPA 540-R-01-007, OSWER No. 9355.7-03B-P), and the U.S. Department of the Navy *Policy for Conducting Five-Year Reviews Under the CERCLA Program* (Navy, 2004). Additionally, the EPA memorandum dated September 13, 2012 with the subject *Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews* was considered during the preparation of the report.

1.1.1 Public Notification

To initiate the five-year review for NCBC Davisville, discussions occurred between the Navy and regulators [EPA and Rhode Island Department of Environmental Management (RIDEM)] during the Base Realignment and Closure (BRAC) Cleanup Team (BCT) meeting on March 22, 2012. During this meeting, emphasis was placed on notifying the regulators that the Navy was currently re-assessing risk for key risk constituents (e.g. trichloroethylene) with new toxicity criteria data. Additionally, preliminary sampling plans for long-term monitoring at Sites 07 and 09 were provided to the regulators for evaluation in order to ensure robust sampling to support conclusions of data trends in the third five-year review. A teleconference was held on May 7 with the regulators to conclude the long-term sampling strategies for 2012 sampling at Sites 07 and 09. EPA concurrence was received on September 24, 2012. No formal concurrence was received from RIDEM.

As part of the second five-year review, the Navy gave a presentation at the September 20, 2007 Restoration Advisory Board (RAB) meeting, providing information on the five-year review process and sharing the schedule for the review. In addition, to solicit input from the community on the remedial

activities at Calf Pasture Point and Allen Harbor Landfill, a questionnaire was distributed during the meeting and was also distributed through the mail to approximately 125 RAB members, with the notes from the September 20, 2007 RAB meeting. The Navy received only two responses to this questionnaire.

Public attendance during the RAB meetings held between 2008 and 2012 has been generally quite low (some exceptions occur, but are due to non-NCBC-Davisville-related topics). This is despite extensive postcard reminders sent to the approximately 125 RAB members two weeks prior to the meetings.

Based on the lack of public involvement observed in 2007 and during meetings from 2008 to 2012, extensive public notification was not done during the third five-year review. Rather, engaged public personnel were included in the interviews.

1.1.2 Interviews

The following individuals were interviewed as part of the third five-year review for former NCBC Davisville:

Interviewee	Title/Affiliation
Philip Bergeron	North Kingstown Department of Public Works, Director
Steven King	Quonset Development Corporation, Chief Operating Officer
Elyse LaForest	National Park Service
Jay O'Brien	RAB Member/North Kingstown Resident
Susan Licardi	North Kingstown Water Department

The types of questions that were asked of interviewees are provided on the RAB Questionnaire, included in Appendix A, which also includes a summary of information gathered during these interviews.

1.2 ROLES AND RESPONSIBILITIES

Tetra Tech was contracted by the Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic to perform the five-year review and prepare this Five-Year Review Report with their review and input. The review team for this document includes EPA and RIDEM. The Navy is the responsible party and will approve the Five-Year Review Report. Concurrence on the Final Five-Year Review Report is expected from EPA and RIDEM upon addressing and integrating their respective comments.

In accordance with CERLA, the Navy is the lead agency responsible for the enactment and maintenance of the selected remedies for the effected sites as outlined in Section 1.1. On February 13, 2013, EPA inspected the facility and found the remedies to be intact. The Navy routinely inspects and confirms the

remedies to be intact during long-term monitoring events. The most recent inspections occurred in June 2012 for Site 7 and September 2012 for Site 9.

1.3 SCOPE OF THE FIVE-YEAR REVIEW

This third five-year review addresses Navy Installation Restoration (IR) Site 07 [EPA Operable Unit (OU) 8], Calf Pasture Point and Navy IR Site 09 (EPA OU1), Allen Harbor Landfill, the two sites at former NCBC Davisville that meet the criteria discussed in Section 1.1.

1.4 STATUS OF OTHER CERCLA SITES AT NCBC DAVISVILLE

Table 1-1 provides a summary of the status of other CERCLA sites at NCBC Davisville.

1.5 NEXT REVIEW

The next five-year review for the former NCBC Davisville is required by March 2018, five years from the date of this review.

2.0 SITE 07 – CALF PASTURE POINT

This section presents the findings of the five-year review for the remedy that was implemented at Navy IR Site 07 (Calf Pasture Point) at the former NCBC Davisville. The format of this section follows that which is presented in the EPA *Comprehensive Five-Year Review Guidance* (June 2001).

2.1 CALF PASTURE POINT SITE CHRONOLOGY

Event	Date
During this time period, a trench was reportedly filled with containers that contained Decontaminating Agent Non-Corrosive (DANC) solution [1,1,2,2-tetrachloroethane (1,1,2,2-PCA) and oxidizing agents that readily break down to release chlorine when contacted by water].	1968-1974
Completion of the Initial Site Assessment of the former NCBC Davisville facility (Hart, 1984).	9/1984
Completion of the Verification Step – Confirmation Study of the former NCBC Davisville facility (TRC, 1987).	2/1987
EPA's Hazard Ranking Scoring Package for the former NCBC Davisville facility.	1989
NCBC Davisville facility placed on the CERCLA NPL.	11/21/1989
Federal Facilities Agreement (FFA) signed by the Navy, EPA, and the State of Rhode Island.	3/1992
Munitions bunker, Building 339, demolished by the Navy (FWENC, 1997).	2/1997
Remedial Investigation completed (EA, 1998a).	9/11/1998
Record of Decision (ROD) signed.	9/30/1999
Class I survey of Parcel 9 completed and annotated with references to the deed for groundwater use and land use restrictions.	2/2000
Final Conceptual Long-Term Monitoring Plan (LTMP) which included establishment of the performance standards (New Fields, 2000a).	3/7/2000
Finding of Suitability to Transfer (FOST) to transfer the property (Parcel 9) to the U.S. Department of Interior, for transfer to the Town of North Kingstown, Rhode Island (Navy, 2000a). The FOST includes the Environmental Land Use Restrictions (ELUR), required by the ROD, and deed covenants. Effective date of Memorandum of Agreement (MOA) between Navy, EPA, and Town of North Kingstown	5/2000
Munitions bunker, Buildings 59 and 60, demolished by the Navy (FWENC, 2000a).	9/2000
Final Quality Assurance Project Plan (QAPP) for LTM of Site 07.	7/2001
LTMP initiated with Monitoring Event (ME) 01: 16 wells and 10 piezometers.	8/2001
Parcel 9 received by the Town of North Kingstown and the deed recorded.	10/2001
Final Land Use Control Implementation Plan (LUCIP) that includes the inspection procedures for Site 07 to document compliance with the land use controls and/or deed covenants placed by the Navy on this transferred Navy property (Parcel 9).	1/2002

Event	Date
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2001.	2/14/2002
Site 07 Remedy Design Hydrogeologic Investigation Report (EA, 2002a).	5/2002
Revision 01 to the Final QAPP for Long-Term Monitoring of Site 07, to add 14 piezometer sampling locations (P07-11 through P07-24) along the Allen Harbor shoreline, and to add salinity testing to the analytical program for the piezometer samples.	5/2002
ME 02 sampling: 26 wells (9-month and 27-month lists) and 24 piezometers.	5/2002
Shallow wells, MW07-35S and MW07-36S, installed along the Allen Harbor shoreline for the LTMP.	10/2002
EPA Conceptual Site Model (CSM) Presentation for Site 07 – December 2002 BCT meeting.	12/2002
Nine piezometer locations (P07-25 through P07-33) added to LTMP as recommended in the Five-Year Review Report.	2/2003
ME 03 sampling: 18 wells (9-month list) and 33 piezometers.	2/2003 - 3/2003
Signature date of the *First Five-Year Review Report* for NCBC Davisville.	3/28/2003
ME 04 sampling: 18 wells (9-month list) and 33 piezometers.	12/2003 - 1/2004
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2003 (EA, 2004e).	2/11/2004
Nine monitoring wells installed at Site 07 (MW07-27S, MW07-35D, MW07-37S/D, MW07-38S/D, and MW07-39S/I/D) as recommended in the *First Five-Year Review Report* (EA, 2003c).	3/2004 - 4/2004
Navy collects pore water and surface water samples from P07-06 through P07-10 locations for volatile organic compounds (VOC) analysis.	5/2004
Navy submits draft *Revised Conceptual Site Model and Monitoring Optimization Report for Site 07, Calf Pasture Point* (Battelle, 2004).	8/4/2004
ME 05 sampling: 37 wells (9-month and 27-month list) and 33 piezometers	8/2004
Final *Project Plan for Coastal Contamination Migration Monitoring Assessment* (SPAWAR, 2004) submitted by Navy to describe investigation to collect samples from off-shore areas in order to delineate chlorinated VOC (CVOC) plume discharge areas.	10/2004
Navy initiates bi-monthly piezometer sampling in entrance channel (P07-04, 05, 06, 07, 08, 09, 10, and 24), with collocated surface water samples, in response to elevated detections of CVOCs in piezometers.	10/2004
EPA conducts plume discharge investigation along Calf Pasture Point shoreline.	10/2004 - 11/2004
Second bi-monthly entrance channel piezometer/surface water sampling event.	12/2004
Third bi-monthly entrance channel piezometer/surface water sampling event.	1/2005
EPA submits draft *Plume Discharge Investigation* report.	1/2005
Navy submits draft *Coastal Contaminant Migration Monitoring Assessment for Site 07* (SPAWAR, 2005), summarizing results of off-shore investigations.	2/9/2005
Fourth bi-monthly entrance channel piezometer/surface water sampling event.	3/2005

Event	Date
Fifth bi-monthly entrance channel piezometer/surface water sampling event.	4/2005
EPA CSM Evaluation included in comment letter for ME 05.	4/27/2005
ME 06 sampling: 27 wells (9-month list) and 33 piezometers.	5/2005
Sixth bi-monthly entrance channel piezometer/surface water sampling event.	7/2005
Seventh bi-monthly entrance channel piezometer/surface water sampling event.	9/2005
Eighth bi-monthly entrance channel piezometer/surface water sampling event.	11/2005
Ninth bi-monthly entrance channel piezometer/surface water sampling event.	1/2006
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2004 (Tetra Tech, 2006b).	6/12/2006
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2005 (Tetra Tech, 2006c).	8/15/2006
ME 07 sampling: 27 wells (9-month list) and 33 piezometers.	11/2006
Navy submits final *Sampling Recommendations to Minimize Impacts to Wetlands at Site 07 (Calf Pasture Point)* (Battelle, 2007).	2/5/2007
ME 08 sampling: 46 wells (9-month, 27-month, and contingency wells) and 33 piezometers.	3/2007
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2006 (Tetra Tech, 2007h).	5/21/2007
Navy submits final *Human Health Risk Assessment of Shoreline Surface Waters and Sediments, and Groundwater in Shallow Piezometers* (Tetra Tech, 2007l) for Calf Pasture Point, using bi-monthly piezometer/surface water data and other LTMP data to determine that there are no unacceptable risks to swimmers/waders associated with CVOC discharges to the shoreline environment at Site 07.	6/2007
ME 09 sampling: 45 monitoring wells, 31 piezometers and 6 sediments.	11 and 12/2007
Navy submits *Revised CSM and Monitoring Optimization Report for Site 07* (Battelle, 2008a)	1/2008
Signature date of the Second Five-Year Review Report for the NCBC Davisville facility.	3/28/2008
Draft Monitoring Report for ME 09.	5/2008
Three additional groundwater monitoring wells added – MW07-24S, MW07-32D, MW07-32R.	5/2008
ME 10 sampling: 49 monitoring wells, 33 piezometers and 6 sediments.	5 and 6/2008
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2007 (Tetra Tech, 2008e).	6/2008
ME 11 sampling: 49 monitoring wells, 32 piezometers and 6 sediments.	9 and 10/2008
Draft Monitoring Report for ME 10.	10/2008
Navy submitted Calf Pasture Point – Metals Evaluation.	10/2008
EPA response and concurrence (with additional comments) on Metals Evaluation.	12/2008
Draft Monitoring Report for ME 11.	2/2009
Navy submitted Draft Sampling and Analysis Plan (SAP) for Long-Term Monitoring at Site 07.	3/2009

Event	Date
ME 12 sampling: 49 monitoring wells, 33 piezometers and 6 sediments.	4/2009
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2008 (Tetra Tech, 2009b).	4/2009
ELUR for Site 7 (Parcel 9) Calf Pasture Point Recorded on Deed	5/8/2009
Draft Monitoring Report for ME 12.	8/2009
ME 13 sampling: 49 monitoring wells, 33 piezometers and 6 sediments.	9 and 10/2009
Modifications with BCT approval to LTMP for Monitoring Events in 2010 and 2011 – Reduction in number of groundwater wells and shoreline piezometers.	10/2009 through 2/2010
Final Monitoring Report for ME 09.	11/2009
Final Monitoring Report for ME 10.	11/2009
Final Monitoring Report for ME 11.	11/2009
Draft Monitoring Report for ME 13.	12/2009
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2009 (Tetra Tech, 2010d).	4/2010
ME 14 sampling: 37 monitoring wells, 21 piezometers and 6 sediments.	4/2010
Navy Submits Draft Long-Term Monitoring Data Summary Report (ME 09 through 13).	5/2010
EPA (and their consultant) performed two site visits in order to assess groundwater monitoring network and shoreline environment.	6/2010
Draft Monitoring Report for ME 14.	7/2010
EPA Region 1 installs 12 new groundwater monitoring wells and 14 shallow piezometers.	7/2010
EPA Region 1 performs shoreline monitoring in three areas to assess freshwater discharge.	8, 9 and 10/2010
Navy submitted Draft SAP for Source Area Investigation.	9/2010
EPA Kerr Research Center performs first phase of Passive Flux Meter work at 5 groundwater monitoring wells.	9/2010
Final Monitoring Report for ME 12.	1/2011
Final Monitoring Report for ME 13.	1/2011
Navy submitted the Draft Final SAP for Source Area Investigation.	2/2011
EPA Kerr Research Center performs second phase of Passive Flux Meter work at 11 groundwater monitoring wells.	3/2011
Tetra Tech performed Source Area Investigation including installation of 8 new groundwater monitoring wells (includes Tidal Study in spring/summer 2012 though not part of SAP).	4/2011 through 6/2012
EPA Kerr Research Center installs 22 groundwater monitoring wells.	6/2011
Shaw Environmental and Infrastructure performed Source Area Removal of trench filled with DANC cans.	6 to 9/2011
EPA Kerr Research Center performs third phase of Passive Flux Meter work at 29 groundwater monitoring wells.	9/2011
ME 15 sampling: 55 monitoring wells, 23 piezometers and 6 sediments.	9 and 10/2011

Event	Date
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2010 (Tetra Tech, 2011h).	10/2011
Draft Monitoring Report for ME 15 – via email to Regulators (dominantly data tables).	2/21/2012
EPA Kerr Research Center and Navy perform multi-month, large-scale Tidal Study.	3 to 6/2012
Draft LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 9 (Calf Pasture Point) during 2011 (Tetra Tech, 2012c).	5/2012
Tetra Tech performs shoreline screening of discharging fresh water/surface water along Entrance Channel based on interpretations of Tidal Study.	6/2012
ME 16 sampling: 73 monitoring wells, 15 piezometers and 7 sediments.	6 and 7/2012
Tetra Tech performs shoreline sampling of discharging fresh water and surface water during large tidal cycle event in support of Third Five-Year Review.	7/2012
Navy submits Draft Source Area Investigation and Long-Term Monitoring Data Summary Report – includes investigative work conducted in 2010, 2011 and 2012, monitoring report for ME 16	2/12/2013

2.2 CALF PASTURE POINT BACKGROUND INFORMATION

In this section, background information for Calf Pasture Point, such as physical characteristics, current and former land use, and a history of environmental actions is presented.

2.2.1 Physical Characteristics

Calf Pasture Point is a peninsula located on the northeast portion of the Former NCBC Davisville facility (Figure 2-1). An existing tidal estuary was filled with dredged material during World War II to form the current peninsula. Site 07 is located in the southern portion of Calf Pasture Point (Parcel 9) on the northeastern edge of Allen Harbor (Figure 2-2). Narragansett Bay, the harbor entrance, and the harbor itself form the eastern, southern, and southwestern shorelines of Site 07, respectively.

There is a bedrock outcrop in the center of the peninsula that forms a prominent hill with a maximum elevation of approximately 55 feet above mean sea level (msl), located north of well MW07-07S (Figure 2-3). IR Site 07 is comprised of the forest and grass covered area of Calf Pasture Point south of the bedrock outcrop to the Allen Harbor and Narragansett Bay shorelines.

2.2.2 Land and Resource Use

From the early 1940s until the mid-1970s, Site 07 was used for the training of Naval Seabees (construction battalions) in the use of heavy construction equipment. Calf Pasture Point formerly contained three munitions bunkers (Buildings 59, 60, and 339) located along Magazine Road, which formerly traversed the site from north to south between Sanford Road/Finn Street and the southern tip of

Calf Pasture Point. The bunkers were earthen-covered and were located in the middle of Calf Pasture Point, to the north, east, and south of the bedrock outcrop. This outcrop is a prominent hill with a maximum elevation of approximately 55 feet above mean sea level (MSL), located north of well MW07-07S (Figure 2-2). The bunkers were demolished by the Navy in February 1997 (Building 339) and September 2000 (Buildings 59 and 60). IR Site 07 is comprised of the forest- and grass-covered area of Calf Pasture Point, south of the former munitions bunkers (i.e., south of the bedrock outcrop) to the Allen Harbor and Narragansett Bay shorelines.

Additionally, a portion of the site was used for the disposal of cans of Decontaminating Agent Non-Corrosive (DANC) solution. This was confirmed during the 2011 Source Investigation and the containers were subsequently excavated and removed.

Currently, the site is undeveloped property with forest and grass cover. Site 07 will not be used for residential purposes in the future because Calf Pasture Point has been transferred to the Town of North Kingstown via Public Benefit Conveyance for use as an open space/conservation area. Acquisition in this manner restricts the transferee to use the property as a park and for recreational purposes, in perpetuity, with no opportunity for residential or commercial development. Additionally, under CERCLA, land use restrictions with compliance monitoring have been placed on the property to ensure that future use will not conflict with the remedy.

Groundwater underlying Calf Pasture Point has been classified by RIDEM as GA (i.e., presumed to be suitable for public or private drinking water use without treatment). Allen Harbor is used for recreational boating, and contains two marinas. In 1984, RIDEM closed much of Allen Harbor to shellfishing due to suspected bacterial contamination. Subsequently, an additional basis for closure was due to surface runoff which included Allen Harbor Landfill and other source areas. In 2004, the remainder of the Harbor (the entrance channel) was closed to shellfishing. No groundwater production wells are located on, or downgradient of, Site 07.

Allen Harbor is classified by RIDEM as SA {b} [i.e., class SA waters are designated for shellfish harvesting, contact recreational activities, and fish and wildlife habitat; the {b} designation indicates a “partial uses" status (that can affect the application of criteria) for waters in the vicinity of marinas and/or mooring fields where seasonal shellfishing closures are likely].

In accordance with the ROD (EA, 1999b) and as outlined in the Land Use Control Implementation Plan (LUCIP) (EA, 2002b), Parcel 9 includes the following environmental land use restrictions. These environmental land use restrictions apply to the use of the contaminated site by the Grantee, its successors, and assigns, as delineated on Figure 2-2 (land use restriction boundary).

- For the entire parcel, no construction of buildings for residential or commercial use.

- No construction or development of any building, structure, facility, or other improvement without adequate ventilation, as approved by the Navy, EPA, and RIDEM, within the portion of land south of the east-west line shown on Figure 2-2. This restriction will be required for as long as site conditions may pose an unacceptable risk to human health and the environment.

- For the entire parcel, water supply wells shall not be installed nor shall groundwater be utilized, except for sampling or other remedial purposes.

LUCIP inspections of Parcel 9 are performed in conjunction with each Site 07 Long-Term Monitoring Plan (LTMP) monitoring event, but no less frequently than annually, to document that there has been no variance from the environmental land use restrictions stated above and that there has been no interference with the implemented remedy.

The purpose of the environmental land use restriction is to ensure that:

- the entire parcel shall be used for only park and recreational uses, not for residential or commercial use, as stated in the ROD.

- no building, structure, facility or other improvement will be constructed without adequate ventilation, in areas of the contaminated Site (Site 07), where a risk exists from contaminated groundwater.

- groundwater for the entire parcel shall not be withdrawn or utilized except for sampling or other remedial purposes.

- the contaminated site as delineated on Figure 2-2 ('land use restriction boundary') is used by the Grantee, its successors, and assigns, in accordance with the above restrictions.

2.2.3 History of Contamination

Sometime between 1968 and 1974, in the area south of the former munitions bunkers, a trench was filled with cans that contained DANC solution. This trench (with cans of DANC) was located during the Source Area Investigation conducted in the spring of 2011. The chemicals buried in the trench are the source of a dissolved chlorinated volatile organic compound (CVOC) plume that has been identified in groundwater

beneath Site 07. Prior to the Source Area Investigation completed in 2011, the approximate location of the disposal area has been inferred through various phases of investigation of this site.

DANC is a reactive, chlorinated compound consisting of two separate chemicals that were mixed to form a decontaminating solution: 1,3-dichloro-5,5-dimethyl-hydantoin, a white crystalline solid with a chlorine-like odor, and acetylene tetrachloride [1,1,2,2-tetrachloroethane (1,1,2,2-PCA)], a heavy colorless liquid. The compound, 1,3-dichloro-5,5-dimethyl-hydantoin, and hydantoin products are oxidizing agents and readily break down to release chlorine when contacted by water. 1,3-Dichloro-5,5-dimethyl-hydantoin, on contact with water, will liberate hypochlorous acid, a weak acid and strong oxidizing agent. In general, it can be used as a chlorinating agent, disinfectant, or industrial deodorant. In water treatment, it has been used as the active ingredient in powdered laundry bleach such as Sage's Dry Bleach and Colgate's Pruf (EA, 1999b). The DANC cans within the trench were removed in 2011 by Shaw Environmental and Infrastructure, Inc. under separate Navy contracts. Contract and details of which are provided in the Removal Action Completion Report (Shaw, 2012). Three monitoring wells were sealed to facilitate the removal and were not replaced.

2.2.4 Initial Response

The only pre-ROD cleanup activity performed at Calf Pasture Point was the demolition of one of the munitions bunkers in 1997. The other two bunkers were demolished in 2000.

2.2.5 Basis for Taking Action

Potential human health risks associated with exposure to the contaminants of concern (COCs) were estimated through the evaluation of several potential exposure scenarios. These scenarios were developed to reflect the potential for exposure to COCs based on the present land uses, the potential future land uses, and the location of the site. The Human Health Risk Assessment (HHRA) was prepared in accordance with CERCLA guidance using the Phase I, II, and III Remedial Investigation (RI) data (TRC 1991 and 1994; EA 1998a).

The Base Re-use Plan for Calf Pasture Point specifies open space/conservation, which may include recreational activities. Accordingly, the Navy evaluated exposure pathways for hypothetical future recreational users and consumers of locally-caught, non-depurated shellfish. For purposes of completeness, the Navy also evaluated future construction/remediation workers and hypothetical future residents. The future recreational scenario assumed a showering facility may be constructed utilizing groundwater from the site; however, it is more likely that any future showering facility at Calf Pasture Point would use municipal water available in the area from the Town of North Kingstown. The following exposure pathways were considered to represent potentially completed pathways for potential receptor

exposure to COCs in soil, groundwater, air, offshore sediment, shellfish, and/or surface water, and were evaluated in the HHRA for Site 07:

Exposures via Soil

- Incidental ingestion of total soil (by future construction workers)
- Incidental ingestion of surface soil (by recreational users)

Exposure via Sediment

- Incidental ingestion of sediment (by recreational users)

Exposures via Groundwater

- Incidental ingestion of shallow groundwater (by future construction workers)
- Consumption of deep/bedrock groundwater (by hypothetical future residents)
- Inhalation of volatile organic compounds (VOCs) from deep/bedrock groundwater while showering (by recreational users)
- Dermal contact with deep/bedrock groundwater while showering (by recreational users)

Exposures via Surface Water

- Incidental ingestion of surface water while swimming (by recreational child/adult users)
- Dermal contact with surface water while swimming (by recreational child/adult users)

Exposure via Shellfish

- Ingestion of shellfish collected from Allen Harbor adjacent to Site 07.

A detailed description of these exposure scenarios and pathways can be found in Section 6.4 of Volume I of the Phase III RI (EA, 1998a).

CVOCs [predominantly 1,1,2,2-PCA and trichloroethylene (TCE) in groundwater] were identified as the primary COCs for Site 07. Risk estimates for the following COCs exceeded a Hazard Index (HI) of 1 (i.e., an indication of the potential for adverse non-carcinogenic health effects) or the EPA target cancer risk range of 10^{-4} to 10^{-6}:

aluminum	chloroform	1,1,2-trichloroethane (1,1,2-tca)
arsenic	benzene	trichloroethene (tce)
beryllium	vinyl chloride	1,1,2,2-tetrachloroethane
chromium	1,1-dichloroethene (1,1-dce)	tetrachloroethene (pce)
manganese	1,2-dce (total)	

Risk estimates for the following human exposure pathways were identified as unacceptable based on the risk assessment of COCs in the environmental media at Site 07:

- Ingestion of deep overburden and bedrock groundwater by residential populations (due to elevated concentrations of VOCs and several inorganics)

- Inhalation of VOCs in deep and bedrock groundwater by recreational populations while showering

- Dermal contact with VOCs in deep and bedrock groundwater by recreational populations while showering.

The HHRA also evaluated risks assuming human exposure to COCs in shoreline and offshore sediment and shellfish. The marine Ecological Risk Assessment (ERA) (SAIC, 1996) evaluated risks to the environment using data for offshore sediment and shellfish samples collected along the western and southern shorelines of Calf Pasture Point. VOCs (the COCs at Site 07) were not identified as a concern in either the shoreline sediment or shellfish samples. No significant terrestrial ecological risks were identified at Site 07.

2.3 REMEDIAL ACTIONS

This section discusses the remedy selection and implementation history for Calf Pasture Point, along with a discussion of the long-term monitoring program currently in place at Site 07.

2.3.1 Remedy Selection

The ROD for Site 07 was signed on September 30, 1999. The selected remedy was deed restrictions with long-term monitoring (LTM). As stated in the ROD, the Remedial Action Objectives (RAOs) for Site 07 are to prevent human exposure to COCs in deep overburden and bedrock groundwater and to ensure that the discharge of groundwater to wetlands and offshore areas continues to pose no unacceptable risks from COCs. The selected remedial alternative includes the following components:

- A deed restriction prohibiting the use of groundwater in order to prevent human contact with, or use of, impacted groundwater from the site (e.g., for drinking or showering purposes) maintained for as long as the site groundwater conditions may pose an unacceptable risk to human health or the environment. No use of groundwater for any purpose (including showering, drinking, and irrigation) will be available onsite. In addition, any design, construction or development of any building, structure, facility, or other improvement within the southern portion of the property (Figure 2-2) shall include adequate ventilation, as approved by the Navy, EPA, and RIDEM. The Grantee under the deed shall be required to submit a yearly certification to the Navy, EPA, and RIDEM of compliance with the deed restrictions. The groundwater and land use restrictions contained in the deed shall be incorporated into an Environmental Land Use Restriction (ELUR), which also shall be filed and recorded by the Navy or disposal agency in the land records of the Town of North Kingstown, Rhode Island, in accordance with state and local law.

- Long-term monitoring of the groundwater plume to ensure that the site continues to pose no unacceptable risks to human health or the environment. Other media such as sediment from the shoreline or interior wetlands are also sampled, based upon trends identified from groundwater data.

- Five-year reviews of the remedy for the site by the Navy, EPA, and RIDEM to ensure the continued protection of human health and the environment (EA, 1999b).

Additionally, the ROD stated that signature of the ROD constituted final documentation that the three former munitions bunkers were closed appropriately as described in the Foster Wheeler Environmental Corporation (FWENC) Close-out Report (FWENC, 1997).

2.3.2 Remedy Implementation

During August 2001, the LTMP was initiated with Monitoring Event (ME) 01. LUCIP inspections were initiated in May 23, 2001. The deed was recorded on October 17, 2001. Implementation of the LTMP began in August 2001. The ELUR was recorded on May 8, 2009.

2.3.2.1 Long-Term Monitoring: Sampling Events through ME 08

At Site 07, the Navy is performing LTM as part of the actions required by the ROD, dated September 27, 1999 (EA, 1999b). The selected site remedy is long-term monitoring with institutional controls to ensure the continued protection of human health and the environment. In 2001, a *Quality Assurance Project Plan (QAPP) for Long-Term Monitoring at Site 07* (EA, 2001a) was established pursuant to the ROD. The QAPP establishes the requirements for monitoring, sampling, and analysis of groundwater and

sediment, along with the implementation of institutional controls to prevent human contact with contaminants in groundwater at Site 07.

The scope of LTM at Site 07 has been continually re-evaluated and modified since the inception of the program in a progressive, pro-active manner. In 2001, the initial scope of groundwater monitoring included sampling at nine-month intervals from a network of 16 wells and 10 shoreline piezometers, and sampling at 27-month intervals from an expanded list of 26 wells and 24 piezometers. Based on the evaluation of LTM data and a review of the remedy for the first Five-Year Review (EA, 2003); several new wells and piezometers were added to the LTMP network between 2002 and 2004. The new wells and piezometers were added to the nine-month sampling list, resulting in a nine-month list consisting of 27 wells and 33 piezometers, and a 27-month list consisting of 37 wells and 33 piezometers.

During the first monitoring event in 2001, the LTMP sampling network consisted of 16 on-site monitoring wells and 10 shoreline piezometers. All ten of the ME 01 piezometers were located along the southern shoreline of Calf Pasture Point, within the entrance channel to Allen Harbor. For ME 02, an expanded (27-month) list of wells was sampled and 14 new piezometers were installed to monitor the western shoreline of Calf Pasture Point.

Based on the results of ME 01 and ME 02 sampling, and as recommended in the first *Five-Year Review Report for Former NCBC Davisville* (EA, 2003c), nine additional piezometers were installed and sampled during ME 03. The new piezometers were installed along the western shoreline of Calf Pasture Point between the two clusters of piezometers that were installed prior to ME 02, so that complete coverage of the plume discharge area in Allen Harbor was achieved. Also added to the LTMP network for ME 03 were monitoring wells MW07-35S and MW07-36S: these wells were installed in October 2002 to further characterize the extent of the CVOC plume in the shallow groundwater zone along the western edge of the site, in the “cove” area south of well cluster MW07-33.

During March and April 2004, eight monitoring wells were installed at Site 07, as recommended in the first *Five-Year Review Report for Former NCBC Davisville* (EA, 2003c). In addition, a monitoring well was added based on field-screening information obtained during drilling. These nine monitoring wells were added to expand the LTM network for groundwater and to allow further evaluation of the site hydrogeology in the area southwest of the source area to the harbor “cove” area and the CVOC plume migration in the central portion of the site. These wells have been sampled during each LTMP event since ME 05 (August 2004).

2.3.2.2 Bi-Monthly Sampling of Piezometers and Surface Water

In May 2004, in response to the detection of elevated concentrations of CVOCs in shoreline piezometers during the December 2003 sampling round, "No Swimming – No Wading" signs were erected along the shoreline in the entrance channel. After similar magnitude detections during the August 2004 sampling event were observed in October 2004, the Navy commenced supplementary bi-monthly sampling of shallow water from eight piezometers and sampling of surface water locations adjacent to these piezometers. These samples were analyzed for the same list of targeted VOCs specified for groundwater samples collected from Site 07. Bi-monthly piezometer and surface water sampling continued until January 2006.

2.3.2.3 Shoreline Human Health Risk Assessment

In June 2007, the Navy completed a human health risk assessment using the shoreline surface water, sediment, and piezometer groundwater data collected during the LTMP (through ME 06) and the bi-monthly piezometer and surface water sampling program. The objective of the risk assessment was to evaluate human health risks associated with potential human exposure to surface water, sediment, shallow groundwater, and shellfish located along the shoreline of Calf Pasture Point.

The risk assessment evaluated the following potential exposure pathways:

- Dermal contact (skin surface exposure) with or incidental ingestion of surface waters and sediments while swimming, wading, or gathering shellfish
- Dermal contact with shallow groundwater while digging into shoreline sediments to gather shellfish
- Consumption of shellfish collected from along the Calf Pasture Point shoreline.

Standard EPA methodology, as presented in the EPA's *Risk Assessment Guidance for Superfund (Part A)* (December 1989), was used to estimate cancer and non-cancer risks associated with these potential exposure pathways.

Quantitative risk estimates for the receptors evaluated and a listing of the primary COCs are provided on Tables E-1 and E-2 of Appendix E, respectively. All of the cancer risk estimates developed for potential human exposure to chemicals of potential concern (COPCs) in surface water, sediment, and shallow groundwater while swimming, wading, or shellfishing were within the EPA's acceptable risk range and below RIDEM's cancer risk benchmarks. All of the non-cancer risk estimates associated with these exposures were below EPA and RIDEM risk benchmarks (Tetra Tech, 2007l). It should be noted that the 2007 shoreline risk assessment for Site 07 was based on data available at the time the assessment was

prepared; the assessment was not based on modeled, future concentrations for environmental media along the shoreline.

The cancer and non-cancer risk estimates developed for the consumption of shellfish exceeded both EPA and RIDEM risk management benchmarks. The primary COPCs contributing to the cancer and non-cancer risk estimates were arsenic, mercury, and PCBs. A review of source area data for Calf Pasture Point and background data for sediments and shellfish indicated that the presence of these chemicals is not a consequence of disposal activities at Site 07 (Tetra Tech, 2007l).

In 2012, the shoreline risk assessment was updated using surface water, sediment, and shallow groundwater data collected since 2007. The results of the updated risk assessment are presented in detail in Appendix F, and are summarized in the associated Table F-3FF. All of the cancer risk estimates developed for potential human exposure to COPCs in surface water, sediment, and shallow groundwater while swimming, wading or shellfishing were within the EPA's acceptable risk range and below RIDEM's cancer risk benchmarks. All of the non-cancer risk estimates associated with these exposures were below EPA and RIDEM risk benchmarks.

2.3.2.4 Changes in Monitoring Frequency since ME 08

Starting in the fall of 2007, the Navy increased the frequency of long-term monitoring at Calf Pasture Point to semi-annually, and temporarily added nine monitoring wells to the LTMP network. These changes were made in order to augment the database of groundwater chemistry information, refine the conceptual site model (CSM), and aid in optimizing the monitoring program. Semi-annual monitoring was conducted for the full 27-month well list plus six "contingent" wells and three additional wells not originally included in the LTM well list, for a total of 46 monitoring wells. Each round of monitoring also included the collection of shallow groundwater samples from 33 piezometers and the collection of six sediment samples from along the entrance channel shoreline. The rationale for the inclusion of each of the nine monitoring wells is provided below:

- MW07-05S: Provide an updated measure of VOCs present in the shallow aquifer within the presumed source area.

- MW07-05D: Provide additional characterization of VOC levels in the deep aquifer within the source area.

- MW07-16D: Assist in delineating the extent of contamination to the southeast.

- MW07-18D: Assist in delineating the extent of contamination to the southeast.

- MW07-20S: Assist in delineating contamination in the shallow aquifer to the southeast of the suspected source area.

- MW07-20D: Assist in delineating the extent of contamination to the southeast.

- MW07-23S: Assist in evaluating if upwelling has occurred in the downgradient area located south of the source area, near the entrance channel and to the west of MW07-21S.

- MW07-24D: Assist in delineating the extent of contamination to the south/southeast of the suspected source area.

- MW07-29D: Assist in delineating the extent of contamination to the east of the source area.

During ME 10 (May 2008), the Navy added three additional wells to the LTM network for additional refinement of the conceptual site model.

- Monitoring wells MW07-32D and MW07-32R were added to evaluate groundwater quality on Spink Neck, located across the Allen Harbor Entrance Channel from Calf Pasture Point, and

- Monitoring well MW07-24S was added to verify the southern boundary of the groundwater plume in the shallow overburden aquifer.

These monitoring wells were retained for ME 11 through ME 13, resulting in a total of 49 monitoring wells sampled during the May 2008 through September/October 2009 monitoring rounds.

In March 2009, the Navy submitted a Draft *Sampling and Analysis Plan (SAP) for Long-Term Monitoring at Site 07* proposing revisions to the LTMP in an effort to optimize the program. Optimization of the LTMP for Site 07 was one of the action items provided in the *Second Five-Year Review for NCBC Davisville* completed in 2008 (Tetra Tech, 2008b). EPA and RIDEM provided comments on the revised sampling strategy in April/May 2009, and the Navy provided responses in June 2009. EPA and RIDEM comments on the draft plan have not been resolved. Resolution of comments is not anticipated until the Navy finalizes the formal report regarding the Source Area Investigation, which occurred in spring 2011 through summer 2012. A revised Draft SAP, reflective of and inclusive of the findings of the completed Source Area Investigation, will be completed and submitted in summer 2013.

During the October 1, 2009 BCT meeting, Navy, EPA, and RIDEM discussed interim scope changes to the existing LTMP for Site 07. The Navy documented these modifications in a letter dated October 9, 2009, and in notes from the January 21, 2010, BCT meeting. EPA issued a letter, dated February 11, 2010, concurring with nearly all of the suggested scope changes; the interim revisions to the LTMP were to be followed through the Fall 2011 sampling event. To summarize the agreement, the interim monitoring program for Site 07 during 2010 and 2011 consisted of semi-annual sampling from 39 monitoring wells, 21 shoreline piezometers, and six shoreline sediment locations for VOCs and salinity.

In April, 2010 the Navy notified EPA and RIDEM that all but one of the "No swimming –No Wading" signs were damaged over the previous winter and that they would not be replaced, pending the outcome of the updated shoreline risk assessment (see Appendix F).

ME 14 for Site 07 was completed in April 2010 in accordance with the interim monitoring program. In June 2010, EPA performed two site visits in order to assess the monitoring well network and shoreline environment. A Trip Report dated August 2, 2010, was provided to the Navy. In August and September, EPA performed various investigative activities along the Site 07 shoreline and shallow groundwater system. On September 30, 2010, the Navy submitted the Draft SAP for the Source Area Investigation at Site 07. Because of the investigative activities that EPA performed, recommendations contained in the August 2 Trip Report, and activities that were planned to occur as part of the Source Area Investigation by the Navy, concurrence was agreed that the fall 2010 LTM sampling event would be postponed until spring 2011, when the source area fieldwork was anticipated to occur.

After addressing several rounds of comments from EPA and RIDEM on the draft document, the Draft Final SAP for the Source Area Investigation was submitted on February 15, 2011. During the BCT meeting on March 17, 2011, EPA, RIDEM and the Navy concurred that the Spring LTM sampling event would be postponed until fall 2011 because new monitoring wells would be installed during the source area investigation to provide a more complete understanding of site conditions. This agreement is documented in Navy correspondence dated March 28, 2011. Per this agreement, ME 15 for Site 07 was completed in the fall of 2011.

As outlined in the interim monitoring program agreement, the interim revisions were only valid through the end of 2011. In follow-up to the Source Area Investigation and in support of the Third Five-Year Review, a one-time comprehensive LTM was proposed for the summer of 2012. During the BCT meeting on March 22, 2012, a preliminary sampling program was presented to EPA and RIDEM for evaluation and consideration. The proposed sampling program was further refined and discussed during a BCT teleconference dated May 7, 2012. EPA provided comments on the sampling plan on June 19, 2012. Navy responded to the comments on September 12, 2012, and EPA accepted the comments and

sampling plan on September 24, 2012. The fieldwork was completed in the summer of 2012 and is considered ME 16.

The following table summarizes ME 01 through ME 16:

Monitoring Event	Date	Wells Sampled	Piezometers Sampled
ME 01	August 2001	16	10
ME 02	May 2002	26	24
ME 03	February 2003	18	33
ME 04	December 2003	18	33
ME 05	August 2004	37	33
ME 06	May 2005	27	33
ME 07	November 2006	27	33
ME 08	February/March 2007	46	32
ME 09	November/December 2007	45	31
ME 10	May/June 2008	49	33
ME 11	September/October 2008	49	32
ME 12	April 2009	49	33
ME 13	September/October 2009	49	33
ME 14	April 2010	37	21
ME 15	September/October 2011	55	23
ME 16	June/July 2012	73	15

Currently, the only approved LTMP for Site 07 is the 2001, *QAPP for Long-Term Monitoring at Site 07* (EA, 2001a). As indicated above, this scope includes sampling at nine-month intervals from a network of 16 wells and 10 shoreline piezometers, and sampling at 27-month intervals from an expanded list of 26 wells and 24 piezometers. These well lists do not include new wells installed since the inception of the plan, and also do not reflect current conceptual understanding of the site. Therefore, an updated LTMP is an action item for this Third Five-Year Review.

2.4 PROGRESS SINCE THE LAST REVIEW

The Second Five-Year Review concluded that the remedy at Calf Pasture Point is currently protective of human health and the environment, and exposure pathways that could result in unacceptable risks are being addressed through institutional controls that prevent exposure to contaminants in site groundwater. In order to ensure that the remedy continues to be protective in the long term, further investigation within the source area and along the shoreline was performed (see Section 2.5).

This section presents the recommendations and follow-up actions that were included in the Second Five-Year Review, with a brief description of the actions taken by the Navy since the last review.

2.4.1 Issue 1: LTM program needs to be reviewed/updated. CVOC plume expansion to the south and east suggests the plume may not be stable.

To address the issue of reviewing and updating the LTM program for Site 07, the following recommendations were made:

1. *Finalize Revised CSM and Monitoring Optimization Report for Site 07.*

Actions Taken: Based on comments from regulators in February and March of 2008, a *Final Revised Conceptual Site Model and Monitoring Optimization Report for Site 07, Calf Pasture Point was completed and submitted on April 11, 2008.*

Results of Actions: Based on the completed *Final Revised Conceptual Site Model and Monitoring Optimization Report for Site 07, Calf Pasture Point, the issue was addressed.*

2. *Schedule a Data Quality Objectives (DQO) meeting to discuss optimization and establish the objectives and scope of the LTMP.*

Actions Taken: Several scoping meetings were scheduled between June and November 2008 to establish the objectives and scope of the optimization of the LTMP.

Results of Actions: A full DQO meeting in compliance with the *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP) DQO process was held on June 26, 2008, at RIDEM headquarters in Providence, Rhode Island. During the meeting, it was determined that the Navy and EPA were not in agreement regarding the CSM for Site 07. Regardless, it was agreed that modifications to the LTM program could proceed. To support preparation of the revised Work Plan/SAP for Long-Term Monitoring, three teleconferences were held, each targeting a specific topic or conceptual idea. A teleconference to discuss the risk issues was held on October 2, 2008, while a teleconference to discuss the relevant hydrogeological issues was held on October 9, 2008. Approximately a month later, on November 6, 2008, a final teleconference was held to complete the DQO process started in June.

3. *Prepare a revised Work Plan/SAP for Long-Term Monitoring at Site 07.*

Actions Taken: As a result of the four scoping meetings held between June and November 2008, the Navy prepared a Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point. This document was submitted in March 2009.

Results of Actions: A significant number of comments were received from EPA and RIDEM regarding the March 2009 submittal of the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point. The Navy has responded to the comments, however, the revised LTMP has not been finalized. The BCT agreed that no further work on modifications to the LTMP would be pursued until the Source Area Investigation report was completed and the CSM for Site 07 was updated.

2.4.2 Issue 2: Uncertainty regarding CVOC source area.

To address the issue of uncertainty regarding the CVOC source area, the following recommendations were made:

1. *Schedule a DQO meeting to establish objectives and scope for Source Area Investigation.*

Actions Taken: Several scoping meetings were scheduled between October 2009 and January 2011 to establish the objectives and scope of the Source Area Investigation for Site 07.

Results of Actions: In compliance with the UFP-DQO process, a full DQO meeting was held on October 1, 2009, at RIDEM headquarters in Providence, Rhode Island. Based on this DQO meeting, the project team agreed upon a general scope of investigations to be performed. The proposed investigation would entail more than a Source Area Investigation. In addition to the source area, the investigation would include further evaluation and delineation of the current contaminant plume(s) and potential discharge to the offshore environment. This resulted in the identification of three problem statements to be addressed in the UFP-SAP Work Plan.

Two teleconferences were held to support the preparation of the UFP-SAP Work Plan for the Source Area Investigation. The first teleconference was held on February 9, 2010. During this teleconference, field sampling methods to be utilized during the investigation were discussed. The second teleconference was held on January 11, 2011, with the goal of resolving regulator comments on the Draft SAP for the Source Area Investigation, submitted September 2010, so that a Draft Final SAP could be prepared and submitted, and fieldwork could begin in the spring of 2011.

2. *Prepare a Work Plan/SAP to support the Source Area Investigation.*

Actions Taken: As a result of the first two scoping meetings (October 2009 and February 2010), the Navy prepared and submitted the Draft SAP (Field Sampling Plan and QAPP) in September 2010.

Results of Actions: To facilitate completion of the Draft Final version of the document, a teleconference was held on January 11, 2011 to discuss/resolve comments received on the Draft document (see above). The Navy published the Draft Final document in February 2011.

2.4.3 Issue 3: Historical increase in CVOC concentrations in Entrance Channel piezometers.

To address the issue of historical increases of CVOC concentrations in the Entrance Channel piezometers, the following recommendations were made:

1. *At the DQO meeting for LTMP, establish the objectives and scope for future shoreline monitoring.*

Actions Taken: During the aforementioned DQO meetings (see Section 2.4.1), the objectives and scope of future shoreline monitoring were discussed and incorporated into the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point. The Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point was not completed.

Results of Actions: Worksheets #11, #14, and #17 of the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point summarized the objectives and scope of the future shoreline monitoring. However, as summarized in Section 2.4.1, a significant number of comments were received from EPA and RIDEM and a revised LTMP was not completed. The BCT agreed that no further work on modifications to the LTMP would be pursued until the Source Area Investigation report was completed and the CSM for Site 07 was updated.

2. *Develop trigger values for shoreline media to verify that CVOCs reaching the shoreline continue to pose no unacceptable risks.*

Actions Taken: During development of the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point, a trigger value for a sentinel well was developed for each COC; the trigger value is intended to alert the BCT to potentially unacceptable CVOC concentrations in groundwater (from a risk assessment point of view), should the groundwater discharge to surface water. The Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point was not completed.

Results of Actions: The BCT agreed that no further work on modifications to the LTMP would be pursued until the Source Area Investigation report was completed and the CSM for Site 07 was updated.

3. *Develop decision matrix to guide decision-making for shoreline monitoring program.*

Actions Taken: During development of the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point, a decision matrix was prepared. The Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point was not completed.

Results of Actions: The BCT agreed that no further work on modifications to the LTMP would be pursued until the Source Area Investigation report was completed and the CSM for Site 07 was updated.

2.4.4 Issue 4: Increasing monitoring costs.

To address the issue of increasing monitoring costs, the following recommendations were made:

1. *Finalize Revised CSM and Monitoring Optimization Report for Site 07.*

Actions Taken: See Section 2.4.1, number 1.

Results of Actions: See Section 2.4.1, number 1.

2. *At DQO meeting for LTMP, discuss optimization of LTMP.*

Actions Taken: See Section 2.4.1, bullet 2.

Results of Actions: See Section 2.4.1, bullet 3. While the Draft SAP (Field Sampling Plan and QAPP), Long-Term Monitoring, Site 07, Calf Pasture Point has not been finalized, and proposed modifications to the LTMP contained therein have not been agreed upon by the BCT, several expansions of the LTMP have occurred since the Second Five-Year Review. Changes to the LTMP are outlined in Section 2.3.2.1, 2.3.2.2 and 2.3.2.4.

3. *Based on results of the Source Area Investigation, consider source reduction technologies that might reduce long-term monitoring costs.*

Actions Taken: The Source Area Investigation was conducted between April 2011 and July 2012. The results of the investigation are currently being evaluated and a report is being prepared by the Navy. The source area material discovered during the Source Area Investigation was removed in 2011 (see

Section 2.2.3). It is anticipated that this source area reduction will impact the long-term source loading to the groundwater and, thus, the number of years that COCs will exceed the remedial goals established for Site 07.

Results of Actions: No actions have occurred yet, pending submission of the comprehensive evaluation of Site 07 data.

2.4.5 Issue 5: Risk communication to community

The following recommendation was provided in the Second Five-Year Review, to address the issue of communication of risk to the community: *Develop fact sheet for Site 07 providing information to the public in laymen's terms, regarding risks associated with planned activities and uses for Calf Pasture Point.*

Actions Taken: A fact sheet was posted at Site 07 in August of 2009. The fact sheet summarizes the site history (including the environmental investigations conducted at Site 07), the scope of the LTM, and the results of the Five-Year Review reports for Site 07.

Results of Actions: The public is more effectively informed regarding the risks associated with planned activities and uses for Calf Pasture Point.

2.4.6 Issue 6: ELUR has yet to be recorded.

To address the issue that the ELUR has not yet been recorded at the time of the Second Five-Year Review, the following recommendation was made:

1. *Work with the Town to expedite recording of the ELUR for Parcel 9.*

Actions Taken: Navy developed and provided the ELUR documentation for the Town of North Kingstown to facilitate recording of the ELUR for Parcel 9.

Results of Actions: The ELUR for Parcel 9 was recorded on 8 May 2009. A copy was subsequently forwarded to EPA and RIDEM.

2.5 FIVE-YEAR-REVIEW PROCESS

In this section, a description of the five-year review process specific to Calf Pasture Point, including the document review, data review, and site inspection is provided. Basewide five-year review items, such as community involvement and interviews, are discussed in Section 1.0.

2.5.1 Document Review

A review of documents relevant to the remedial actions and LTM activities conducted at Calf Pasture Point was undertaken as part of the five-year review. The documents reviewed in order to complete the evaluation included Remedial Investigation reports and baseline risk assessments; the Feasibility Study, Proposed Plan, and ROD; LTM work plans; LTM sampling data reports; supplemental LTM efforts, such as the Final *Revised Conceptual Site Model and Monitoring Optimization Report* (Battelle, 2008b), *Coastal Contaminant Migration Monitoring Assessment* (SPAWAR, 2005), EPA *Plume Discharge Investigation* (USEPA, 2005a), *Sampling Recommendations to Minimize Impacts to Wetlands at Site 07* (Battelle, 2007), and the *Human Health Risk Assessment of Shoreline Surface Waters and Sediments, and Groundwater in Shallow Piezometers* (Tetra Tech, 2007l), Draft Long-Term Monitoring Data Summary Report for Site 07: Calf Pasture Point (Tetra Tech, 2010e) and various draft and final ME data reports, as appropriate. For a complete list of documents that were reviewed during this five-year review, please refer to the References section of this report.

2.5.2 Data Review

A review of Calf Pasture Point LTM data, along with data collected from investigative activities to supplement the LTMP, was performed as part of the five-year review. Numerous LTM monitoring events and investigative activities have been performed at the site, (not all specifically designed and performed to update the LTMP or CSM), by different agencies although not all specifically designed and performed to update the LTMP or conceptual site model) since the early 2000s. In particular, many investigative activities have occurred at the site between 2010 and 2012 that have resulted in a more robust and more refined understanding of the current and anticipated future site conditions.

Since inception of the remedy and throughout the LTMP, uncertainty, continuous uncertainties about the nature, extent of contamination have been raised by the BCT. Key areas of uncertainty included: whether a source of contamination remained (e.g. was there a trench backfilled with containers with DANC, or not); extent of contamination in soil and groundwater (e.g. are there areas of COCs at significant concentrations that are acting as residual source areas); migration pathways within the groundwater flow-field (e.g. are there migration pathways not identified and/or does migration occur within specific groundwater site-wide regimes); location of discharge of the contaminant plume(s) to the off-shore (e.g. where do discharges occur – spatial and vertical locations as well as timing within the tidal cycle); and long-term trends of contamination within the various contaminated media [soil, groundwater, shallow groundwater (via piezometers) and sediments] with respect to whether the LTMP accurately samples appropriate media and at appropriate intervals.

2.5.2.1 Investigative Activities

This section summarizes the additional investigative activities conducted at Site 07 from 2010 through 2012, which included:

- Shoreline and groundwater investigations by EPA Region 1
- Several phases of hydrogeological investigations by EPA Kerr Research Center
- The Navy Source Area Investigation
- The Navy shoreline surface water investigation.

Figure 2-3 presents the locations of site groundwater monitoring wells, piezometers, and other site features, grouped by investigation.

All of the investigative activities were conducted in the central to south, and central to east portions of the site and/or along the Entrance Channel and Narragansett Bay shorelines. No investigative work was performed in the central to west portion of the site, where the CVOC plume migrates toward and discharges to the Allen Harbor shoreline.

A comprehensive summary of the work performed is provided under separate cover (Source Area Investigation and Long-Term Monitoring Data Summary Report for Site 7 Calf Pasture Point, Tetra Tech 2013).

2.5.2.1.1 EPA Region 1 and EPA Kerr Research Center

During 2010, 2011, and 2012, several phases of investigative work by EPA have been completed at Site 07. Some phases of work are ongoing (and will continue into 2013 and beyond). This section summarizes the work completed by EPA at Site 07 between 2010 and 2012.

EPA Region 1 Investigative Work

In late summer to Fall 2010, EPA Region 1 began various investigative activities conducted to address perceived data gaps regarding:

- The location of discharge of fresh groundwater to the shoreline environment;
- Environmental conditions in the shallow groundwater zone across the site; and,
- Environmental conditions in the intermediate and/or deep groundwater zones at select locations across the site.

To address perceived data gaps regarding the discharge of fresh groundwater to the shoreline environment, EPA Region 1 installed temporary piezometers in three groups along the shoreline. The piezometers were installed in transects and along a grid pattern (distance between successive locations being 25 to 50 feet) – east of P07-02 to Spink's Neck and along two portions of the shoreline along the Narragansett Bay shoreline. The temporary piezometer locations are depicted on Figure 2-3.

EPA Region 1 collected groundwater samples from these locations (as applicable and appropriate) during three separate sampling events (August 5, September 20 to 22, and October 20 and 21). The groundwater was measured for temperature, salinity, conductivity, and select CVOC parameters. Temperature, salinity, and conductivity were measured in the field; groundwater samples were analyzed for the CVOC parameters at the EPA Regional Laboratory in North Chelmsford, Massachusetts.

EPA Region 1 installed monitoring wells (screened at various depths) at 12 locations deemed to be potential data gaps. All of the wells were installed with Direct Push Technology (DPT) GeoProbe® pre-packed 1.5-inch-diameter wells with 10-foot screen sections. EPA Region 1 also installed 14 shallow-depth piezometers across the site to assess groundwater in the shallow (water table) zone. All of the piezometers were 0.75-inch-diameter Solinst® stand pipes. The locations of the 12 DPT groundwater wells and 14 shallow piezometers are shown on Figure 2-3. The following table summarizes pertinent installation details for monitoring wells and piezometers.

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone (feet below ground surface)	Diameter (inches)
DPT Groundwater Monitoring Wells			
DPT-16S	Shallow	5 - 15	1.5
DPT-16I	Upper Deep	45 - 55	1.5
DPT-18S	Shallow	5 - 15	1.5
DPT-18I	Upper Deep	45 - 55	1.5
DPT-30S	Shallow	5 - 15	1.5
DPT-30I	Upper Deep	45 - 55	1.5
DPT-29/34S	Shallow	5 - 15	1.5
DPT-29/34I	Upper Deep	45 - 55	1.5
DPT-24I	Intermediate	33 - 43	1.5
DPT-24D	Deep	45 - 55	1.5
DPT-09/27D	Deep	30 - 40	1.5
DPT-09/28D	Deep	40 - 50	1.5
Solinst® Piezometers			
PZ-1	Shallow	4 - 7	0.75
PZ-2	Shallow	4 - 7	0.75
PZ-3	Shallow	4 - 7	0.75

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone (feet below ground surface)	Diameter (inches)
PZ-4	Shallow	4 - 7	0.75
PZ-5	Shallow	4 - 7	0.75
PZ-6	Shallow	4 - 7	0.75
PZ-7	Shallow	4 - 7	0.75
PZ-8	Shallow	4 - 7	0.75
PZ-9A	Shallow	1.5	0.75
PZ-9B	Deep Shallow	3.5 - 6.5	0.75
PZ-10A	Shallow	3	0.75
PZ-10B	Deep Shallow	3.8 - 6.8	0.75
PZ-11	Shallow	4 - 7	0.75
PZ-12	Shallow	4 - 7	0.75
PZ-13	Shallow	4 - 7	0.75

No soils were recovered or sampled during installation of the DPT wells and Solinst® piezometers. Therefore, no lithological information was obtained during the investigation to confirm that the wells were accurately placed with respect to lithologies or with regard to highest contaminant screening position.

Groundwater samples were collected from the DPT wells on January 31, February 1, March 22, or March 23, 2011, by EPA. The wells were sampled by low-flow/low-stress procedures and samples were submitted to the EPA Regional Laboratory in North Chelmsford, Massachusetts for analysis of VOCs.

Additional details regarding the work completed, interpretations and conclusions have been provided under separate cover (Source Area Investigation and Long-Term Monitoring Data Summary Report for Site 7 Calf Pasture Point, Tetra Tech 2013) and EPA-New England in consultation with Gannett Fleming/CDW.

EPA Kerr Research Center Work

Researchers from the University of Florida (UF) and the EPA's Kerr Research Center, in coordination with EPA Region 1 and the Navy, have performed several phases of hydrogeological investigations since the fall of 2010. The focus of the UF and EPA Kerr Research Center's work is source decay and contaminant flux evaluation; the objective of better understanding the long-term flow and transport mechanisms of the primary site contaminants, the CVOCs.

Since the fall of 2010, work performed has occurred in two main areas:

- Passive flux meters (PFMs) for measuring groundwater flow and contaminant flux in monitoring wells were deployed and the resultant data evaluated

- A multi-month tidal study was conducted to better calibrate and understand groundwater migration pathways.

To date, PFMs have been deployed and data collected during three phases of work. The first phase began on September 22, 2010 and involved the following wells: MW07-31I, MW07-15D, MW07-04D, MW07-05D, and MW07-17D. This phase of the work was conducted to investigate groundwater and contaminant flux within and near the inferred source zone. Additionally, groundwater samples were collected from wells MW07-03D, MW07-14D, MW07-15D, and MW07-31I and submitted for CVOC analysis. These wells were not part of the LTM program at that time, and were last sampled during the Phase III RI in 1995. Consequently, these wells were sampled to assess potential changes in source-zone characteristics since that time. Samples were collected using a stainless steel bailer which was washed with Alconox soap and rinsed with deionized (DI) water prior to sampling at each well. The bailer was also used to check for possible dense non-aqueous-phase liquid (DNAPL) at the bottom of each of the wells. Based on visual observation of the recovered groundwater, DNAPL was not detected; however, the recovered groundwater was fairly turbid.

A second PFM deployment, focusing on areas downgradient from the inferred source area, was completed in the spring of 2011. The wells included were MW07-09D, MW07-14D, MW07-27D, MW07-39S/I/D, MW07-34D, MW07-13D, MW07-11D and MW07-21S/D. Based on preliminary evaluations of this PFM data, the EPA Kerr Research Center coordinated with the Navy to analyze grain size data from soil samples throughout the site 07 area during the site 07 Source Area Investigation. Additionally, in the late summer of 2011, 22 groundwater monitoring wells were installed along three planes in order to evaluate contaminant flux occurring along the primary groundwater migration pathway to assess long-term contaminant migration rates/trends. Consistent with EPA Region 1, all of the wells were installed with DPT GeoProbe® pre-packed 1.5-inch-diameter wells with 10-foot screen sections. The following table summarizes pertinent installation details for the wells:

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone Interval (feet below ground surface/top of casing)	Diameter (inches)
DPT-15-1D	Deep	31.7 - 41.9	1.5
DPT-15-2I	Intermediate	21.4 - 31.6	1.5
DPT-15-3I	Intermediate	26.5 - 36.7	1.5
DPT-15-4D	Deep	32.1 - 42.3	1.5
DPT-15-5I	Intermediate	21.8 - 32.0	1.5

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone Interval (feet below ground surface/top of casing)	Diameter (inches)
DPT-17-1I	Intermediate	27.5 - 37.7	1.5
DPT-17-2D	Deep	38.5 - 48.7	1.5
DPT-17-3I	Intermediate	28.1 - 38.3	1.5
DPT-17-4D	Deep	37.5 - 47.7	1.5
DPT-17-5I	Intermediate	27.6 - 37.8	1.5
DPT-17-6D	Deep	39.4 - 49.6	1.5
DPT-17-7I	Intermediate	29.6 - 39.8	1.5
DPT-17-8D	Deep	34.5 - 44.7	1.5
DPT-17-9I	Intermediate	24.2 - 34.4	1.5
DPT-39-1I	Intermediate	28.9 - 39.1	1.5
DPT-39-2S	Shallow	17.4 - 27.6	1.5
DPT-39-3S	Shallow	21.4 - 31.6	1.5
DPT-39-3I	Intermediate	30.9 - 41.1	1.5
DPT-39-3D	Deep	40.8 - 51.0	1.5
DPT-39-4S	Shallow	20.6 - 30.8	1.5
DPT-39-4D	Deep	39.0 - 54.4	1.5
DPT-39-5S	Shallow	18.5 - 28.7	1.5

With the exception of DPT-39-4S, well development was completed between August 10 and September 14, 2011 by EPA Region 1, Tetra Tech and EPA Kerr Research Center. In general, well development was performed in three steps:

- First, approximately 15 liters of water (i.e., the approximate volume of water introduced into the well during installation) was removed;

- Second, well development continued until stable values of temperature, specific conductivity and turbidity were achieved; and,

- Third, well development continued until turbidity values less than 50 NTUs were achieved.

During the period of September 23 to 27, 2011, a third PFM deployment occurred utilizing a combination of the recently installed DPT groundwater monitoring wells and selected Site 07 groundwater monitoring wells. Emphasis was placed on selecting wells along three control planes situated at varying distances downgradient of the release area. The wells involved were: in the 15-series control plane - MW07-15D, DPT-15-3I, DPT-15-5I, DPT-15-4D, DPT-15-2I, and DPT-15-1D; in the 17-series control plane - MW07-17D, DPT-17-9I, DPT-17-8D, DPT-17-4D, DPT-17-5I, DPT-17-1I, DPT-17-3I, DPT-17-2D, DPT-17-6D and DPT-17-1I; and additionally, wells MW07-09D, MW07-39S, MW07-39I, MW07-39D,

DPT-09/27I, DPT-39-4D, DPT-39-4S, DPT-39-3S, DPT-39-3I, DPT-39-3D, DPT-39-2S, DPT-39-5S and DPT-39-1I. The locations of these wells are shown on Figure 2-3.

In order to better understand the groundwater migration pathways and help calibrate the PFMs in a tidally active area, a large-scale, multi-month tidal study was performed in late spring to summer 2012. To provide a more robust understanding of real-time groundwater impacts, the Navy opted to augment this proposed tidal study. In total, pressure transducers with data loggers were installed in 34 groundwater monitoring wells, at 1 staff gauge location in Allen Harbor, and at three barologgers. The Navy installed pressure transducers with data loggers in wells MW07-05S, MW07-05D, MW07-40D, MW07-27S, MW07-27D, MW07-41I, MW07-39I, MW07-42I, MW07-19S (and barologger), MW07-19D, MW07-13S, MW07-44D, MW07-43S, DPT07-24D and Allen Harbor Staff Gauge. The EPA Kerr Research Center installed pressure transducers with data loggers at: MW07-15D (and barologger), DPT-17-1I, MW07-17D, DPT-39-3S, DPT-39-3D, DPT-39-5S, MW07-39S, MW07-39D, MW07-13D, MW07-21S, MW07-21D, MW07-43D, MW07-24D, MW07-11D (and barologger), MW07-20S, MW07-20D, MW07-09D, MW07-45S and MW07-45D. Prior to installation of the pressure transducers with data loggers, times were synchronized between the Navy and EPA Kerr Research Center devices. During installation, depth to groundwater was recorded for the 34 monitoring wells.

The tidal study was performed from March 21 to June 11. Water levels were recorded every 15 minutes, resulting in approximately 7,680 total water level records. On April 24 and 25, the depth to water was recorded and data downloaded to ensure that data was being properly recorded. Additionally, Tetra Tech installed a second pressure transducer, with data logger capable of recording specific conductance, at five monitoring wells along the primary groundwater flow pathway toward the Entrance Channel. These were installed to evaluate real-time salinity effects and were left in place until May 25.

Upon completion of the tidal study, depth to water was recorded and data downloaded from all wells. The data was processed by correcting the direct pressure readings in the data file for barometric effects (from site barometers) and then converting the readings to elevations. Data analysis of the tidal study is presented in Section 2.5.2.3.4.

Based on the preliminary results of the third PFM deployment and tidal study, the EPA Kerr Research Center plans additional work at the site, including installation of more DPT groundwater monitoring wells and a fourth PFM deployment. This work is currently planned for the spring of 2013.

2.5.2.1.2 Source Area Investigation

Per the approved Final SAP for the Source Area Investigation:

- More accurate delineation of the nature and extent of the CVOC source area so that the potential benefit of supplemental remedial actions could be evaluated

- Further evaluation of potential preferential groundwater flow pathways (currently unmonitored) to determine whether those pathways are conveying significant concentrations of contaminants to the Calf Pasture Point shoreline or to Spink Neck. Migration to the shoreline or to Spink Neck could ultimately result in unacceptable risks to human receptors along the Calf Pasture Point shoreline or on Spink Neck

- Further evaluation of the potential discharge of contaminants into the surface water and sediments in the Allen Harbor Entrance Channel to determine whether CVOC concentrations are creating unacceptable risks to ecological receptors.

Background/Field Sampling Data Needs

To address the objectives listed above, a three-part investigation was implemented:

- **To accomplish the Objective Number 1, a surface geophysical survey was proposed with an initial grid of eight soil borings placed to coincide with the inferred source area.** Based on the results of the geophysical survey, a test pit was excavated to confirm the presence of buried drums/material. Soil samples were collected from each soil boring and evaluated using field-screening techniques to determine the presence of CVOCs, and, if present, to evaluate the corresponding depth(s) and geological unit(s) associated with the contaminants. Soil samples were shipped for laboratory analysis to verify field-screening observations.

- **To accomplish Objective Number 2, 21 soil borings were proposed to be advanced along the groundwater flow pathways from the source area toward Narragansett Bay and toward the Entrance Channel to Allen Harbor, and 12 groundwater monitoring wells were proposed for installation.** Soil samples were collected and evaluated using field-screening techniques to determine the presence of CVOCs, and, if present, to evaluate the corresponding depth(s) and geological unit(s) associated with the contaminants. Soil samples were shipped for laboratory analysis to verify field-screening observations.

- **To accomplish Objective Number 3, a grid of 30 screening locations were proposed along three transects oriented parallel to the Entrance Channel shoreline.** Pore-water samples were collected from targeted locations and analyzed in the field for salinity. Sediment, deep surface water, and pore water samples were collected from these locations and analyzed for CVOCs.

Field work was completed from April 2011 through July 2012. A brief summary of the activities that were implemented is provided below, and more comprehensive details of the work are provided under separate cover (in process).

Summary Of Pertinent Field Work Performed

The activities completed in the field between April 2011 and July 2012 are discussed below.

Surface Geophysical Survey - Tetra Tech conducted three geophysical surveys using a Geonics EM31-MK2 (EM31), a Geometrics G-858 magnetometer, and a GSSI SIR-3000 ground penetrating radar (GPR). A Differential Global Positioning System (DGPS) unit was used to locate the EM31 and magnetometer geophysical data. A tape-measured grid was used to position GPR data. Magnetometer and GPR surveys were not originally planned; however, these relatively low cost surveys were conducted as a cost effective way to help refine geophysical interpretations and provide assistance in planning and implementing follow-on ground truth investigations.

As a result of the geophysical surveys performed, the source area was delineated and subsequently removed in the summer of 2011.

Field-Screening of Soil, Groundwater, and Surface Water/Sediment - To maximize the efficiency and cost-effectiveness of soil sampling from soil borings, field-screening was conducted to identify contaminated soil and to semi-quantitatively assess the magnitude of contamination. Two types of screening techniques were used: the photoionization detector (PID) to identify the presence of VOCs in soil cores, and the Color-Tec® test kit to test for the presence of CVOCs (more quantitative than PID readings) in soil, water, and sediment samples.

DPT Soil Borings/Collection of Soil Samples - Between April 11 and May 4, 28 DPT soil borings were advanced in accordance with Worksheet #17 of the approved UFP-SAP. Total depths varied between 30 and 65 feet below ground surface (bgs), with most borings advanced to a total depth of approximately 50 feet bgs. Locations of the DPT soil boring are provided in Figure 2-3.

Eight DPT soil borings were advanced in the inferred source area (Objective Number 1 – SB07-100 to SB-107). All eight DPT soil borings were advanced to refusal, which was assumed to be within the lower till unit (when present), immediately above the bedrock or approximately at the bedrock surface. Total depths ranged from 44 feet bgs (SB07-103) to 63.5 feet bgs (SB07-106). Twenty soil borings were advanced downgradient from the inferred source area (Objective Number 2 – SB07-200 to SB07-223, not including SB07-203, SB07-206, SB07-220 and SB07-221). All 20 DPT soil borings were advanced to

refusal [assumed to be the lower till unit, below the lower sands and above the bedrock, or approximately at the bedrock surface (estimated based on previous investigative activities)]. Based on the shallow refusal at SB07-208, SB07-209 and SB07-211 (33 feet, 35 feet and 30 feet bgs, respectively), it was assumed that refusal was not at the bedrock interface. However, total depths reached at all other DPT soil boring locations suggest that appropriate refusal was reached. These total depths ranged from 45 feet (SB07-205 and SB07-210) to 65 feet (SB07-216) bgs.

Samples from each soil boring were selected for fixed-base laboratory analysis of VOCs, according to the decision criteria specified in Worksheet #17 of the approved UFP-SAP. In accordance with the approved UFP-SAP, at least two subsurface soil samples were collected for laboratory analysis from the SB07-100 to SB07-107 soil borings, based on field-screening results and/or field observations. Subsurface soil samples were collected as follows: three at SB07-100; four at each of the borings, SB07-101, SB07-103, and SB07-107; and five at each of the remaining locations. While the approved UFP-SAP required that at least one subsurface soil sample be collected for laboratory analysis from each of the SB07-200 to SB07-223 soil borings, based on field-screening results and/or field observations, no less than three were collected. In general, at least three subsurface soil samples were collected, with most locations having four or more subsurface soil samples. The additional soil samples at the 100- and 200-series locations were collected at the direction of the Navy in order to provide a more thorough data set to evaluate the CVOC plume in 3-D throughout the site.

In addition to the collection of samples analyzed for VOCs as described above, soil samples for grain size analysis were also collected in order to support field work being performed by EPA Kerr Research Center (and Navy Source Area Investigation). A total of 113 soil samples were submitted to EPA Kerr Research Center on May 9, 2011 for grain size analysis. Additionally, fractional organic carbon (foc) samples were collected and analyzed at 37 locations.

Overburden Monitoring Well Installation - Based on a preliminary analysis of the field-screening results (Color-Tec®, PID and EPA Region 1 CVOC sampling results) and in consultation with, and approval by the BCT, eight overburden groundwater monitoring wells were installed during the Source Area Investigation. The following table summarizes pertinent monitoring well installation details.

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone (feet below ground surface)	Diameter (inches)
MW07-40D	Deep	30.5 to 40.5	1.5
MW07-41I	Intermediate	16.5 to 26.5	1.5
MW07-42I	Intermediate	23.5 to 33.5	1.5
MW07-43S	Shallow	10 to 15	1.5
MW07-43D	Deep	33 to 43	1.5

Well/Piezometer Identifier	Description of Screened Zone	Depth of Screened Zone (feet below ground surface)	Diameter (inches)
MW07-44D	Deep	44.5 to 54.5	1.5
MW07-45S	Shallow	15 to 25	1.5
MW07-45D	Deep	37.5 to 47.5	1.5

Locations of the eight new groundwater monitoring wells are shown on Figure 2-3. All groundwater monitoring wells were completed as above-ground wells.

The total number of monitoring wells at the site is now approximately 120 (including shallow piezometer/stand pipes) as a result of numerous investigative activities.

Sediment, Deep Surface Water, and Pore Water Sampling at the Entrance Channel - A flat-bottom boat was used in the collection of marine sediment, deep surface water, and pore water samples in the Entrance Channel to Allen Harbor, from June 6 to 10, 2011. As depicted on Figure 2-3, an initial grid of 30 screening locations was established, spaced approximately 50 feet apart along three transects oriented parallel to the Entrance Channel shoreline.

The first phase of work involved collecting and field-screening samples at alternating boring locations along the first two transects. Screening samples were collected from locations 300, 302, 304, 306 and 308 along the first transect, and 311, 313, 315, 317 and 319 along the second transect. Field-screening included Color-Tec® screening and review of geochemical data from the groundwater flow-through cell. Based on these results, additional (second phase) samples were then collected and field-screened at locations 301, 303, 305, 312, 314, 316, 320, 324, 326 and 328, resulting in a total of 20 samples collected.

Pore water samples collected from each of the screening locations and measured for salinity using a real-time screening instrument demonstrated that salinity was not less than 10 ppt at any of the locations. Although the decision rule from the approved work plan stated that no laboratory samples would be collected if field salinity measurements were greater than 10 ppt, a decision was made to collect sediment, deep surface water and pore water samples from 12 locations for analysis at the fixed-base laboratory.

Sediment samples were collected at depths of 1 to 6 inches and 6 to 12 inches below the harbor floor. Deep surface water samples were collected at each sediment core location, from as close to the harbor floor as possible, approximately within 3 inches of the harbor floor.

Pore water samples were collected from a 2-inch-diameter stainless steel pipe with a 1-foot screen. Each piezometer was advanced into the sediment using Vibracore techniques so that the top of the screen was approximately 0.5 to 1.5 feet below the sediment surface (harbor floor). This centered the screen at 1 foot below the harbor floor to ensure that bridging of surface water did not occur. All sampling points were located using global positioning system (GPS) equipment, as depicted on Figure 2-3.

Monitoring Well Development - Well development is conducted to clear sediment and foreign matter that may be within the well screen, and to clear out fine particles (i.e. silt and clay) from the surrounding sand pack, as much as possible; proper well development maximizes the representativeness of the groundwater samples. Development of a new well did not occur until at least 24 hours elapsed after the well had been installed, to allow the bentonite chips in the well annulus to fully hydrate. All permanent monitoring wells that were newly installed by the Navy (8 wells) underwent development, including wells MW07-40D, MW07-41I, MW07-42D, MW07-43D, MW07-43S, MW07-44D, MW07-45D, and MW07-45S.

In addition to the 8 new wells listed above, 20 existing monitoring wells were redeveloped, including MW07-05S, MW07-15D, MW07-18D, MW07-23S, MW07-24D, MW07-04D, MW07-10D, MW07-12D, MW07-13D, MW07-19D, MW07-21D, MW07-24S, MW07-24DUT, MW07-27S, MW07-35D, MW07-37S, MW07-38S, MW07-38D, and MW07-39S. These wells were redeveloped either because they had not been sampled within the past three years, or because elevated turbidity levels were observed during recent sampling events.

Four additional wells that were newly installed by EPA were developed, including DPT-39-03S, DPT-39-03I, DPT-39-03D, and DPT-18I.

Redevelopment of monitoring wells was conducted in two stages. The first stage was performed using a Waterra® inertial pump/foot valve method to remove fines and water. In this stage, an alternating swabbing action was performed over the full length of the well screen until the water was visibly clear of sediment. A minimum of one standing-well-volume, plus any water "lost" during well installation, was removed during well development. The second stage, often performed days later, included pumping using a peristaltic pump to attempt to achieve low turbidity measurements, since most of the wells were redeveloped due to historically high turbidity. Additionally, emphasis was placed on developing wells to ensure that key geochemical parameters [pH, conductivity, temperature, dissolved oxygen (DO) and oxidation-reduction potential (ORP)] were indicative of typical formation water.

Groundwater Purging and Sampling - During the next LTM event (summarized in Section 2.3.2.4), groundwater samples were collected from all monitoring wells that were newly installed by the Navy, and

were analyzed for VOCs and salinity by the fixed-base laboratory. Sampling procedures were consistent with the site 07 LTMP.

2.5.2.1.3 2012 Shoreline Surface Water Investigation in Support of the Third Five-Year Review

As a component of the Source Area Investigation, and as summarized in the previous section, surface water samples were collected in the Allen Harbor Entrance Channel. While the primary objective of this effort was to provide data to assist in evaluating potential ecological risk, a second objective was to provide data that could also be used to update the human health risk assessment for Site 07. However, because of the depth of the surface water sampled in that effort (generally at least 4 feet deep, even at low tide) it is unlikely that human receptors would be routinely exposed to that surface water. Therefore, a shoreline surface water investigation was conducted at Site 07 to obtain data more representative of surface water to which human receptors would be exposed, to better support a human health risk assessment. This surface water investigation is described in the following paragraphs.

Based on a preliminary evaluation of the tidal study (performed from March to June 2012), it was determined that tides have a significant impact on the transport of contamination to the off-shore. Further, since tidal ranges vary throughout a given month, it was postulated that the location of the groundwater discharge to surface water also varies along the shoreline (see discussion in Section 2.5.2.2). To further determine where and when surface water sampling should be performed in order to best evaluate human risk scenarios in support of the Third Five-Year Review, a Color-Tec® field-screening study was performed on June 13 and 14, 2012. During this field-screening event, including three different sets of tidal conditions, surface water samples were collected from four fixed positions with respect to six selected piezometer locations, as follows: 10 feet beyond (into the Entrance Channel) the piezometer; at the piezometer; 20 feet toward the shoreline from the piezometer; and 40 feet toward the shoreline. The surface water samples were collected in reference to selected piezometers P07-06 through P07-10, and P07-24, the locations where the highest CVOC concentrations in piezometers have typically occurred. These sample locations are presented on Figure 2-3. Surface water samples were collected during three different phases of tidal cycles – incoming mid-tide, outgoing mid-tide, and low tide. The surface water samples were analyzed per the Color-Tec® screening method. No samples collected during the screening event were submitted to the fixed-base laboratory.

Based on the results of the June 2012 screening event, it was determined that surface water samples for fixed-base laboratory analysis should be collected, as follows - near low tide, at the surface water/sediment interface, and where the water is approximately 6 to 9 inches deep, in order to obtain “worst case” CVOC discharge concentrations. This determination, and a consideration of “how” exposure occurs while a receptor is wading or swimming, guided the 2012 shoreline surface water investigation conducted in support of the Third Five-Year Review. Specifically, as detailed in the following narrative,

these factors were used to design a sampling event that would result in exposure point concentrations (EPCs) that would be representative of the Entrance Channel concentrations to which a wader or swimmer would be exposed (not just a “worst case” scenario).

The date of July 2, 2012 was selected for surface water sample collection because the tidal range on this date exceeded those occurring throughout the remainder of the month (and slightly higher compared to previous few months). It was therefore reasoned that discharge gradients at low tide should be maximized on this date, likely resulting in higher CVOC groundwater concentrations discharging to surface water (versus other times of the month). Section 2.5.2.3 provides additional details regarding this conclusion.

Surface water samples were collected for fixed-based laboratory analysis of VOCs (Method 8260 B) along transects in the vicinity of 10 piezometer locations. Similar to the June 2012 surface water screening event, the samples were collected in the area of those piezometers where CVOCs had been previously identified: P07-02, P07-04, P07-06 through P07-10, P07-20, P07-24, and along EPA Line C (at P07-34, designated for sampling). The samples were collected within the Entrance Channel, not immediately adjacent to the piezometer locations, but at three distinct sampling positions located along a line running perpendicular to the shoreline, at low tide, at mid-tide and at high tide. During each of these tides, the direct-fill method was used to fill sample bottles at three distinct sampling positions:

- Location 1: At the harbor floor where water was approximately 6 inches deep (to support the evaluation of a wading scenario);

- Location 2: At the harbor floor where the water was 3 feet deep (to support the evaluation of a swimming scenario); and

- Location 3: At the mid-point of the water column where the water was 3 feet deep (to support the evaluation of a swimming scenario).

The sampling positions were consistent within the water column during each tidal event.

The direct-fill method was used to fill sample bottles, and appropriate QA/QC samples [duplicates, matrix spike/matrix spike duplicates (MS/MSD), etc.] were also collected. The Color-Tec® method was used to perform real-time field-screening, although screening results were not used to select samples for fixed-base laboratory analysis. Locations of the sampling positions along each of the piezometer transects were measured with respect to the piezometers and are shown on Figure 2-3. This resulted in the collection of 90 surface water samples.

2.5.2.2 Current Extent of Soil and Groundwater Contamination and Identification of Primary Migration Pathways

Figure 2-4 presents the CSM for Site 07. Contamination migrates from the source area toward the shorelines (Allen Harbor, the Entrance Channel and Narragansett Bay) primarily in the deep overburden and shallow bedrock groundwater. The overburden is generally divided into a shallow and deep zone, separated in many parts of the site by a semi-confining silt layer. The shallow and deep zones are dominantly composed of sands and gravels, with a till also occurring in the deep zone.

Figures 2-5 through 2-17 present total CVOC concentrations in soil at Site 07. For purposes of data presentation, the soil was separated into layers, each representing a 5-foot elevation interval, [from +5 feet mean sea level (msl) to -60 feet msl]. Data provided on these figures include both Color-Tec® screening results and fixed-base laboratory results from 2011. Figures 2-18 through 2-23 present cross-sections annotated with total CVOC concentrations in soils sampled at locations along the primary migration pathways (based on Figures 2-5 through 2-17). The following general conclusions are based on the data presented in these figures:

- Where detected, CVOC concentrations in soils ranged between 1 and 50,000 µg/kg.

- CVOC contamination in soils at shallow elevations (as deep as -20 feet msl) occurs predominantly in the area between the former source area and the Entrance Channel.

- The highest CVOC concentrations in soil are observed from DPT-39-03 to SB16-106 to SB16-107, between the elevations of -35 to -45 feet msl.

- While evidence of CVOC contamination migrating toward Narragansett Bay is observed at depths lower than -30 feet msl, the most pronounced evidence of migration is observed at elevations deeper than -40 feet msl.

- For locations along the migration pathways extending toward Narragansett Bay, maximum CVOC concentrations are detected in soils collected between -40 and -50 feet msl. However, the contamination does not daylight (migrate) into the shallower elevations, or discharge along the shoreline.

Based on the distribution of contamination in soils, the cross sections for groundwater were updated to better reflect migration of contamination from the former source area to the off-shore environments. Figure 2-24 presents the updated cross-section for groundwater, while Figures 2-25 through 2-36 present

results for selected CVOCs [1,1,2,2-PCA, TCE, cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE) and vinyl chloride (VC)] and salinity for locations along cross sections A-A' and B-B' for the June 2012 (ME 16) LTM sampling event. The following general conclusions are based on Figures 2-25 through 2-36:

- Contamination has migrated downward from the former source area towards the Entrance Channel, with most contamination occurring in the deep overburden and shallow bedrock aquifer in the approximate central portion of the site.

- Along cross-section A-A', contamination migrates to the off-shore environment between DPT-39-03D and MW07-39I, and then subsequently to MW07-42I, MW07-19S, and MW07-21S (in that order), and, within the bedrock, towards MW07-21R.

- Along the eastern portion of cross-section B-B' (MW07-05 to MW07-18), contamination does not appear to be effectively migrating beyond MW07-09D (at concentrations greater than 10,000 µg/L). Contaminant migration is likely impeded by the increased silt thickness in this area

- Along the eastern portion of cross-section B-B' (MW07-05 to MW07-18), contamination does not appear to be migrating upward through the silt layer to the shoreline.

- Along the western portion of cross-section B-B' (MW07-05 to MW07-35/P07-15), most contamination is confined to the deep zone and is generally at lower concentrations than contamination observed in other eastern portions of the plume.

One of the primary observations regarding the current extent of contamination in soil and groundwater is that the migration pathways are complex, in that contaminants migrate within different groundwater zones at different locations across the site. The presence or absence of a laterally extensive silt layer dominates the overall contaminant migration pattern and dictates whether the discharge reaches the shoreline environments. As indicated by the soil and groundwater data, the highest concentration of contaminants is currently near the central portions of the site. From a migration perspective, significant contamination (relative to other Site 07 shoreline areas) has reached the shoreline only at locations along the Entrance Channel, where the silt layer is absent. However, low-level contamination has also been detected along the Allen Harbor shoreline, along the western portion of cross-section B-B'.

2.5.2.3 Hydrogeology (Groundwater Flow/Potentiometrics)

Synoptic groundwater level measurements were collected during each LTM event, providing hydraulic head data for developing potentiometric maps, evaluating groundwater flow directions, and estimating

hydraulic gradients, in order to understand site-wide groundwater flow. During each monitoring event, the measurements were conducted at up to 106 monitoring wells/piezometers within a time frame of approximately 40 to 65 minutes, at mid-tide conditions. This subsection provides a discussion of hydrogeological interpretations, based on the groundwater level data collected during the LTM program and since 1995, as well as a brief summary of the condition of the monitoring well network at. Detailed figures are provided in the Draft: Long-Term Monitoring Data Summary Report for Site 07: Calf Pasture Point. The hydrogeological interpretations also take into account observations from the large-scale, multi-month tidal study performed in the late spring to summer 2012 (and discussed in Section 2.5.2.1.1), to better understand tidal impacts on the primary groundwater migration pathways. (Tetra Tech, 2010e).

In general, groundwater flow directions at Site 07 are similar in both the shallow and deep zones, and between monitoring events. Groundwater elevations vary between seasonal highs and lows, but overall groundwater flow pathways are generally uniform throughout the year(s). As expected, the highest groundwater elevations are consistently observed in the northern portion of the site, near the bedrock outcrop, and the lowest are observed along the shoreline. Groundwater flow is generally radial, from the northern bedrock outcrop outward toward the eastern, southern, and western shorelines of Calf Pasture Point. The following subsections present a more detailed groundwater flow analysis for each groundwater zone.

2.5.2.3.1 Shallow Zone

Groundwater in the shallow overburden is interpreted to flow generally from the vicinity of the bedrock outcrop in the northern portion of the site in a radial direction toward the shoreline of Allen Harbor, the Entrance Channel, and Narragansett Bay. Near the central portion of the site (in the vicinity of MW07-39), a preferential flow area is observed trending northeast-southwest to north-south (toward MW07-19 and MW07-21), likely the result of topography and/or shallow subsurface lithology, resulting in convergent (southeast and southwest) flow toward the Entrance Channel.

Generally, the gradients are fairly uniform throughout the site, especially from the bedrock outcrop area toward the shoreline of Allen Harbor and the Entrance Channel. Gradients are more level between the bedrock outcrop area and Narragansett Bay (to the east), most likely due to the longer travel distances (and possibly higher hydraulic conductivities). Water level elevations were approximately 9 to 13 feet msl in the vicinity of the bedrock outcrop, and approximately 1 to 3 feet msl along the shorelines.

2.5.2.3.2 Deep Zone

Groundwater in the deep overburden is interpreted to flow generally toward the southeast, south, and southwest, from the northern portion of Site 07 toward Narragansett Bay, the Entrance Channel, and the

shoreline of the harbor, respectively. An apparent groundwater divide occurs in the western portion of the site (generally from MW07-04 and MW07-38 to MW07-25 to MW07-37). Another groundwater divide occurs in the central to eastern portions of the site (generally from MW07-03 to MW07-27 to MW07-39). These interpreted groundwater divides are associated with the radial flow observed in this area. Localized deviations in the flow field result in slightly convergent flow in the areas of MW07-19 and MW07-21D toward the Entrance Channel.

Prior to ME 10, the lowest observed groundwater elevations occurred along the shoreline (abutting the Entrance Channel and Narragansett Bay). Since ME 10, the lowest observed groundwater elevation occurs across the Entrance Channel on Spink Neck at MW07-32 (MW07-32 groundwater levels were not measured prior to ME 10), while the highest groundwater elevations are consistently in the vicinity of the bedrock outcrop. Similar to the shallow groundwater zone, water level elevations were approximately 8 to 11 feet above msl in the vicinity of the bedrock outcrop, and approximately 1 to 2 feet above msl along the shorelines.

In general, while it appears that groundwater is converging toward the Spink Neck and the Entrance Channel area (flowing south from Site 07 and flowing north from Site 16), the precise discharge location of shallow groundwater from Site 07 is not known; it may be within the Entrance Channel or near Spink Neck. Regardless, groundwater along this pathway at Site 7 (from central portion of site to Allen Harbor Entrance Channel) migrates from the deep to shallow overburden groundwater zones (where the silt confining layer is absent). Deep groundwater migrating toward Narragansett Bay would flow towards and beneath Narragansett Bay since a confining silt layer is present, preventing effective upward migration from the deep to shallow overburden groundwater zones.

In general, there are two gradients across the site, and they are approximately uniform within each area. The gradients are highest between the vicinity of the bedrock outcrop and the central portion of the site (approximately between MW07-05 and MW07-27). Typically, approximately 4 to 5 feet of elevation change occurs over a distance of approximately 300 to 400 feet. From approximately the central portion of the site to the shorelines, generally only 2 to 3 feet of elevation change occurs over a distance of approximately 500 to 700 feet. These relative areas of gradients are maintained even under lower water level elevations, demonstrating that flow directions are generally maintained, even as site-wide groundwater elevations vary.

2.5.2.3.3 Bedrock Zone

The groundwater flow pattern in bedrock is comparable to the pattern observed in deep overburden, generally toward the south, southeast, and southwest, from the northern portion of the site, as described above.

Overall, the groundwater gradient in bedrock appears to be fairly uniform throughout the site, from the vicinity of the bedrock outcrop and central portions of the site to the shorelines. Approximately 1.5 to 2.0 feet of elevation change occurs over this distance (highest elevations of site to shoreline). As such, gradients are higher toward Allen Harbor and the Entrance Channel as compared to Narragansett Bay, since the total travel distance is shorter and the potentiometric elevation along the shoreline is similar.

2.5.2.3.4 Tidal Study

A tidal study was performed between March 21 and June 11, 2012. In total, pressure transducers with data loggers were installed in 34 groundwater monitoring wells, at 1 staff gauge location (in Allen Harbor), and at 3 barometer locations. Details of the tidal study are summarized in Section 2.5.2.1.1. A preliminary evaluation of the tidal study data was provided by the Navy during the BCT and RAB meetings of September 20, 2012. The following conclusions are based on a comparison of the data from the staff gauge location and several wells located between the former source area and the Entrance Channel, based on Figures 2-37 through 2-39:

- There are two distinct tidal ranges each day, and four distinct tidal ranges (or patterns) are observed over the course of a month, as follows:

  - Approximately 6.3 feet (largest)
  - Approximately 4.9 feet (mid)
  - Approximately 3.9 feet (average)
  - Approximately 3.1 feet (lowest).

- Heavy, extended precipitation events do affect water level measurements.

- The measured effect of the tidal cycle on water level measurements/groundwater flow decreases as distance from the shoreline increases.

- Tidal offset (temporal) increases with distance from the shoreline (tidal cycle almost out of phase at furthest onshore locations).

- The rate of change per unit time is non-uniform at harbor and near-shore locations; the magnitude of the change decreases with distance from the shoreline.

The following observations are based on the spatial analyses of data collected during the four distinct tidal ranges (Figures 2-40 through 2-75):

- During a typical tidal cycle (regardless of tidal magnitude), groundwater flow is both toward and away from the shoreline, depending on the position monitored.

- While tidal cycles are observed to induce temporary reversals in flow directions in portions of the Site 07 study area, the predominate groundwater flow direction remains radial to the west, south, and east.

- During high tide conditions, groundwater flow is northerly from the Entrance Channel to onshore:

  - The impact of the tides on water levels/flow at Site 07 wells is observed as far north as the DPT-39-3 cluster, though the northern extent of the impact is more typically observed near MW07-42I.
  - Magnitude and location of onshore extent different with each tidal range – decreasing in magnitude and being closer to shoreline as tidal range decreases.

- During mid- and low-tides, groundwater flow is generally southwesterly, toward the Entrance Channel.

- Generally, the gradient between DPT-39-3 and MW07-42I is relatively flat.

2.5.2.3.5 Impacts of Tidal Study on Primary Migration Pathways

As summarized in Section 2.5.2.2, there is only one migration pathway that results in elevated groundwater contaminant concentrations potentially discharging to the shoreline: this occurs along cross-section A-A'. As noted in the previous section, the tides also significantly impact the groundwater movement along this pathway. Based on tidal considerations, travel times from the area of highest contaminant concentrations to the Allen Harbor entrance channel is expected to be on the order of decades (approximately 30 to 40 years). Additional details regarding the estimation of contaminant migration travel times have been provided under separate cover (Source Area Investigation and Long-Term Monitoring Data Summary Report for Site 7 Calf Pasture Point, Tetra Tech 2013).

While contaminant migration from MW07-42I to the shoreline is estimated to be approximately 1.5 years, a significant ebb and flow action occurs between the groundwater and surface water systems as a consequence of the tides (observed most strongly between MW07-19 and MW07-21). Contaminants migrating in groundwater are not consistently flowing and discharging at the shoreline; rather, the concentrations of contaminants reaching the shoreline are a function of *both* the predominant groundwater flow patterns at Site 07 (i.e., from the source areas to the Entrance Channel) *and* the impact

of the tidal cycle on groundwater/surface water flow systems at Site 07. During periods of high tide, contaminant migration (and contaminant mass/concentrations) approaching the shoreline environment are impeded and depending on magnitude of high tide even reversed, and concentrations at the shoreline, in effect are diluted, and dispersed. During periods of low tide, contaminant migration (and contaminant mass/concentrations) approaching the shoreline environment is facilitated by the tidal cycle. Due to the tidal cycles, there is a limited area in the near shore area where fresh and saline groundwater is exchanged and contaminant concentrations are impacted (degree to which is uncertain). Therefore, it is likely that the contaminant concentration of the discharging groundwater will vary with the tidal cycle, with few contaminants discharged during periods of high tide (or none based on elevations), some diluted discharge occurring during mid-tide periods, and highest contaminant concentrations during low tide. At a minimum, the tidal cycles will impact the contaminant concentrations observed in the near shore groundwater by introducing greater variability in the contaminant concentrations discharging to surface water.

The tidal cycles also impact groundwater elevations, flow, and migration towards Narragansett Bay as far inland as MW07-11D. While the tides may impact as far inland as MW07-11D, a nearly consistent downward gradient occurs between MW07-20S and MW07-11D. Upward gradients only occur for a limited time during extreme low tides. In addition to the nearly consistent downward gradient, a silt layer approximately 10 to 15 feet thick (see Figure 2-21) is also present in this area. Therefore, hydraulic connection between the source areas and the shoreline that could result in a significant discharge of contamination at the Narragansett Bay shoreline are not present.

2.5.2.4 Groundwater Sampling Data

As of this five-year review, 16 long-term monitoring events have been completed at Calf Pasture Point (in-text tables in Sections 2.3.2.1 and 2.3.2.4 present the dates, number of wells sampled, and analytical parameters for each event). As provided for in the *Quality Assurance Project Plan for Long-Term Monitoring at Site 07* (EA, 2001a), a statistical analysis of results for all detected contaminants was completed. The results of this analysis are summarized in this section and are detailed in Appendix B. Appendix G contains data validation summaries and supporting documentation for data collected from 2011 through 2012 that have not been presented previously in data reports.

Table 2-1 presents a summary of all chemicals that have been detected in LTM groundwater samples at a concentration that exceeds project action limits (PALs). Appendix B provides the frequency of detections, a summary of statistical analyses, and contaminant concentration graphs for detected CVOCs (at least three detections were required for statistical analyses and trend analysis).

As presented in Table 2-1 and Appendix B, VOCs detected in groundwater include the following CVOCs: TCE, 1,1,2-trichloroethane (TCA), 1,1-dichloroethene (DCE), 1,2-dichloroethane (DCA), chloroform, *cis*-1,2-DCE, *trans*-1,2-DCE, tetrachloroethene (PCE), and VC; the CVOC, 1,1,2,2-PCA, was also detected at elevated concentrations, however, a PAL was not established in the LTMP. In addition, one non-chlorinated VOC, benzene, was detected. The principal and most frequently detected CVOCs include the parent chemical, 1,1,2,2-PCA, its degradation product, TCE, and the TCE daughter products, *cis*-1,2-DCE and VC.

The results of the VOC statistical analysis indicate the following statistically-significant trends (at a 95 percent confidence level) for the principle CVOCs:

- 1,1,2,2-PCA – Downward trends observed at 20 monitoring wells, no trends at eight monitoring wells, and only one increasing trend (MW07-11D);

- TCE - Downward trends observed at ten monitoring wells, no trends at 13 monitoring wells, and increasing trends at 5 monitoring wells (MW07-11D, -12D, -19D, -24D and -34D);

- *cis*-1,2-DCE - Downward trends observed at seven monitoring wells, no trends at 18 monitoring wells, and increasing trends at eight monitoring wells (MW07-09R, -11D, -19D, -21D, -23D, -24DUT, -34D and -39D);

- VC - Downward trends observed at two monitoring wells, no trends at 14 monitoring wells, and increasing trends at 3 monitoring wells (MW07-11D, -19D and -34D);

In general, the statistical analyses indicate that the parent chemical concentrations are decreasing while the daughter product concentrations are slightly increasing. Further, increasing trends for several principle CVOCs are consistently observed principally at MW07-11D, -19D and -34D, each located immediately downgradient of elevated CVOC concentration areas, along each of the respective migration pathways. This demonstrates that CVOC contamination continues to move along the various identified migration pathways toward the shoreline(s).

Based on data presented in Table 2-1 and Appendix B, CVOC levels in the high concentration areas (e.g., MW07-17D, -39I and -39D) generally do not demonstrate many significant statistical trends. However, this conclusion is somewhat impacted by the limited amount of data available for some locations (e.g., DPT-39-3D and DPT-39-4D). The few trends that have been observed are primarily downward trends (1,1,2,2-PCA); very few increasing trends have been observed. While increasing trends are observed for daughter products along the leading edges of the plume, no significant trends are

occurring where the concentrations (parent and daughter products) are persistently elevated. This suggests that large-scale migration of the plume is likely not occurring, or is not occurring at a rate that is discernible, based on current LTM data.

In the course of the 16 LTM events conducted to date, groundwater samples have also been periodically analyzed for total and dissolved metals; however, the frequency of monitoring has varied over time, particularly since 2009 (see Sections 2.3.2.1 and 2.3.2.4). Table 2-1 and Appendix B present total and dissolved metals data. As discussed in the Metals Evaluation submitted in October 2008 (Tetra Tech, 2008h), the following five metals were selected for trend analysis in order to further evaluate the potential impact of Site 7 on groundwater quality: antimony, arsenic, beryllium, lead and nickel. The results of the trend analysis are summarized below:

- Antimony – Infrequently detected in total and dissolved fractions

- Arsenic – For total arsenic, decreasing concentration trends at 10 locations, no trends at 25 locations, and an increasing trend at one location (MW07-28D). For dissolved arsenic, decreasing trends at 11 locations, no trends at 23 locations, and an increasing trend at two locations (MW07-29D and MW07-37S)

- Beryllium – Infrequently detected in total and dissolved fractions, though an increasing trend noted at MW07-38S for the unfiltered (total beryllium) samples

- Lead – Infrequently detected in total and dissolved fractions, although for total lead, six locations have downward trends and one location has an upward trend; and for dissolved lead, five locations have downward trends

- Nickel – For total nickel, decreasing trends at 13 locations, no trends at 29 locations, and increasing trends at three locations (MW07-32R, -38S and -39I). For dissolved nickel, decreasing trends at 9 locations, no trends at 32 locations, and increasing trends at four locations (MW07-20D, - 24D, -32R and MW07-37S). Three exceedances of the PAL were reported, and all other detections are below the PAL.

Based on a review of the descriptive statistics and trend graphs (Table 2-1 and Appendix B), no apparent metals plumes are discernible across the site. This is consistent with the CSM, which does not include a metals release at Site 07. Rather, the observed metals concentrations are likely reflective of background conditions and the impact of CVOC contamination on water quality conditions.

2.5.2.5 Piezometer Sampling Data

The LTMP specifies the collection of shallow groundwater samples (2 to 3 feet below sediment surface) from a network of up to 33 piezometers placed along the shoreline of Calf Pasture Point. While the water collected from the piezometer is assumed to be shallow groundwater, based on the tidal impacts observed across the site, the sampled water is more likely a composite of shallow groundwater and surface water. Most importantly, the water sampled is representative of water that a receptor would be exposed to.

As of the writing of this five-year review, 16 LTM events have been completed at Calf Pasture Point (in-text tables in Sections 2.3.2.1 and 2.3.2.4 present the dates of each event, the number of piezometers sampled, and analyses conducted during each round). As specified in the *Quality Assurance Project Plan for Long-Term Monitoring at Site 07* (EA, 2001a), a statistical analysis of results for all detected contaminants was completed. The results of this analysis are summarized in this section and are detailed in Appendix B.

A summary of chemicals detected in piezometer samples at concentrations exceeding the PALs (as established in the LTMP) is provided in Table 2-2. Appendix B provides the frequency of detections, a summary of statistical analyses, and graphs of CVOC concentrations, as detected during the LTM program (at LTMP. At least three positive detections were required for statistical analyses and trend analysis.

CVOCs have consistently detected during the LTM program, at the following piezometer locations: P07-01 through P07-03; P07-11 through P07-14; P07-17 through P07-19; and P07-25 through P07-33. The piezometers most consistently demonstrating CVOC contamination is concentrated in two general areas: 1) the southern shoreline (including the Entrance Channel) and 2) the western cove area (see figure 2-3).

The most significant detections of CVOCs are reported for samples from piezometers located along the Entrance Channel shoreline, at locations P07-04 through P07-10, and P07-20 through P07-24 (Figure 2-3). The highest concentrations of CVOCs have historically been reported at P07-07, P07-08, and P07-09, which are located between MW07-21 and MW07-23. In general, the concentrations of CVOCs in these three piezometers were relatively low during the first three monitoring events, and then increased dramatically during ME 04 (December 2003). Since ME 04, CVOC concentrations in P07-07 through P07-09 have decreased, but remain elevated (at approximately 2,000 to 3,000 µg/L). CVOCs have been detected consistently in other piezometers located in the Entrance Channel area, but at lower concentrations.

Since ME 04, the concentrations of CVOCs in samples collected from the Entrance Channel piezometers have been relatively stable (may be slowly declining over past few year). However, statistical analysis of concentration trends over the entire LTM program indicates increasing trends (95 percent confidence level) for CVOCs at locations P07-05 (VC), P07-06 (1,2-DCA and VC) and P07-09 (1,2-DCA and cis-DCE); and decreasing trends for CVOCs at locations P07-05 (1,1-DCE), P07-08 (1,1,2,2-PCA) and P07-10 (1,1,2,2-PCA and trans-DCE). Where significant trends do occur, most increasing trends are for daughter products, whereas most decreasing trends are for parent chemicals.

Detectable concentrations of CVOCs have also been consistently reported for two piezometers located in the western cove area (P07-15 and P07-16). However, based on all available data, either no trends or statistically significant downward trends are observed.

The highest CVOC concentrations were detected in piezometers in 2004/2005, and have generally declined in the following seven years.

2.5.2.6 Sediment and Surface Water Sampling Data

Sediment samples are collected from six shoreline locations, collocated with piezometers having the highest concentrations of VOCs. There are no PALs for sediment because the Site 07 RI did not identify unacceptable risks associated with exposure to sediment.

A summary of chemicals detected in sediment samples collected from Calf Pasture Point during the LTM program is provided in Appendix B, which also includes the frequency of detections, a summary of statistical analyses, and graphs of CVOC concentrations detected during the LTM program (at least three detections are required for statistical analyses and trend analysis).

As shown in the data tables in Appendix B, VOCs are detected in less than 10 percent of sediment samples, the most frequently detected VOCs being TCE, cis-1,2-DCE and trans-1,2-DCE. Overall, for each of these parameters, concentrations have typically ranged from near non-detected to several hundred parts per billion (µg/kg). Concentrations exceeding 200 µg/kg have been reported for sediment samples from locations SED07-05, -07, -09, -10 and -20, co-located with piezometers where elevated CVOC concentrations have also been detected.

Surface water samples were collected from SW07-04 through SW07-10 and SW07-24 during the bi-monthly sampling events conducted between October 2004 and January 2006. Additionally, surface water samples were collected in July 2012 in support of this Five-Year Review report (see Section 2.5.2.1.3). There are no PALs for surface water because unacceptable risks were not predicted for

receptors exposed to chemicals detected in the surface water samples collected in support of the Site 07 RI.

A summary of all chemicals detected in surface water samples is included in Appendix B, which also presents the frequency of detections, a summary of statistical analyses, and graphs of CVOC concentrations as detected during the LTM program (at least 3 detections are required for statistical analyses and trend analysis).

The data from sediment and surface water samples were utilized together with data from shallow groundwater samples collected along the shoreline to evaluate human health risks associated with swimming, wading, and shellfishing along the Calf Pasture Point shoreline. All of the cancer risk estimates developed for potential human exposure to COPCs in sediment, surface water, and shallow groundwater while swimming, wading, or shellfishing were within the EPA's generally acceptable risk range and below RIDEM's cancer risk benchmarks. All of the non-cancer risk estimates associated with these exposures were also below EPA and RIDEM risk benchmarks (Tetra Tech, 2007l). See Section 2.3.2.3 and Appendix G for further descriptions of the risk assessment methodology.

2.5.2.7 Spatial Analyses of Long-Term Trends for Groundwater, Piezometers and Sediment

Since the first Five-Year Review, one of the principle questions asked by the BCT was whether or not the CVOC plume(s) at Site 07 were advancing or at steady-state. Fundamentally, this question has been the driving factor for all of the investigative work and modifications to the LTMPs over the past nearly 10 years. As summarized in the previous Five-Year Review (Tetra Tech, 2008b), when the 2007 CVOC plume to the CVOC plume of the mid-1990s, it was concluded that the plume has significantly advanced. However, when consideration is given to the fact that the initial CVOC distribution map was developed without the benefit of several new monitoring wells, it is evident that, while the plume has advanced in certain areas (for instance, in the deep zone to the east), the overall rate of advancement is slow.

The Draft LTM Data Summary Report for Calf Pasture Point (Tetra Tech, 2010e) further evaluated the long-term spatial analysis of CVOC migration from the source area to the shorelines. One key conclusion was that the extents of the various principle CVOC plumes along the primary migration pathways have remained consistent since ME 09 (November/December 2007). Figures 2-25 through 2-34 present data for ME 16 (June 2012) and continue to show that the extent of the various principle CVOCs have not significantly changed. This is further supported by the long-term statistical analyses (Appendix B), since most chemicals show no trends, particularly where CVOC concentrations are significantly elevated.

2.5.3 Site Inspection

This section summarizes the routine LTM program site inspection activities, as well as the site inspection activities performed specifically for this third five-year review.

2.5.3.1 LTM Program Site Inspections

Site inspections are conducted at Calf Pasture Point in conjunction with each LTM event. During the inspections, each monitoring well is checked to ensure that it is locked, labeled, and in good condition. Observations are noted on a monitoring well inspection form that is included in the appendices of the LMT results reports. The site inspection also includes an on-site verification of the effectiveness of land use controls, by observing land use conditions (presence of buildings and level of recreational use at the site) and evidence of groundwater extraction wells.

A review of site inspection forms completed during the LTM program indicates the following:

- All wells are locked and properly labeled.
- Erosion has occurred between the concrete pad and the ground surface at monitoring wells MW07-16D, MW07-16R, MW07-20S and MW07-20D. These wells are located in sandy areas adjacent to the Narragansett Bay shoreline.

Land use control inspections performed during the LTM program have not detected any evidence of water supply wells or new construction (see references).

2.5.3.2 Tetra Tech Site Inspections

Tetra Tech has performed site inspections during each of the monitoring events conducted since the last five-year review (March 2008). The inspections include a site walkover, including the Narragansett Bay shoreline, and annotation of conditions. Inspections are frequently performed in order to document changes that occur due to increased public use of the property/parcel. Photographs from the site inspections are included in Appendix C.

The site was observed to consist of a mix of forested, grassy, and sandy areas. The inspection began at Sanford Road, which runs to the west of the site, and proceeded to the east along a gravel road, and then south, until reaching monitoring well MW07-23S. The inspection then proceeded toward the east along the southern shoreline of Calf Pasture Point, and monitoring wells MW07-21 and MW07-24 were observed. All wells encountered along the western and southern shorelines of the site appeared in good condition and the casings were locked.

The portion of the site adjacent to Narragansett Bay was then observed. While walking along the Narragansett Bay shoreline, individuals are typically observed harvesting shellfish in the bay.

Generally, not many changes occur across the site in the interim between site inspections. While not detrimental to the overall site conditions, numerous deep ruts have developed throughout portions of the site, due to the various investigative activities performed since 2010. In addition, in 2011, large gravel was laid down on the gravel/dirt road in order to facilitate hauling of waste materials from the source removal activity. Impacts from these events are minimal and no modifications to current conditions are recommended.

2.6 TECHNICAL ASSESSMENT

2.6.1 Question A: Is the remedy functioning as intended by the decision documents?

Based on the document review, data review, and site inspections, the remedy at Calf Pasture Point is functioning as intended by the ROD. Groundwater samples are collected from monitoring wells screened in the overburden (shallow and deep) and bedrock zones throughout the interior portions of Calf Pasture Point, and from shallow piezometers along the shoreline of Calf Pasture Point.

Analytical data collected during each monitoring event are compared to the PALs, as follows: for groundwater samples from monitoring wells, the PALs are the Maximum Contaminant Levels (MCLs) (summer 2000); for samples from piezometers, the PALs are site-specific, surface water risk-based screening concentrations. The results from each monitoring event are presented in a data report, with exceedances of PALs highlighted in tables and shown on tag maps. In addition, total CVOC concentration trends from each sampling event between the RI (1995/1996) and the most recent LTM event are presented in table form and on a tag map.

The remedy selected for Calf Pasture Point did not include active remediation because site groundwater is not likely to be used as a water supply and because an effective, implementable, and cost-effective technology to treat groundwater in fractured bedrock has not been identified. Instead, the remedial strategy for Site 07 utilizes institutional controls and long-term monitoring to mitigate and monitor risk from site-related contamination. The conceptual LTMP envisioned a LTM program that would be continually adjusted to achieve the objectives of the remedial action. Based on the evaluation of data collected during the LTM program, changes to the program have been implemented and supplemental data have been collected to verify that unacceptable risks are not present:

- Based on the review of sampling data evaluated during the first five-year review, nine new monitoring wells were installed at the site in 2004 to allow a better understanding of groundwater and contaminant flow patterns in the western cove and central portions of Site 07.

- Based on sampling results from the early rounds of monitoring, 23 new shoreline piezometers were added to the LTM program to enable more comprehensive monitoring of shallow groundwater along the Calf Pasture Point shoreline.

- After the December 2003 detection of elevated CVOC concentrations at specific shoreline piezometer locations, an off-shore investigation was conducted to identify potential groundwater and contaminant discharge zones in Allen Harbor.

- Concurrent with the performance of the off-shore investigation, the frequency of sampling at eight key piezometer locations within the Entrance Channel was increased to bi-monthly. Collocated surface water samples were also collected during these supplementary data collection events.

- Based on the data collected during bi-monthly piezometer and surface water sampling events, a human health risk assessment was performed in 2007 to evaluate risks associated with potential exposures to shallow groundwater, surface water, and sediment along the Calf Pasture Point shoreline, within the Entrance Channel. No unacceptable CERCLA risks were predicted.

- In order to update the CSM and address potentially unmonitored contaminant migration pathways, several phases of investigative work were performed by various regulatory agencies and the Navy, between 2010 and 2012 (some are still ongoing).

- Based on the geophysical survey performed during the Source Area Investigation (Spring 2011), the source of CVOC was found (a trench with cans of DANC in the vicinity of the suspected source area) and removed (summer to fall 2011).

- Based on extensive investigations performed between 2010 and 2012, a comprehensive understanding of the current extent of contamination in both soil and groundwater, in both on-shore and off-shore environments, has been gained.

- Based on the results of activities identified below, contaminant transport along the primary migration pathway can now be accurately estimated. The activities include: 1) a large-scale tidal study performed between the spring and summer of 2012; 2) the investigations of the current extent of

contamination in soil and groundwater; and 3) the analysis of long-term contaminant trends (including statistical evaluations).

- Extensive off-shore surface water sampling occurred in 2012 to support an update to the human health risk assessment, initially performed in 2007. The risk assessment evaluated risks associated with potential exposures to shallow groundwater, surface water, and sediment along the Calf Pasture Point shoreline within the Entrance Channel. No unacceptable risks were predicted.

- The remedy has been protective over the past 13 years even though previous Five-Year Reviews have suggested that the remedy may not be protective in the future. The remedy will continue to be evaluated every five years as required.

As demonstrated by the supplemental monitoring, investigations, and risk assessments discussed above, the remedy at Calf Pasture Point is meeting the RAO stated in the ROD, to "ensure that the discharge of groundwater to wetlands and off-shore areas continues to pose no unacceptable risks from COCs." The current sampling network is adequate to evaluate the protectiveness of the remedy. The current network includes piezometers placed at a spacing of approximately 50 feet along the entire length of the Calf Pasture Point shoreline to monitor CVOC concentrations at the most likely points of human exposure. Based on all of the data collected to date, it is recommended that the LTM program be optimized so that it continues to be protective, and uses environmental funding in the most cost-effective manner.

The other RAO identified in the ROD for Calf Pasture Point is to "prevent human exposure to COCs in deep and bedrock groundwater." To achieve this objective, the remedy includes environmental land use restrictions that: a) prohibit the construction or development of any building, structure, facility, or other improvement without adequate ventilation; and b) prohibit the installation of water supply wells or the use of groundwater for any purpose, except for sampling or remediation. At least once per year (usually more frequently), compliance with these controls is verified through a review of Town records to ensure that no permits have been issued that would change the use of the site, allow the construction of residential or commercial units, or allow the installation of groundwater supply wells. An on-site inspection is also conducted to verify that no buildings or water supply wells are installed on the site.

During the time period of approximately 13 years since the selection of the site remedy, the groundwater CVOCs within the interior portions of Calf Pasture Point (in the shallow and deep overburden and in the bedrock aquifers, and along the primary contaminant migration pathways) have remained elevated, at concentrations that exceed the PALs. Based on the concentrations and the spatial distribution (both horizontal and vertical), PALs are not expected to be achieved in the foreseeable future, particularly since no appreciable long-term trends are identified where concentrations remain significantly elevated. As

detailed in the preceding sections of this report, the Navy has expanded the monitoring network at Calf Pasture Point in several instances, as a result of regulatory uncertainty. As the cost of long-term monitoring at Calf Pasture Point increases, optimization of the LTMP is recommended. Upon completion of the Long-Term Monitoring Data Summary Report (in preparation), which includes a comprehensive evaluation of all site data and investigative activities performed to date, the LTM program will be optimized for continued verification of the effectiveness of the selected remedy.

2.6.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

Changes in Exposure Pathways: There have been no changes at the site that would have resulted in new exposure pathways to human or ecological receptors.

Changes in Land Use: There have been no changes in land use that would impact the protectiveness of the remedy. The property is used for passive recreation, with land use controls to prevent exposures to contaminants in site groundwater. Periodic on-site inspections (Section 2.5.3) are conducted by the Navy to verify that land use controls are effective.

The Town of North Kingstown has plans to develop trails on Calf Pasture Point. Even with increased access to the site, the remedy will be protective, as long as there are no water supply wells installed on the site and no unventilated buildings are constructed on the site.

New Contaminants and/or Contaminant Sources: There have been no new contaminants detected at the site since the first five-year review, and no new contaminant sources have been identified, although a specific source area was identified and removed in 2011, as summarized in various sections throughout this report. It is possible that the removal action may cause a temporary increase in CVOC concentrations near the source removal area, and subsequently in downgradient areas, over time; however, the impact will be of limited time and mass (both unknown, but assumed to be minor). With removal of the source, a long-term positive impact on the site is expected, since there is no longer a continuing source area.

Changes in Standards and TBCs: ARARs and TBCs considered during preparation of the ROD were reviewed to determine changes since the LTMP for Site 07 was issued. There have been no changes to currently relevant ARARs, with the exception of monitoring (comparison) criteria.

The primary monitoring criteria for the Calf Pasture Point Site are the EPA Safe Drinking Water Act (SDWA) MCLs and State Groundwater Quality Standards, as listed in Table 1 of RIDEM's Rules and Regulations for Groundwater Quality. The current MCLs are presented in EPA's Drinking Water and

Health Advisory Table (USEPA, April 2012), and the State's Groundwater Quality Standards were updated in March 2005. The monitoring criteria were presented in Table 8-3 of the *QAPP for the Long-Term Monitoring Plan for Site 07* (EA, 2001a). A comparison of the former and current groundwater monitoring criteria are presented in Table 2-3 of this five-year review. As shown in the table, there have been no changes in the primary groundwater monitoring criteria for Site 07.

Additional monitoring criteria for Calf Pasture Point surface water and sediment were listed in Table D-2 of the ROD. These values are the lesser of the federal Ambient Water Quality Criteria (AWQC) and the RIDEM Water Quality Standards (WQS) and Ambient Water Quality Guidelines. As indicated in Table D-2, these criteria were to be used to monitor discharges of groundwater to shoreline/offshore sediment and surface water within the discharge area of the site, based on trends identified from groundwater data. The federal AWQC were last updated in 2009, and the Rhode Island WQS were last updated in July 2006. A review of the old and new values indicates that the changes in the AWQC and WQS would not impact the protectiveness of the remedy. A comparison of old and new AWQC and WQS values is provided in Table 2-4.

Changes in Toxicity and Other Contaminant Characteristics: There have been no changes in human health toxicity criteria that would impact the monitoring criteria. The toxicity factors [i.e., Cancer Slope Factors (CSFs) and Reference Doses (RfDs)] used in the human health risk assessment for Site 07 were obtained primarily from IRIS or other sources (e.g., HEAST) in 1995. The toxicity factors for some COCs at Site 07 have changed since that time. The most noticeable of these are beryllium; 1,1-DCE; PCE; TCE; and PCBs:

- Beryllium and 1,1-DCE are no longer classified by EPA as carcinogens for the oral route of exposure. Therefore, the risks calculated for these chemicals today would be significantly less than the risks that were calculated in the risk assessment.

- The CSFs currently recommended by EPA for PCE and TCE have increased by an order of magnitude or more, since 1995. In addition, TCE is now considered to be a mutagenic chemical. Therefore, the risks calculated for these COCs would increase. However, these changes would not impact the results and conclusions of the risk assessment, and do not affect the values of the monitoring criteria (as shown in Tables 2-3 and 2-4) or the protectiveness of the remedy.

The CSF for PCBs used in the risk assessment is approximately 4 times greater than the value currently used. Therefore, the risks for PCBs in shellfish as calculated in the risk assessment may be overestimated. For example, the risk for PCBs in shellfish was 2×10^{-4}. If the current CSF were used, the new risk for total PCBs would be 5×10^{-5}. It should be noted that the oral RfD for PCBs has not

changed since the publication of the Phase III RI risk assessment. [The hazard index (HI) of 2 was estimated for the consumer of locally caught shellfish, as reported in the Phase III risk assessment.]

A comparison of old versus new toxicity criteria values is provided in Table E-4 of Appendix E. A comparison of exposure factors used in the Site 07 risk assessment with currently used values is provided in Table E-5 of Appendix E.

Changes in Screening Criteria: When the risk assessment for Site 07 was conducted in 1996, the 1995 EPA Region 3 RBCs were used as the basis of the COPC screening criteria for soil, groundwater, and shellfish, in accordance with Region 1 policy. In 1999, Region 1 recommended that the Region 9 PRGs be used for screening, instead of the Region 3 RBCs. In 2008, the Region 9 PRGs were discontinued and replaced with the EPA Regional Screening Levels (RSLs). Some RSLs are based on different exposure assumptions and are generally lower than the Region 3 RBCs. For example, the Region 3 RBCs for soil are based on ingestion only but the RSLs are based on the combined effects of ingestion, dermal contact, and inhalation. The differences in the values of RBCs and RSLs can be significant for some types of chemicals (especially VOCs). However, a review of the COPC selection tables for the chemicals that changed significantly indicates that the list of COPCs would not change if the RSLs were used. A comparison of old versus new screening criteria values is provided in Tables E-6 through E-9 of Appendix E.

Changes in Risk Assessment Methods: There have been no major changes in HHRA methodology that would impact the protectiveness of the remedy, since the signing of the ROD. However, several changes in EPA risk assessment methodology have occurred since the Phase III report was finalized in 1998. Among these are:

- The implementation of EPA's Dermal Guidance (RAGS-Part E) which was finalized in July 2004 (http://www.epa.gov/oswer/riskassessment/ragse/index.htm). Use of the RAGS-Part E guidance would result in slight changes in some dermal exposure parameters, such as exposed skin surface areas and dermal absorption factors. However, the effect of these changes on the calculated risks would be minimal and would not affect the results and conclusions of the risk assessment for Site 07.

- Calculation of EPCs: For soil in the Site 07 Phase III HHRA, EPCs were determined according to the *Supplemental Guidance to RAGs: Calculating the Concentration Term* (USEPA, May 1992). Using this guidance, risks for the reasonable maximum exposure (RME) were calculated using either the maximum detected concentration or the 95 percent UCL based on a lognormal distribution. New guidance for estimating EPCs was published in the EPA's *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA, December 2002)

(http://www.epa.gov/oswer/riskassessment/pdf/ucl.pdf) and the ProUCL guidance (USEPA, May 2010) (http://www.epa.gov/osp/hstl/tsc/software.htm). The effects of using the new guidance on the Site 07 soil data are not known. However, because risks were based on maximum detected concentrations or lognormal 95 percent UCLs, it is unlikely that soil risks have been underestimated (risks for soil at the site ranged from approximately 1×10^{-9} to 1×10^{-7}), by using the 1992 guidance.

- Carcinogens that Act by a Mutagenic Mode of Action: In March 2005, the EPA provided general direction on implementing the USEPA's 2005 *Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (http://www.epa.gov/cancerguidelines/guidelines-carcinogen-supplement.htm) because of special considerations for carcinogens that act via a mutagenic mode of action (e.g., VC, TCE, and PAHs). This guidance affects risks calculated for children and adolescents. For Site 07, this could, for example, potentially affect risks calculated for residential exposure to TCE and VC in groundwater. The risks calculated in the Phase III risk assessment for hypothetical residents assumed to be exposed to TCE and VC in groundwater exceeded 1×10^{-3}. If the new guidance were used, this risk would increase, but the results and conclusions of the risk assessment and the remedy for the site would not change.

- EPA's RAGs Part F, Supplemental Guidance for Inhalation Risk Assessment, was published in January 2009. Use of the RAGs Part F guidance would result in minor changes in the inhalation risks. However, the effect of these changes on the calculated total risks would be minimal and would not affect the results and conclusions of the risk assessment for Site 07.

- At the time the HHRA was prepared, EPA Region 1 recommended that, for a resident, inhalation exposures to chemicals volatilizing from groundwater be evaluated by assuming that the risks from the inhalation exposure pathway were equal to the risks from the ingestion exposure pathway. EPA Region 1 now recommends that such inhalation exposures be evaluated using the Andleman method, which assumes that 50 percent of the chemical volatilizes from groundwater to indoor air. This change in methodology would result in higher risks from exposures to volatiles in groundwater. However, since risks associated with the potential domestic use of the groundwater were already unacceptable, the conclusions of the risk assessment are not affected by the changes in methodology.

- Evaluation of Exposures from Vapor Intrusion: At the time the original risk assessment was prepared, guidance was not available for the evaluation of the vapor intrusion pathway. In November 2002, EPA released the *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*

(http://www.epa.gov/epawaste/hazard/correctiveaction/eis/vapor.htm). In 2012, EPA released the *Vapor Intrusion Screening Level (VISL) Calculator* (http://www.epa.gov/oswer/vaporintrusion/guidance.html#Item6) which provides screening levels for evaluating the potential for risks from vapor intrusion. The concentrations of VOCs in groundwater at Site 07 exceed the screening criteria by several orders of magnitude, indicating that unacceptable risks would be predicted for receptors exposed to VOCs via the vapor intrusion pathway. For example, the maximum detected concentration of VC in the most recent groundwater samples was 180 µg/L; the risk estimate associated with this concentration is approximately 1×10^{-3}. The maximum detected concentration of TCE was 96,000 µg/L, which corresponds to a 9×10^{-2} cancer risk. However, the ROD prohibits construction of a building for residential or commercial use across the entire site, and in the southern section of the site, any structure must have adequate ventilation as approved by the Navy, EPA, and RIDEM. Therefore, the selected remedy is protective of exposures associated with the vapor intrusion pathway (there can only be risk of vapor intrusion where the plume is present at the water table, which is only a small area of the large plume - near the source and from MW07-39I to the shoreline).

Supporting risk assessment tables and calculations for the analysis presented in this section are found in Appendix E (Risk Assessment Support Documentation). It should be noted that the June 2007 and November 2012 HHRA of environmental media along the Site 07 shoreline (Section 2.3.2.3) was conducted per current Navy and EPA risk assessment guidelines.

2.6.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

The rationale for remedy selection at Site 07 was based, in part, upon the assumption that the extent of the plume was stable or decreasing. Based on an evaluation of the CVOC plume configuration in 2012 versus 1995/96, some plume expansion has occurred to the east/southeast of the source area (including previously unidentified migration pathways through MW07-11D toward Narragansett Bay). The location of the center of mass in 2012 is different from that observed in 1995/96, as the center of mass has moved from the source area to the south and is currently located near the center of the site. Site. This could be due in part to depletion of source material adsorbed to the aquifer material close to the release area.

With the exception of the migration pathway from the source area through MW07-11D toward Narragansett Bay, there have been no changes regarding our understanding of the extents of the leading edges of the plumes, even though long-term trends are increasing at several locations along certain migration pathways (MW07-11D, -19D and -34D).

Of particular note, the contamination in areas where migration may be occurring (MW07-11D, -19D and -34D) is all within the deep overburden groundwater aquifer. Along two of these pathways, MW07-19D (along cross-section A-A') and MW07-34D (in the eastern portion of cross-section B-B'), contamination has already been detected beyond these locations, demonstrating that the extent of contamination is not changing; however, the distribution along the migration pathways may be changing. The only identified migration pathway where the overall extent is likely changing is the pathway from the source area through MW07-11D, where the plume is getting closer to Narragansett Bay over time. However, as determined through the tidal study, upward gradients in this area are infrequent (only occurring over short periods of time under certain low tides). Additionally, as determined from soil borings and well installations, a laterally extensive confining silt layer is present and typically is at least 10 to 15 feet thick. Consequently, the connection and discharge of deep groundwater to the shoreline environment are very complicated and limited. CVOC contamination may eventually reach the Narragansett Bay shoreline; however, the contaminant migration rate towards the shoreline is likely to be very slow as a consequence of both the gradient and laterally extensive silt layer. Also, the same groundwater/surface water interactions observed along the Entrance Channel are likely to impact both groundwater flow and contaminant discharge along the Narragansett Bay shoreline (see Section 2.5.2.3.5 for details).

While the rationale for the remedy selection included the assumption that the extent of the plume was stable or decreasing, the objective of the remedy was to "ensure that the discharge of groundwater to wetlands and off-shore areas continues to pose no unacceptable risks from COCs." While the extent of CVOC contamination may continue to increase along the MW07-11D pathway (i.e., towards Narragansett Bay), the protectiveness of the remedy is unaffected. Contaminant concentrations are at least an order of magnitude higher at MW07-21 (near the Entrance Channel) versus those detected at MW07-11D (near Narragansett Bay). Unacceptable risks are not predicted for COC concentrations in the environmental media at the Entrance Channel. Based on the distribution of contamination observed during 2012, it is also unlikely that concentrations will ever be comparable at MW07-11D (versus MW07-21) and as a consequence, unacceptable human health risks would not be predicted as a consequence of the potential discharge of CVOCs to the shoreline area downgradient from MW07-11D.

2.6.4 Technical Assessment Summary

Based on the LTM data reviewed and the site inspection results, the remedy at Calf Pasture Point is functioning as intended by the ROD. Supplemental data collection and risk assessment have been conducted during LTM to monitor the protectiveness of the remedy. The results of these assessments have indicated that there are currently no unacceptable risks resulting from site-related contamination.

There have been no changes in physical conditions at the site that would affect the protectiveness of the remedy; although the source has been removed (area has been returned to like material and similar elevation/relief). There have been no changes to ARARs or TBC guidance that would impact the protectiveness of the remedy. The changes in risk assessment methods and in the toxicities of contaminants that have occurred since the last five-year review are not expected to adversely impact the remedy. The exposure assumptions, PALs, and RAOs established at the time of the remedy selection and the LTMP development are still valid.

Statistical analysis of data collected during the LTM program, and a comparison of the distribution of CVOCs in 2007 versus 1995/96, suggest that the extent of the dissolved CVOC plume may not be stable, which could impact the protectiveness of the remedy in the future.

2.7 ISSUES

There were no protectiveness issues identified in this review.

2.7.1 Concerns

The following concerns are identified for Calf Pasture Point:

Concern	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
1. Implement EPA Region 1 request to complete an ESD to document the removal action (excavation and off-site removal) of the source area that was not a component of the 1999 Site 07 ROD.	N	N
2. LTM program needs to be reviewed/updated, including updating PALs based on new MCLs or EPA RSLs (as appropriate).	N	N
3. LTM ME data reporting and LTM comprehensive reviews of site data need to be reviewed/updated to ensure appropriate data is shared with BCT in a timely manner to ensure continued protectiveness.	N	N

2.8 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Concern	Recommendations/Follow-Up Actions	Responsible Party	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
1	Prepare ESD to document the removal action (excavation and off-site removal) of the source area that was performed in summer to fall 2011.	Navy	EPA/ RIDEM	3/1/14	N	N
2	a) Schedule a DQO meeting to discuss optimization of the LTMP and establish the objectives and scope of the LTMP. b) Prepare a revised UFP-SAP for Long-Term Monitoring at Site 07.	Navy	EPA/ RIDEM	a) 7/1/13 b) 11/30/13	N	N
3	Schedule a DQO meeting to discuss reporting requirements for data reports and schedule for comprehensive data reviews.	Navy	EPA/ RIDEM	6/1/13	N	N

2.9 PROTECTIVENESS STATEMENT

The remedy at Calf Pasture Point is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through institutional controls. These controls are effectively preventing exposure to site-related contaminants in groundwater.

In order to verify that the remedy continues to be protective, changes to the LTM program are warranted since the concurred upon LTM scope does not provide for sampling in optimal locations. The objectives and scope of these changes will be developed through the DQO process, as described in the UFP-QAPP Guidance.

3.0 SITE 09 - ALLEN HARBOR LANDFILL

This section presents the findings of the five-year review for the remedy that was implemented at Navy IR Site 09 (Allen Harbor Landfill) at the former NCBC Davisville. The format of this section follows that which is presented in the USEPA *Comprehensive Five-Year Review Guidance* (2001).

3.1 ALLEN HARBOR LANDFILL SITE CHRONOLOGY

Event	Date
Allen Harbor Landfill was used for the disposal of waste material generated by the former NCBC Davisville facility and NAS Quonset Point.	1946 - 1972
After landfilling operations had ceased, the landfill was closed by placing a discontinuous 2-foot soil cover over the fill materials.	1972
Completion of the *Initial Site Assessment of the former NCBC Davisville* (Hart, 1984).	9/1984
Completion of the *Verification Step - Confirmation Study of the former NCBC Davisville Facility* (TRC, 1987).	2/1987
EPA's Hazard Ranking Scoring Package for the former NCBC Davisville facility.	1989
NCBC Davisville facility placed on the CERCLA NPL.	11/21/1989
FFA signed by the Navy, EPA, and the State of Rhode Island.	3/1992
Remedial Investigation for Allen Harbor Landfill completed.	12/1996
Record of Decision signed.	9/29/1997
Submittal of Final *Design Analysis Report For Closure of the Allen Harbor Landfill* (EA, 1998c). Construction of landfill cap begins.	3/31/1998
Submittal of Draft *Allen Harbor Landfill Offshore Investigation Report* (EA, 1998c)	4/1998
Construction of landfill cap completed and Explanation of Significant Differences (ESD) submitted for polychlorinated biphenyl (PCB)-contaminated soil removal and extension of the soil cap and the revetment (EA, 1999a).	8/1999
First Quarterly Landfill Inspection	12/29/1999
Second Quarterly Landfill Inspection.	3/30/2000
2000 Annual Landfill Settlement Survey.	4/2000
Final *Remedial Action Report for Site 09-Allen Harbor Landfill Cap* (FWENC, 2000b).	6/2000
Class I survey of Parcel 10 completed and annotated with references to the deed for groundwater use and land use restrictions.	11/2000
FOST to transfer Parcel 10 to the U.S. Department of Interior for transfer to the Town of North Kingstown, Rhode Island (Navy, 2000b).	12/14/2000
Final Conceptual Long-Term Monitoring Plan (CLTMP) which included establishment of the performance standards (Newfields, 2000b).	12/22/2000
Final Remedial Action Operations and Long-Term Management Plan for Allen Harbor Landfill (FWENC, 2001a).	5/2001
Work Plan Addendum No. 2 and Installation of MW09-25S as agreed to in the CLTMP.	7/2001

Event	Date
Final Landscape Plan for Allen Harbor Landfill (Beckman-Weremay, 2001).	10/2001
Final QAPP for Long-Term Monitoring of Site 09 (EA, 2001b).	11/2001
LTMP initiated with ME 01.	11/30/2001
2001 Annual Landfill Settlement Survey.	12/2001
Final LUCIP that includes the inspection procedures for Site 09 to document compliance with the land use controls and/or deed covenants placed by the Navy on this transferred Navy property (Parcel 10) (EA, 2002b).	1/2002
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2001 (EA, 2002c).	2/14/2002
ME 02 sampling.	2/2002
ME 03 sampling.	6/2002
ME 04 sampling.	9/2002
ME 05 sampling.	1/2003
Final, Revision 1: Quality Assurance Project Plan for Long-Term Monitoring of Site 09 (Allen Harbor Landfill), Naval Construction Battalion Center, North Kingstown, Rhode Island (EA, 2003b).	2/2003
Signature date of the First Five-Year Review Report for the NCBC Davisville facility.	3/30/2003
ME 06 sampling.	4/2003
Semi-Annual Landfill/Wetland Inspection 3; 2003 Annual Landfill Settlement Survey.	5/2003
ME 07 sampling.	6/2003
ME 08 sampling. Semi-Annual Landfill/Wetland Inspection 4.	9/2003
ME 09 sampling.	12/2003
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2003 (EA, 2004e).	2/11/2004
ME 10 sampling.	3/2004
Parcel 10 transferred.	5/10/2004
Parcel 10 ELUR recorded.	6/8/2004
ME 11 sampling.	6/2004
Semi-Annual Landfill/Wetland Inspection 5.	7/2004
ME 12 sampling.	8/2004
ME 13 sampling.	10/2004
ME 14 sampling.	3/2005
ME 15 sampling.	6/2005
Semi-Annual Landfill/Wetland Inspection 7.	7/2005
2005 Annual Landfill Settlement Survey.	8/2005
ME 16 sampling.	9/2005
ME 17 sampling.	12/2005
ME 18 sampling.	3/2006

Event	Date
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2004 (Tetra Tech, 2006b).	6/12/2006
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2005 (Tetra Tech, 2006c).	8/15/2006
Draft 2005 Annual Data Summary Report, including evaluation of LTM data collected during the first 15 events of quarterly monitoring at Allen Harbor Landfill (Tetra Tech, 2006d).	9/2006
ME 19 sampling. 2006 Annual Landfill Settlement Survey.	11/2006
ME 20 sampling.	3/2007
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2006 (Tetra Tech, 2007h).	5/21/2007
Inspection of constructed wetland to assess shellfish populations (Tetra Tech, 2007m).	5/22/2007
Well integrity inspection at Site 09 to assess status of “damaged” wells (Tetra Tech, 2007n).	5/23/2007
ME 21 sampling.	6/2007
ME 22 sampling.	11/2007
Revisions to QAPP for Long-Term Monitoring at Site 09 Allen Harbor Landfill, Former Naval Construction Battalion Center Davisville (Tetra Tech, 2007r).	11/2007
Semi-Annual Landfill/Wetland Inspection.	12/2007
2007 Annual Landfill Settlement Survey.	12/2007 and 1/2008
ME 23 sampling.	1 and 2/2008
Signature date of the Second Five-Year Review Report for the NCBC Davisville facility.	3/28/2008
ME 24 sampling.	4 and 5/2008
Semi-Annual Landfill/Wetland Inspection.	6/2008
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2007 (Tetra Tech, 2008e).	6/2008
ME 25 sampling.	7/2008
ME 26 sampling.	9 and 10/2008
2008 Annual Landfill Settlement Survey.	11/2008
ME 27 sampling.	12/2008
Semi-Annual Landfill/Wetland Inspection.	12/2008
ME 28 sampling.	3 and 4/2009
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2008 (Tetra Tech, 2009b).	4/2009
Installation of replacement wells MW09-08DA, MW09-09DA and MW09-14IA and Landfill Liner repairs (from installation of wells).	6/2009
Semi-Annual Landfill/Wetland Inspection.	7/2009
ME 29 sampling.	8/2009

Event	Date
2009 Annual Landfill Settlement Survey.	9/2009
ME 30 sampling.	10/2009
Revision 2 to the Long-Term Monitoring at Site 09 Allen Harbor Landfill, movement of sediment sampling zone from 2 to 3 feet bgs to 2 to 6 inches bgs	12/2009 and 1/2010
Semi-Annual Landfill/Wetland Inspection.	1/2010
ME 31 sampling.	1/2010
ME 32 sampling.	3/2010
Surface water seep sampling at the stone revetment wall near P09-07 and P09-08.	3/2010
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2009 (Tetra Tech, 2010d).	4/2010
Color-Tec® field screening of “Stressed” portion of Created Wetland.	4/2010
Habitat Evaluation of “Stressed” portion of Created Wetland to identify possible physical causes of the slow wetland growth.	7/2010
Semi-Annual Landfill/Wetland Inspection.	7/2010
ME 33 sampling.	7/2010
Piezometers within the Created Wetland moved from the center of the Created Wetland to the base of the stone revetment (labeled as “A”) based on EPA request.	9/2010
ME 34 sampling.	9/2010
2010 Annual Landfill Settlement Survey.	10/2010
Final 2008 Annual Data Summary Report, including evaluation of LTM data collected from ME 18 to 27 (calendar years 2006, 2007 and 2008) as well as comprehensive evaluation of all quarterly ME data to date (ME 1 to 27) at Allen Harbor Landfill (Tetra Tech, 2010k).	11/2010
ME 35 sampling.	12/2010
Semi-Annual Landfill/Wetland Inspection.	12/2010
ME 36 sampling.	3/2011
ME 37 sampling.	7/2011
Semi-Annual Landfill/Wetland Inspection.	7/2011
ME 38 sampling.	9 and 10/2011
2011 Annual Landfill Settlement Survey.	10/2011
Final LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2010 (Tetra Tech, 2011h).	10/2011
Semi-Annual Landfill/Wetland Inspection.	1/2012
Draft 2009/2010 Annual Data Summary Report, including evaluation of LTM data collected from ME 27 to 34 (calendar years 2009 and 2010) as well as comprehensive evaluation of all quarterly ME data to date (ME 1 to 34) at Allen Harbor Landfill (Tetra Tech, 2012a).	3/2012
ME 39 sampling.	3/2012
Proposed Revisions for Landfill Gas Monitoring Program for Site 09 Allen Harbor Landfill. RIDEM approval for reduced monitoring received April/May.	3 and 4/2012

Event	Date
Draft LUCIP Annual Letter Report documenting compliance with land use controls for Parcel 10 (Allen Harbor Landfill) during 2011 (Tetra Tech, 2012c).	5/2012
ME 40 sampling.	9 and 10/2012
Semi-Annual Landfill/Wetland Inspection.	11/2012

3.2 ALLEN HARBOR LANDFILL BACKGROUND INFORMATION

In this section, background information for Allen Harbor Landfill such as physical characteristics, current and former land use, and a history of environmental actions is presented.

3.2.1 Physical Characteristics

Allen Harbor Landfill is located in the Main Center of the former NCBC Davisville facility, within Parcel 10, as shown on Figure 3-1. Allen Harbor Landfill is an approximately 15-acre grassy area formerly used by the Navy as a landfill. The site is located within a 100-year floodplain, bounded to the north and south by vegetated wetlands, to the east by Allen Harbor, and to the west by Sanford Road. Allen Harbor is used for recreational boating and is supported by two marinas. In 1984, RIDEM closed Allen Harbor to shellfishing due to suspected contamination from several sources, including Site 09.

The site was closed in accordance with the ROD (September 1997) and is currently capped with an impermeable geosynthetic liner (a multimedia landfill cap) and is covered with grass and small shrubs. A revetment wall and constructed wetland are located along the southern and eastern boundaries of the landfill. A stone breakwater structure separates the wetland from the harbor (Figure 3-1). The site terrain is gently sloping, with a topographic high in the center of the landfill.

No groundwater production wells are located on or downgradient of the site. Groundwater at the site is classified by RIDEM as GB (i.e., presumed to be not suitable for public or private drinking water use without treatment).

3.2.2 Land and Resource Use

Between 1946 and 1972, the Allen Harbor Landfill was used for the disposal of waste material generated by NCBC Davisville and NAS Quonset Point. Parcel 10, which includes Site 09, is currently owned by the Town of North Kingstown, after being transferred from the Navy via the U.S. Department of the Interior. In the future, Allen Harbor Landfill will not be used for residential purposes due to environmental land use restrictions placed on the property, as required by the ROD. The Town's planned use of the property is as open space/conservation land.

In accordance with the ROD (EA, 1997), deed, ELUR, and LUCIP (EA, 2002b), Parcel 10 (Site 9) includes the following environmental land use restrictions:

- For the entire parcel, no residential or commercial use, as stated in the ROD (park/recreational uses are permitted).

- For the entire parcel, water supply wells shall not be installed nor shall groundwater be utilized, except for sampling or other remedial purposes

- For the contaminated site, as delineated on Figure 3-1 (land use restriction boundary), use by the Grantee, its successors, and assigns, will be for pedestrian traffic only. Restrictions include, but are not limited to: digging, use of motorized vehicles, or other activities that may damage the remedy components (multimedia cap, gas vents, monitoring wells, stone revetment, etc.) or otherwise allow direct exposure to hazardous waste under the cap.

LUCIP inspections of Parcel 10 are performed in conjunction with each Site 09 LTM program event, but no less frequently than annually, to document that there has been no variance from the environmental land use restrictions stated above.

3.2.3 History of Contamination

A 1939 aerial photograph of the Allen Harbor area depicts the landfill as an undeveloped open grass field lined with shrubs and bushes. From 1946 to 1972, the Allen Harbor Landfill was used for the disposal of waste materials including municipal-type waste, construction debris, rubble, preservatives, paint thinners, degreasers (e.g., solvents), PCB, oil, asbestos, ash, sewage sludge, and waste fuel oil. Disposal activities usually included burning the waste and covering it with soil. In 1972, after landfilling operations had ceased, the landfill was closed by placing a discontinuous 2-foot soil cover over the fill materials.

Prior to construction of the cap (one portion of the site remedy) in 1998, the Allen Harbor Landfill was vegetated similar to typical upland coastal areas (i.e., grasses/perennials, shrub communities, and deciduous forest components), which provided habitat for numerous species of birds and mammals. Also, building debris and rusted metallic objects were visible at various locations across the site, including the site shoreline and the harbor-side face of the landfill.

3.2.4 Initial Response

In 1972, after landfilling operations had ceased, the landfill was closed by placing a discontinuous 2-foot soil cover over the fill materials.

3.2.5 Basis for Taking Action

Groundwater data from the RI indicated the presence of elevated concentrations of VOCs and low level concentrations of PAH, pesticides, and metals. Elevated concentrations of PAH, pesticides, PCBs, and metals were detected in surface and subsurface soil samples. Semi-volatile organic compounds (SVOCs), pesticides, PCBs, and metals were detected in sediment samples throughout the harbor (Allen Harbor).

According to the HHRA that was completed during the RI, the contaminants with a cancer risk greater than 10^{-4} and/or a HI greater than 1.0 included the following:

Groundwater		Sediment	Shellfish
arsenic	1,2-DCE (total)	heavy metals	arsenic
manganese	1,2-dichloropropane	PAHs	copper
bis(2-chloroethyl)ether	TCE	PCBs	zinc
1,2-DCE	vinyl chloride		aroclor 1254
			aroclor 1260

The human health risks that exceeded risk management goals at Site 09 were associated with the following exposure scenarios:

- Ingestion of deep groundwater by future residents
- Use of site groundwater for showering in a potential recreational facility
- Dermal contact with or incidental ingestion of site surface soil by recreational users of the site
- Incidental ingestion of shoreline sediment by recreational users of the site
- Consumption of shellfish from the site shoreline.

Potential health risks to site workers during remedial activities were associated with the incidental ingestion of soil (EA, 1996c).

Ecological risks to marine organisms in Allen Harbor were reported to be “moderate" to “slight.” Moderate risk to marine organisms was reported to be limited to the narrow inter-tidal zone to the north and south of the site. Risks to terrestrial ecological receptors were reported to be moderate to high within the Allen Harbor Watershed (an area in which the Allen Harbor Landfill was one of the contributors to elevated risk) (EA, 1996c). The ecological risk assessment (ERA) identified elevated risks to several terrestrial receptors, resulting from exposure to contaminants. Elevated concentrations of PAHs, pesticides, PCBs, and metals in surface soil and sediment were the primary sources of ecological risk to terrestrial

receptors. Sediment samples collected from Allen Harbor had concentrations of PAHs, pesticides, PCBs, and metals in excess of benchmark screening values. A benthic community structure analysis showed no obvious toxicological effects relative to reference stations; however, the elevated concentrations of contaminants were identified in the risk assessment as “flags” of potential ecological risk (EA, 1996c).

3.3 REMEDIAL ACTIONS

This section discusses the remedy selection and implementation history for Allen Harbor Landfill, along with a discussion of the LTM program currently in place at Site 09.

3.3.1 Remedy Selection

The ROD for Site 09 was signed on September 29, 1997 and includes the following components: the construction of a multimedia cap (including a gas venting system), a stone shoreline revetment, an offshore breakwater, and the construction of inter-tidal wetlands, along with LTM and land use controls. RIDEM concurred with the remedy on September 25, 1997.

As stated in the ROD, the RAOs for Allen Harbor Landfill are as follows:

Surface Soil

- Prevent human and terrestrial animal exposure to COCs in surface soil
- Prevent offsite migration of surface soil and surface soil contaminants through overland runoff

Subsurface Soil

- Reduce leachate generation
- Reduce or eliminate surface erosion and exposure of fill materials along landfill shoreline

Groundwater

- Prevent human exposure to COCs in deep groundwater

Sediment

- Minimize risks from marine ecological exposure to COCs in sediment
- Control potential future sediment contamination from landfill constituents (COCs)

Wetlands

- Control potential future contamination of wetlands from landfill constituents (COCs)
- Improve quality of existing wetlands and create new wetlands onsite along the shoreline

Shellfish

- Control potential future contamination of shellfish from landfill constituents
- Prevent or minimize human ingestion of shellfish from the landfill shoreline containing COCs above health advisory concentrations.

Based upon the results of the Remedial Investigation/Feasibility Study (RI/FS), and the community response to the Proposed Plan, the selected remedy for Site 09 was Alternative 3 - Multimedia Cap. A complete description of the selected alternative is presented in Section VIII of the ROD (EA, 1997) and in the ESD of August 1999 (EA, 1999a).

The EPA's *Presumptive Remedy for CERCLA Municipal Landfill Sites* directive (OSWER Directive 9355.0-49FS) states that containment technologies are the preferred remedies for municipal-type landfill waste. Accordingly, cleanup goals (i.e., treatment goals) were not developed as part of the Site 09 remedy. The components of the selected alternative address the identified risk pathways and the RAOs identified for Site 09. The LTM program established as part of the selected alternative was designed to ensure the protection of human health and the environment over time. The selected remedial alternative includes the following components:

- Construction of a multimedia cap above the 100-year storm elevation (14 feet above msl) that consists of multiple soil layers and two impermeable layers and a soil cap in the area below 14 feet msl to comply with current federal and state laws. This component of the remedy addressed the RAOs for surface and subsurface soil.

- Construction of a passive gas venting system as part of the cap system. Landfill gases collected within the gas vent layer are passively vented to the atmosphere via five vents at the landfill. The points of discharge (vents) were fenced in order to protect potential site visitors.

- Removal and/or covering of landfill debris from the landfill shoreline. This addressed the RAOs for surface soil, sediment, and shellfish.

- Construction of a stone revetment along the shoreline of Site 09 to protect the landfill face from wave action (e.g., tidal forces and storm events). This stabilization of the landfill face addressed the RAOs for surface soil, sediment, and shellfish.

- Construction of a breakwater structure just east of a majority of the revetment wall along with construction of a wetland area between the revetment wall and breakwater structure, which together act to trip waves and reduce energy reaching the revetment. Construction of this wetland area along the shoreline of the site also serves as a natural resources/habitat improvement. Material dredged from the entrance channel to Allen Harbor was used in the construction of the wetlands. The progression of wetland development is being monitored over time to verify its sustainability. This addressed the RAOs for sediment, shellfish, and wetlands.

- Establishment of institutional controls, as follows (addressing the RAO for groundwater):

  - Implementation of land use restrictions that include deed restrictions regarding site and groundwater use
  - Implementation of appropriate land use restrictions (i.e., no use of motorized vehicles, no digging, no deep-rooted vegetation) to protect human health and the environment through limiting site development to maintain the integrity of the cap
  - Prevention of the installation or use of groundwater wells, which would be used for drinking water or showering purposes.

- Conduct long-term monitoring of landfill gas, groundwater, sediment, and shellfish quality to evaluate the effectiveness of the remedy.

- Five-year reviews of the decision for the site by the Navy, EPA, and RIDEM.

A Rhode Island prohibition on the collection of shellfish from Allen Harbor addresses human health risks associated with the ingestion of shellfish from the landfill shoreline. As part of the remedy for Allen Harbor Landfill, the Navy maintains signage along the landfill shoreline to warn the public about the shellfishing ban.

The Navy and EPA signed the ROD in September 1997, which declared that the selected remedy is protective of human health and the environment, complies with current federal and state applicable or relevant and appropriate requirements (ARARs), and is cost effective (EA, 1997).

3.3.2 Remedy Implementation

On March 31, 1998, the Final *Design Analysis Report for Closure of the Allen Harbor Landfill* (EA, 1998b) was submitted, and the capping activity commenced. FWENC completed the remedial action in August 1999 (FWENC, 2000b). In addition to the remediation activities outlined in the ROD, a removal action was performed by FWENC in the spring of 1999, when the presence of PCB-contaminated soil was discovered at the northern end of the landfill. Due to the PCB removal conducted as part of the remedy for this site, an ESD was submitted as part of the ROD in August 1999. The ESD did not fundamentally alter the remedy at the site. The ESD included the PCB-contaminated soil removal and a northerly extension of the soil cap and the revetment.

3.3.2.1 Remedy Operations and Maintenance

On March 30, 2000, quarterly physical inspections of the landfill were initiated and were continued on a quarterly basis for the first two years. Since 2002, inspections have been conducted semi-annually, and are completed in accordance with the Final *Remedial Action Operations and Long-Term Management Plan for Allen Harbor Landfill* (FWENC, 2001a). Maintenance and repairs are performed on an as-needed basis, based on the findings of the inspections. Prior to 2008, most maintenance/repairs were performed annually – typically in the fall (generally, August, September and October). Since 2008, most repairs are completed concurrent with quarterly LTM activities (or semi-annually, in 2012).

The primary activities associated with operation and maintenance (O&M) of the landfill include:

- Visual inspection of the landfill cap with regard to vegetative cover, settlement, erosion, and need for corrective action.
- Inspection of the storm drainage system for sediment accumulation, erosion, vegetative growth, ponding, and obstructions.
- Inspection of the condition of the gas vents and monitoring wells.
- Inspection of the revetment slope and breakwater structure for areas of sliding or stone displacement.
- Inspection of the constructed wetland, the planted wetland in the former barge area just north of the capped area, and the wetland enhancement area located along the northwest corner of Allen Harbor, for plant percent survivability, physical appearance, density of growth, and the presence of invasive wetland plant species.

- Inspection of shellfish in the constructed wetland, regarding presence (establishment of a population), general location, extent, and abundance of ribbed mussels, hard- or soft-shell clams, and oysters.

O&M or post-closure care at the Allen Harbor Landfill must be performed for 30 years after the landfill closure, in accordance with Resource Conservation and Recovery Act (RCRA) requirements in 40 CFR Parts F, G, and N, Section 2.1.09(c) of the RIDEM Office of Waste Management Solid Waste Regulation No. 2 - Solid Waste Landfills, and the ROD. Five-year reviews must be conducted as long as contamination remains above levels that allow for unlimited use and unrestricted exposure.

Landfill settlement surveys are conducted annually at each monitoring well, each gas vent, and at six locations each, on the revetment and breakwater, to monitor subsidence in the landfill and along the shoreline. Settlement survey data are reviewed to determine if subsidence has exceeded the acceptable range of 6 inches over any 100-linear-foot area of the landfill cap.

Based upon the landfill inspections conducted from 2000 through 2012, it appears that, overall, the site remedy is in good condition and functioning according to design, including the cap, revetment slope, and breakwater structure. Based on the settlement survey results, there has been minor subsidence in a few areas, but this has not exceeded the acceptable range. Additional details regarding the maintenance activities that have occurred since the first and second five-year reviews are provided in Section 3.5.2.

3.3.2.2 Land-Use Control Implementation Plan (LUCIP)

On November 30, 2001, LUCIP inspections were initiated with ME 01. LUCIP inspections are performed in accordance with the Final *QAPP for LTM at Site 09* (EA, 2001b and 2003b) and the Final *Land-Use Control Implementation Plan* (EA, 2002b). Land use control inspections have been performed during each monitoring event at Allen Harbor Landfill to verify compliance with the land use restrictions established as part of the site remedy (Section 3.3.1). Copies of the institutional controls inspection checklists are included in each of the quarterly monitoring event reports and/or monitoring event data reports. Compliance with land use controls is documented annually in the LUCIP Annual Letter Reports.

Based on the Institutional Control Inspections completed during ME 01 through ME 40 and the LUCIP Annual Letter Reports, there was compliance with the institutional controls stated in the ROD and Final LUCIP (see references).

3.3.2.3 Long-Term Monitoring

LTM at Allen Harbor Landfill commenced in December 2001. Since the first monitoring event, there have been three formal scopes performed (as approved by the BCT) for LTM events at Site 09. In addition,

minor changes have also occurred, all concurred with and documented, though not part of a formal scope revision. The changes have generally been related to relocation of sampling locations (e.g. relocation of piezometers closer to revetment wall).

Between December 2001 and December 2010, monitoring has occurred quarterly. The scope of the baseline LTMP in the *QAPP for LTM at Site 09* included quarterly sampling from 20 monitoring wells, ten piezometers, ten sediment locations, five gas vents, and 28 temporary gas probe locations. With one exception (listed below), quarterly monitoring events have met the completeness objectives established in the QAPP, although. (However two monitoring wells have not been sampled during the LTM program, due to damage incurred during cap construction. The one exception is that some piezometer locations were unable to be fully sampled during the early LTM events, due to insufficient volumes; therefore, additional co-located piezometers were installed to allow for adequate volumes to fill all required sample bottles.

Revisions to the baseline QAPP were submitted by the Navy in November 2007 and approved by the BCT, with implementation beginning with ME 23 (January/February 2008). The sampling that was initiated in 2008 from this Revision 1 of the QAPP included: semi-annual groundwater sampling of 26 monitoring wells, with quarterly sampling of 14 of these wells; semi-annual sampling of shoreline piezometers at 12 locations, with quarterly sampling of two of these piezometers; semi-annual sediment sampling from nine shoreline locations (co-located with piezometers), with quarterly sediment sampling from two of these locations; quarterly gas sampling from five gas vents; and quarterly shallow soil gas sampling at 28 locations along the landfill cap. Additionally, in June 2009, the Navy replaced wells MW09-08D, MW09-09D and MW09-14I and re-initiated sampling at these locations.

Additional changes to Revision 1 of the QAPP were submitted by the Navy in December 2009. However, most of the Navy recommendations were not concurred with by the BCT. The only modification agreed to by the BCT was that sediment samples would be collected from two to six inches bgs, versus two to three feet bgs, as specified in the QAPP for the LTM program. The modification was requested by the EPA so that sediment samples would be collected from a depth interval more representative of the interval at which ecological receptors would be exposed. The following additional changes to the Site 09 long-term monitoring have occurred since 2010, though they have not been formalized in a revision to the QAPP:

- At the request of EPA, the piezometers within the created wetland were moved to the base of the stone revetment wall in September 2012. The new piezometer locations were labeled with an “A” on associated figures presented in this document, as the original piezometer locations were left in place.

- Based on recommendations from the Draft 2009/2010 Annual Data Summary Report (submitted by the Navy in March 2012), modifications to the scope of the soil vent and soil gas monitoring were implemented. The first modification involved reduction in air monitoring at the five gas vent locations and 28 soil gas sampling locations. The five gas vents continue to be sampled but only using real-time portable equipment screening probes. For soil gas sampling, the number of sampling points was reduced from 28 to 17 locations. The second modification was a change from quarterly to semi-annual sampling (consistent with details in previous paragraph). Samples for fixed-base laboratory analysis would be collected from the gas vents once per five-year review period.

In addition to the monitoring of groundwater, piezometers, sediment and air gas, the following has also occurred over the course of the long-term monitoring to verify the integrity of the landfill cap, to ensure that LUCs are effectively preventing human exposure to site contaminants, and to increase the BCT's understanding of the hydrogeologic setting at Site 09:

- The landfill cap and associated components were inspected semi-annually to ensure continued integrity and effectiveness

- An annual settlement survey was conducted at 41 locations, including 26 monitoring wells;

- Quarterly (semi-annual since 2012) synoptic water level measurement rounds were conducted prior to each groundwater sampling event; and

- Shellfish samples were also collected from the landfill shoreline and from two reference locations.

Locations of groundwater monitoring wells, piezometers, sediment sample stations, air vents, and soil gas sample stations are provided in Figures 3-2 and 3-3. The following table summarizes the monitoring events completed at Allen Harbor Landfill to date:

Monitoring Event	Date	Monitoring Event	Date
ME 01	December 2001	ME 21	June 2007
ME 02	March 2002	ME 22	November 2007
ME 03	June 2002	ME 23	January/February 2008
ME 04	September 2002	ME 24	April/May 2008
ME 05	January 2003	ME 25	July 2008
ME 06	May 2003	ME 26	September/October 2008
ME 07	June 2003	ME 27	December 2008
ME 08	September 2003	ME 28	March/April 2009

Monitoring Event	Date	Monitoring Event	Date
ME 09	December 2003	ME 29	August 2009
ME 10	March 2004	ME 30	October 2009
ME 11	June 2004	ME 31	January 2010
ME 12	August 2004	ME 32	March 2010
ME 13	October 2004	ME 33	July 2010
ME 14	March 2005	ME 34	September 2010
ME 15	June 2005	ME 35	December 2010
ME 16	September 2005	ME 36	March 2011
ME 17	December 2005	ME 37	July 2011
ME 18	March 2006	ME 38	September/October 2011
ME 19	November 2006	ME 39	March 2012
ME 20	March 2007	ME 40	September/October 2012

Monitoring wells MW09-26S, 26D, 27S, and 27D, and piezometers P09-11 and P09-12 were installed in December 2007 (Figure 3-2). These locations (plus MW09-17I) were sampled during the first monitoring event of 2008. The Navy attempted to repair damaged monitoring wells located within the landfill cap area (MW09-09D and MW09-14I) during the spring of 2008. In June 2009, the Navy replaced wells MW09-08D, MW09-09D and MW09-14I and re-initiated sampling at these locations. Other than relocation of the piezometers within the created wetland in September 2010, no other modifications to the sampling locations have occurred.

The baseline and subsequent revisions to the LTM program anticipated at least one round of shellfish (bivalve) tissue sampling from the constructed wetlands, annually (designated to be late spring, during spawning season) in order to evaluate the potential impacts of site-related contamination on the shellfish along the landfill shoreline. RIDEM and EPA have requested that the shellfish samples be collected from locations in front of the breakwater, to ascertain if VOCs, PCBs, or metals are migrating from the landfill. Sampling in front of the breakwater was conducted in October 2012, and results are currently pending.

During the first five-year review (in 2003), shellfish sampling did not occur because shellfish had not re-colonized the constructed wetland. In May 2007, the Navy conducted a shellfish assessment in the constructed wetland and determined that insufficient numbers of bivalves were present to support sampling. In August 2007, abundant ribbed mussels were observed along the southern and northern shorelines of the landfill (outside of the constructed wetland).

During December 2007, the Navy collected shellfish samples from the landfill shoreline in the areas of P09-01, P09-09, and P09-10. This was the first shellfish sampling event conducted since the inception of the LTM program. Two samples of ribbed mussels were collected from the P09-01 area and two samples

were collected from the P09-09/10 area. In addition, reference samples were collected to evaluate the anthropogenic background levels of contamination present in similar marshy areas within or adjacent to Narragansett Bay. The reference sample locations were in Fishing Cove in Wickford, Rhode Island and along the shoreline of Prudence Island in Narragansett Bay. From 2007 through 2012, the Navy conducted annual shellfish sampling from the landfill shoreline in the areas of P09-01, P09-09, and P09-10. Additionally, in May 2010 and October 2012, adequate quantities of ribbed mussels were observed within the created wetland near P09-07 and P09-08, and therefore, shellfish were collected from these areas, as well.

In March 2012, the Navy completed a data summary report with statistical analyses based on sampling results from ME01 through ME 34. Conclusions and recommendations from this data summary report resulted in the request and approval for reduced monitoring in 2012 (BCT teleconference held May 7 with EPA comments on June 19, therefore changes only reflective in ME 40). An updated analysis of site conditions and statistical trends based on sampling results from ME 01 through ME 39 is included in Section 3.5.

3.4 PROGRESS SINCE THE LAST REVIEW

The second five-year review, conducted in March 2008, concluded that the remedy at Allen Harbor Landfill was protective of human health and the environment, and exposure pathways that could result in unacceptable risks were being addressed through remedy-related institutional controls and a state-enforced prohibition on shellfishing in Allen Harbor. These controls were effectively preventing exposure to site-related contaminants.

Further, in order to verify that the remedy continues to be protective in the long-term, changes to the LTM program were warranted. The objectives and scope of these changes would be developed through the DQO process, as described in the *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP) Guidance.

This section presents the three issues and subsequent recommendations and follow-up actions that were included in the second five-year review, with a brief description of the actions taken by the Navy since that five-year review.

3.4.1 <u>Issue 1: Long-Term Monitoring Program needs to be reviewed/updated</u>

To address the issue of reviewing and updating the LTM Program, the following recommendations were made:

1. *Schedule a DQO meeting to discuss optimization of the LTM program and establish the objectives and scope of the LTM program.*

   Actions Taken: On October 29, 2009, a DQO meeting was conducted to support the preparation of a SAP to revise the LTMP for Site 09, Allen Harbor Landfill. However, the anticipated DQOs did not occur. Instead, EPA provided a technical presentation which focused on the Agency's conceptual understanding of groundwater and potential contaminant transport from the landfill to the adjoining shoreline and off-shore areas.

   Results of Actions: As a result of the October 29, 2009 DQO meeting, the Navy re-located the piezometers within the created wetland to the base of the revetment wall in order to evaluate EPA's contaminant transport pathway concerns. The piezometers were re-located in September 2010 and 11 sampling events have occurred at these new locations (ME 30 through 40).

   A DQO meeting to support the preparation of a SAP to revise the LTMP for Site 09, Allen Harbor Landfill has not been re-scheduled. However, as summarized in Section 3.3.2.3, modifications to the LTMP has occurred starting in in summer 2012 based on a comprehensive data analysis. Further evaluations and modifications are recommended in this Five-Year Review.

2. *Prepare a revised Work Plan/SAP for Long-Term Monitoring at Site 09.*

   Actions Taken: Since the DQO meeting to support the preparation of a SAP to revise the LTMP for Site 09, Allen Harbor Landfill, such a document has not been completed; however, as summarized in Section 3.3.2.3, several BCT-approved modifications to the LTMP have been enacted.

   Results of Actions: While several BCT-approved modifications to the LTMP have been enacted, a comprehensive Work Plan/SAP for Long-Term Monitoring at Site 09 is still outstanding.

3.4.2 Issue 2: Landfill maintenance activities not communicated effectively to BCT

To address the issue of landfill maintenance activities not being communicated effectively to the BCT, the following recommendations were made:

1. *Include a section in quarterly monitoring reports or annual monitoring reports detailing landfill maintenance activities completed.*

Actions Taken: In the Long-Term Data Summary reports (November 2010, covering ME 1 to ME 27, and March 2012, covering ME 1 through 34), a section detailing the landfill maintenance activities has been included.

Results of Actions: Details of completed landfill maintenance activities are effectively being communicated to the BCT.

2. *Maintain a regular inspection schedule and provide draft landfill inspection reports to the BCT within one month of inspections.*

Actions Taken: Semi-annual landfill inspections are performed at Site 09. The dates of the inspections may vary from year to year (primarily due to inclement weather), but the inspections are routinely performed. The semi-annual landfill inspections are included in the final (or draft, as applicable) data summary reports, as appropriate.

Results of Actions: More effective communication of landfill inspections to the BCT has occurred. While separate draft inspection reports are not submitted to the BCT within one month of the inspections, any obvious negative impacts are immediately brought to the attention of the BCT via email or telephone (e.g. potential shellfish poaching).

3.4.3 Issue 3: Risk communication to community

The following recommendation was provided in the second five-year review, to address the issue of communication of risk to the community: *Develop fact sheet for Site 09 providing information to the public in laymen's terms, regarding risks associated with planned activities and uses for Allen Harbor Landfill.*

Actions Taken: A fact sheet was posted at the public trail and bike path entrance to Site 09 in August of 2009 (see photograph 29 of Appendix C). The fact sheet summarizes the site history (including the environmental investigations conducted at Site 09, the scope of the LTM, provides contact information as additional resource, and the results of the five-year reviews for Site 09. The fact sheet is laminated to protect the sheet from adverse weather. During site visits and monitoring event sampling, the field operations leader verifies and if needed, replaces the fact sheet. This ensures that a fact sheet is present for public awareness throughout the year. Fact sheets are also available upon request from the public when Navy (or their contractor) is on-site.

Results of Actions: The public is more effectively informed regarding the risks associated with planned activities and uses for Allen Harbor Landfill and has opportunity for obtaining additional information if desired.

3.5 FIVE-YEAR REVIEW PROCESS

This section provides a description of the five-year review process specific to Allen Harbor Landfill, including the document review, data review, and site inspection. Basewide five-year review items, such as community involvement and interviews, are discussed in Section 1.0.

3.5.1 Document Review

A review of documents relevant to the remedial actions and long-term monitoring activities conducted at Allen Harbor Landfill was undertaken as part of the five-year review. The documents reviewed in order to complete the review included RI reports and risk assessments; the FS, Proposed Plan, and ROD; landfill design documents (including pre-design investigations) and as-built drawings; long-term monitoring work plans; long-term monitoring sampling data reports; long-term data summary reports; semi-annual landfill/wetland inspection reports; annual settlement survey reports; and shellfish/well integrity memoranda. For a complete list of documents that were reviewed during preparation of this document, please refer to the Reference section of this report.

During the review of documents for this third five-year review, it was noted that there was a modification in data reporting for the quarterly LTM events. This change to the quarterly monitoring reports was discussed and agreed to during the October 29, 2009 UFP-SAP DQO meeting for Site 09 Long-Term Monitoring and was implemented beginning with the data report for ME 30 (October 2009). This modification was recommended to facilitate transmittal of the LTM data to the BCT in a more timely fashion. While these issues do not impact the protectiveness of the remedy, they do represent opportunities to improve the data reporting process in the future.

3.5.2 Data Review

A review of LTM data was performed as part of the five-year review. Data from 39 rounds of sampling are included in the review (validated analytical data for ME 40 data are not yet available because sampling occurred in September/October 2012). In general, results and conclusions from the comprehensive Draft Long Term Monitoring Annual Report – 2009 to 2010 for Site 09 Allen Harbor Landfill (Tetra Tech, 2012a) have been updated (or re-iterated, as appropriate, when no significant changes occurred). In the data review, all parameters detected in an environmental medium are evaluated, not just those parameters for which PALs have been established (as is typical in the LTM Data Summary Reports). Details are summarized below, by sample medium. Statistical evaluations and summaries are based on data from ME 01 through ME 39 and are provided in Appendix D.

3.5.2.1 Hydrogeology (Groundwater Flow/Potentiometrics)

Potentiometric data collected from 2011 and 2012 (tables, graphs and figures) were compared to data presented in the Draft Long Term Monitoring Annual Report – 2009 to 2010 for Site 09 Allen Harbor Landfill (Tetra Tech, 2012a). No significant variations were noted. The following items summarize the site data review from ME 01 through ME 39:

1. In general, groundwater flow directions at the site are similar for the shallow and deep zones and similar during each of the MEs, which indicate that although groundwater elevations may vary during each tidal cycle and from season to season, groundwater flow pathways are generally uniform throughout the year(s). Groundwater at Allen Harbor Landfill flows generally in the southeasterly or easterly direction from the inland areas toward the landfill shoreline.

2. The vertical components of hydraulic gradients demonstrate that groundwater flow is generally downward in the interior portions of the landfill and upward near the shoreline (the inflection point is located approximately in the central portion of the landfill, just east of MW09-14), with ultimate groundwater discharge into Allen Harbor. Vertical hydraulic gradient components have changed in the southern portion of the landfill (MW09-24S/D, MW09-20I/D, and MW09-21S/D) since implementation of the remedy, which suggests that potential discharge zones may have shifted closer to the shoreline/landfill.

3. Decreasing groundwater elevations in shallow wells since completion of the remedy demonstrates that the installed geosynthetic cap is effectively limiting the infiltration of surface water through the landfill materials. This is most dramatically observed in the central portion of the landfill (MW09-07/14) and along the downgradient edges of the landfill (MW09-08, MW09-09, MW09-10, MW09-21, and MW09-23).

4. Groundwater elevations outside of the cap are controlled by upgradient groundwater and Allen Harbor surface water elevations, and have not been significantly lowered by the cap.

5. Groundwater elevations and flow directions have remained stable and are not expected to change unless there is failure of the geosynthetic cap or a change in upgradient groundwater conditions. Neither of these conditions are expected or anticipated. Therefore, the established monitoring locations will continue to adequately monitor groundwater at the site.

During the ME 40 sampling event in October 2012, three synoptic rounds of water level measurements were conducted, at high tide, mid-tide, and low tide, in order to evaluate the impacts of tides on the groundwater system at Site 09. These data were collected because it was determined in early 2012 that

tides significantly impact the primary contaminant pathway(s) at Site 07, and given the Site 09 proximity to the shoreline, it was also likely that the tides would impact the transport of contamination from the landfill to the offshore (Allen Harbor). Figures 3-4 through 3-9 present the shallow and deep potentiometric zones during low, mid and high tides. Figures 3-10 through 3-12 present a vertical flow net along cross-section B-B' (parallel to primary groundwater flow direction, through MW09-20I and P09-08). The following preliminary conclusions are based on a review of the data presented in Figures 3-4 through 3-12:

1. As observed in potentiometric maps based on data collected during ME 01 through ME 39, in general, groundwater flow directions at the site are similar for both the shallow and deep zones, and similar during low and mid tides. Gradients (and groundwater flow) are greatest during low tides, when water level elevations in Allen Harbor are lowest. However, no significant changes in gradients are observed for wells within the interior of the landfill; such changes are only observed at the groundwater wells along the edge of the landfill and at the harbor's edge. Groundwater at Allen Harbor Landfill flows generally in the southeasterly or easterly direction, from the inland areas toward the landfill shoreline.

2. The vertical components of hydraulic gradients demonstrate that groundwater flow is generally downward in the interior portions of the landfill and upward near the shoreline, during mid and low tides.

3. At high tide, in the shallow zone, the groundwater typically does not flow from the landfill to Allen Harbor; only groundwater in the northern portion of the landfill flows to Allen Harbor. Rather, the groundwater flow is from the harbor toward the landfill in the areas approximately 50 feet south of MW09-11S, and southward along the landfill edge, to MW09-05S. The potentiometric low in the shallow zone is located approximately 100 to 150 feet onshore in these same areas. The potentiometric low for the whole site during high tide in the shallow zone is near MW09-23S.

4. At high tide in the deep zone, generally, groundwater flow is south in the northern portion of the landfill (from MW09-26 toward MW09-10), and from offshore toward the landfill for the remainder of the landfill area. Potentiometric lows are at MW09-23 and MW09-24. As a result, groundwater. Groundwater flow in the central and southern portions of the landfill is generally westward (the elevation at MW09-14D is slightly higher than surrounding areas).

5. Based on a comparison of the flow nets for low, mid and high tide, groundwater flow under the landfill varies from migrating dominantly downward at low tide, toward the harbor at mid-tide, and upward within the landfill extents (converging between former well MW09-19 and MW20) at high tide.

Ultimately, groundwater discharge is to Allen Harbor; however, the groundwater flow patterns are relatively complex and are impacted by the tides. This complexity also impacts COC migration and the ultimate discharge of the Site 09 groundwater COCs (both concentration and mass) to Allen Harbor.

6. Groundwater flow between MW09-20 (where highest CVOC contamination is observed) and Allen Harbor is generally nearly horizontal. Based on the surface water elevation at mid and low tides, the potential groundwater discharge area is interpreted to be near the Allen Harbor side of the breakwater structure and the adjacent areas.

The primary effect of the tides on groundwater flow at the site and, more importantly, on the impact of contaminant migration, is that a uniform, constant groundwater flow and discharge between areas of elevated contaminant concentrations and the offshore is not apparent. While groundwater flow and the subsequent diffuse discharge of groundwater from the landfill is to Allen Harbor, the actual pathway that contamination follows is longer (physically and temporally) and more contorted than previously understood based on the analyses of pre-ME 40 mid-tide potentiometric maps. Further analyses of the tidal effects on the landfill and contaminant transport are outlined in Sections 3.7 and 3.8.

3.5.2.2 Groundwater Sampling Data

Allen Harbor Landfill sampling data from 39 monitoring events were reviewed. Groundwater monitoring well samples are analyzed for the presence of VOCs, SVOCs, PAHs, pesticides, PCBs, total and dissolved metals, and salinity, per the approved LTMP (and revisions). Appendix G contains data validation summaries and supporting documentation for data collected from 2011 through 2012 that have not been presented previously in data reports.

Groundwater analytical results are compared to PALs, which are RIDEM GA Groundwater Objectives (RIDEM, 2004). In most cases, the RIDEM GA Groundwater Objectives are the EPA SDWA MCLs. Table 3-1 is a summary of analytes exceeding PALs in groundwater samples collected from monitoring wells during the first 39 events of quarterly/semi-annual monitoring at Allen Harbor Landfill. Frequencies of detections tables are included in Appendix D. As shown on these tables, VOCs and metals are the only contaminants that have been detected at concentrations consistently above PALs during the LTM program. The following conclusions were determined based on site data from ME 01 through ME 39:

1. In groundwater at Allen Harbor Landfill, VOCs are the predominant contaminants present at concentrations exceeding PALs. Groundwater sampling data collected during the LTM program have confirmed the nature and extent of VOCs in groundwater identified during the Phase II and III RIs, completed in 1993 and 1995. In particular, a contaminant plume consisting of CVOCs remains in the

shallow and deep overburden in the southern portion of the landfill, extending beyond the footprint of the landfill to the south and east. Benzene is also present above PALs in shallow monitoring wells located in the center of the landfill, in the southern portion of the landfill, and in the northern portion of the landfill. However, long-term trend and spatial analyses do not indicate that spatially extensive plume(s) are present; rather, contamination is limited to a few areas.

- After more than 10 years of LTM at Allen Harbor Landfill, exceedances of PALs for CVOCs (TCE, cis-1,2-DCE, and/or VC) persist at the following monitoring wells: MW09-03D, MW09-08S, MW09-09S, MW09-09DA, MW09-20I, MW09-20D, and MW09-21D. Concentrations of chlorinated VOCs exceeding PALs are generally limited to the southern shoreline of the landfill and predominantly in the intermediate and deep zones. As has been the case since the inception of the LTM program, the vast majority of the CVOC contaminant mass has been detected in groundwater from the intermediate monitoring well MW09-20I. CVOC concentrations in samples collected from this well are several orders of magnitude greater than those from any other monitoring well (also, additional CVOCs are present in samples collected from MW09-20I). Also, concentrations of CVOCs exceeding PALs are generally limited to the southern shoreline of the landfill and predominantly in the intermediate and deep zones.

- The stable or decreasing concentrations of CVOCs in groundwater at Allen Harbor Landfill are likely due to a combination of decreased infiltration due to the low-permeability geosynthetic liner and natural attenuation. At well locations where an increase in an individual contaminant concentration is observed, this is interpreted to be due to continued degradation of parent chlorinated ethenes within well clusters rather than advancement of contamination from upgradient locations.

- Other VOCs such as benzene and chlorobenzene are present at concentrations exceeding PALs in the following monitoring wells: MW09-07S, MW09-09S, MW09-11S, MW09-14I/14IA, MW09-17I, MW09-21S, MW09-21D, and MW09-25S. The only statistically significant upward trend was observed at MW09-09S (concentrations do not exceed 10 µg/L); either no trends, or downward trends, were observed at all other locations.

2. The concentrations of most inorganic contaminants in monitoring wells are stable or decreasing, and are generally less than PALs. While increasing trends are observed for some inorganics, concentrations of these inorganics are significantly less than their respective PALs. The only inorganic detected in monitoring wells at concentrations exceeding the PAL is arsenic at MW09-07S, -14IA, and -24D. Arsenic concentrations are increasing (statistically significant) at MW09-14IA and

MW09-024D. Given the few locations where arsenic exceeds the PALs, it is likely that the observed concentrations are not due to transport processes (likely due to elevated background conditions).

3. SVOCs and PCBs are infrequently detected. No upward or downward trends are observed. The low concentrations and sporadic detections indicate that there is no significant transport of SVOCs and PCBs via the groundwater migration pathway.

These conclusions are supported by the data and statistical analyses presented in Appendix D and are further discussed in the following paragraphs.

In Appendix D, graphs depicting concentration trends are presented for any chemical detected at least once in samples collected during ME 01 through ME 39. In general, many VOCs were detected less than three times, in LTM wells sampled. Further, the detected VOC concentrations have been either steady or decreasing, despite some significant variability in the data available for certain locations. A summary of the statistical analyses for all parameters is provided in Appendix D. The results of the VOC statistical analysis indicate the following statistically-significant (95 percent confidence) trends:

Compound	Well	Trend (95% Confidence)
Acetone	MW09-02S	Downward
Chlorobenzene	MW09-02S	Downward
M+P xylenes	MW09-02S	Downward
1,1-dichloroethene	MW09-03D	Downward
1,2-dichloroethane	MW09-03D	Downward
Cis-1,2-dichloroethene	MW09-03D	Downward
Trans-1,3-dichloropropene	MW09-03D	Downward
Acetone	MW09-07S	Downward
Benzene	MW09-07S	Downward
BTEX	MW09-07S	Downward
Chlorobenzene	MW09-07S	Downward
Chloroethane	MW09-07S	Downward
Cis-1,2-dichloroethene	MW09-07S	Downward
1,2-dichloroethane	MW09-08S	Downward
Acetone	MW09-08S	Downward
Benzene	MW09-08S	Downward
BTEX	MW09-08S	Downward
Cis-1,2-dichloroethene	MW09-08S	Downward
Cis-1,2-dichloroethene	MW09-09DA	Downward
Trans-1,3-dichloropropene	MW09-09DA	Downward
1,1,2-trichloroethane	MW09-09S	Downward
1,1-dichloroethene	**MW09-09S**	**Upward**

Compound	Well	Trend (95% Confidence)
Acetone	MW09-09S	Downward
Benzene	**MW09-09S**	**Upward**
BTEX	**MW09-09S**	**Upward**
Cis-1,2-dichloroethene	**MW09-09S**	**Upward**
Trans-1,2-dichloroethene	**MW09-09S**	**Upward**
M+P xylenes	MW09-10D	Downward
Acetone	MW09-10S	Downward
BTEX	MW09-10S	Downward
Acetone	MW09-11S	Downward
chlorobenzene	MW09-11S	Downward
2-hexanone	MW09-14D	Downward
4-methyl-2-pentanone	MW09-14D	Downward
Vinyl chloride	MW09-14I	Downward
1,2-dichloropropane	**MW09-14IA**	**Upward**
Acetone	MW09-14IA	Downward
Total Xylenes	**MW09-14IA**	**Upward**
Bromomethane	**MW09-17D**	**Upward**
BTEX	**MW09-17D**	**Upward**
ethylbenzene	**MW09-17D**	**Upward**
Acetone	MW09-20D	Downward
trans-1,2-dichloroethene	MW09-20D	Downward
Trichloroethene	MW09-20D	Downward
1,1,2,2-tetrachloroethane	MW09-20I	Downward
cis-1,2-Dicholoroethene	**MW09-20I**	**Upward**
Vinyl Chloride	**MW09-20I**	**Upward**
1,1,2,2-tetrachloroethane	MW09-21D	Downward
1,1-Dichloroethene	MW09-21D	Downward
Acetone	MW09-21D	Downward
Benzene	MW09-21D	Downward
BTEX	MW09-21D	Downward
cis-1,2-Dicholoroethene	MW09-21D	Downward
Toluene	MW09-21D	Downward
trans-1,2-dichloroethene	**MW09-21D**	**Upward**
Trichloroethene	MW09-21D	Downward
Vinyl Chloride	**MW09-21D**	**Upward**
1,2-Dicholorethane	MW09-21S	Downward
2-hexanone	MW09-21S	Downward
4-methyl-2-pentanone	MW09-21S	Downward
Acetone	MW09-21S	Downward
Benzene	MW09-21S	Downward
BTEX	MW09-21S	Downward

Compound	Well	Trend (95% Confidence)
Toluene	MW09-21S	Downward
Trichloroethene	MW09-21S	Downward
Trichloroethene	MW09-23D	Downward
Acetone	MW09-23S	Downward
Benzene	MW09-24D	Downward
BTEX	MW09-24D	Downward
Vinyl Chloride	MW09-24D	Downward
cis-1,2-Dicholoroethene	MW09-25S	Downward
Ethylbenzene	MW09-25S	Downward
1,2-Dichloroethene	MW09-27D	Downward
1,2-Dichloropropane	MW09-27D	Downward
4-methyl-2-pentanone	MW09-27D	Downward
Vinyl Chloride	MW09-27D	Downward

As summarized above, the majority of statistically significant trends are downward. Further, most upward trends are associated with degradation products resulting from the decay of 1,1,2,2-tetrachloroethane and/or TCE, with some locations showing a decreasing trend for the parent compound and an increasing trend for the daughter (i.e., degradation) products (e.g. MW09-20I). Benzene and BTEX is somewhat frequently detected, with statistically significant trends occurring at 8 monitoring wells. Dominantly, trends are downward for benzene (and BTEX) – 6 locations – while only 2 monitoring wells show increasing trends (MW09-09S and MW09-17D).

All other trends for VOCs in monitoring wells were not significantly different than zero [where the minimum numbers of positive detections needed to perform the statistical evaluations (trend tests) were available].

As noted above, the only metal that exceeds its respective PAL is arsenic. The following items summarize the statistical analyses for arsenic:

- Statistically significant increasing trends were observed at MW09-10D, MW09-14I(A), MW09-24D and MW09-27D.
- Statistically significant decreasing trends were observed at MW09-23S, MW09-23D and MW09-24S.
- No trends were observed at the remaining monitoring wells.

The groundwater analytical data indicate that groundwater continues to pose unacceptable risk to human health if used for domestic purposes (e.g., drinking, bathing), however the groundwater use restriction for Parcel 10 prohibits such exposures.

Figures 3-13 through 3-16 present spatial analyses of TCE and VC from ME 28 (March/April 2009) through ME 34 (September 2010). While these figures present data from a two-year time frame, they are representative of plume extents typically encountered at Site 09, as no significant changes are occurring over time, based on the overall trends as summarized above.

3.5.2.2 Piezometers

A network of 12 piezometers (Figure 3-2) is used to monitor contaminants in shallow groundwater at the perimeter of Allen Harbor Landfill. Piezometers are installed to a depth of 3 feet below the sediment surface at the base of the landfill revetment. The one foot long screened interval of the piezometers is 2 to 3 feet below the sediment surface. Groundwater samples are collected from piezometers every quarter and analyzed for the presence of VOCs, SVOCs, PAHs, pesticides, PCBs, total and dissolved metals, and salinity, per the approved LTMP (and revisions).

Analytical results for piezometer samples are compared to PALs, which are the Marine Chronic Criteria from the U.S. EPA National Recommended Water Quality Criteria (USEPA, 2002), with the exception of copper, mercury, and nickel, for which site-specific PALs were developed as part of the *Site 09 Shoreline Risk Monitoring and Remediation Goal Values for Protection of Aquatic, Terrestrial, and Human Exposure Pathways* (NewFields, 2000c). Table 3-2 presents a summary of analytes detected during the first 39 events of quarterly/semi-annual monitoring at Allen Harbor Landfill. While there are no PALs for VOCs detected in piezometer samples from Allen Harbor Landfill, Table 3-2 includes analytical data for TCE, cis-1,2-DCE, and VC, as they are detected in P09-06, P09-08, and P09-10 during the LTM program and are primary contaminants in groundwater locations upgradient from these piezometers.

As shown on Table 3-2, the contaminants most frequently present in piezometers at levels above PALs are metals. In most cases, the metals concentrations were highest in samples collected during the first four monitoring events. Since ME 10 (March 2004), the number of PAL exceedances has decreased significantly, and nickel is the metal that has exceeded its PAL most frequently. In Appendix D, graphs depicting concentration trends are presented for any chemical detected at least once in samples collected during ME 01 through ME 39. Tables presenting frequency of detections are included in Appendix D. The following conclusions were determined based on site data from ME 01 through ME 39.

1. Based on salinity/specific conductance readings for piezometer samples (collected after purging and just prior to fixed-base laboratory sample collection), the water obtained from the piezometers is a mixture of fresh and saline water (brackish).

2. The principle VOCs detected in water samples collected from the piezometers are daughter-product CVOCs (cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride) and benzene in

piezometers located along the southern shoreline of the landfill (P09-08 and P09-10). Based on a review of data collected over the past several years, COC concentrations in piezometer samples are near long-term lows, and there are no increasing trends for any CVOCs. Additionally, changes in locations of the sampled piezometers with respect to the landfill did not result in changes in concentrations or trends.

3. The concentrations of nickel in piezometer samples have consistently exceeded the PAL, although not at all locations at which nickel was detected. Although exceedances of the PAL for nickel are numerous, the datasets demonstrate either downward trends or no trends, based on the statistical analysis. Further, groundwater samples have not exceeded the nickel PAL; therefore, suggesting that the exceedances in piezometer samples are not due to migration from the landfill. Arsenic has been detected at levels exceeding the PAL in numerous events. However, the dissolved arsenic concentrations reported for samples collected since 2007 are less than the PAL, while total arsenic results show relatively frequent exceedances. Upward trends for total arsenic are indicated at P09-01 and P09-09, however, no upward trends are observed for dissolved arsenic. Other inorganics detected in piezometer samples did not consistently exceed PALs, or no trends were demonstrated, based on the statistical trend analysis.

4. Pesticides and total Aroclors are infrequently detected. Exceedances of the PALs are also infrequent.

As shown on Table 3-2, metals are the contaminants most frequently detected at levels exceeding the PALs in piezometer samples. In most cases, the metals concentrations were highest in samples collected during the first four monitoring events. Since ME 10 (March 2004), the number of PAL exceedances has decreased significantly; nickel is the metal that has exceeded its PAL most frequently.

3.5.2.3 Sediment

Sediment samples are collected from the landfill shoreline at each of the 12 piezometer locations. Sediment samples are analyzed for the presence of VOCs, SVOCs, PAHs, pesticides, PCBs, metals, percent solids, and total organic carbon, per the approved LTMP (and revisions).

Sediment sampling results are compared to PALs, which are the Effect Range Median (September 1999), with the exception of 4,4'-DDE, Total Aroclor, and zinc, for which site-specific PALs were developed as part of the *Site 09 Shoreline Risk Monitoring and Remediation Goal Values for Protection of Aquatic, Terrestrial, and Human Exposure Pathways* (NewFields, 2000c). Table 3-3 is a summary of analytes detected during the first 39 events of quarterly/semi-annual monitoring at Allen Harbor Landfill. There are

no PALs for VOCs detected in sediment samples because there were no unacceptable risks associated with exposure to VOCs in sediment (risk was evaluated as part of the RI in 1996).

In Appendix D, graphs depicting concentration trends are presented for any chemical detected at least once in samples collected during ME 01 through ME 39. Frequencies of detections tables are included in Appendix D. The following conclusions were determined from site data from ME 01 through ME 39:

1. With the exception of acetone and carbon disulfide at SED09-08/08A, there are either no trends or only decreasing trends for VOCs in sediments.

2. Except for zinc, inorganic contaminants have not been consistently detected in the shoreline sediments at concentrations in excess of the PALs. The PAL for zinc was exceeded only once in 2009, at SED09-09; zinc was not detected in LTM samples collected in 2010 through 2012. Zinc concentrations at SED09-01 and -11 exhibit increasing trends, while only concentrations at SED09-11 exceed the PAL.

3. Total Aroclor concentrations in sediments consistently exceed the PAL at SED09-01 (outside the constructed wetland, in northern portion of site), and only sporadically exceed the PAL at SED09-09, SED09-10 and SED09-12. Either no trends or downward trends are observed for total Aroclor at these locations. SED09-01 is located within the PCB area that was encountered during construction of the remedy and removed, and that resulted in an ESD. The cleanup goal established for the removal of PCB-contaminated soils and sediment during the remedial action was 1,000 µg/kg (for Total Aroclors). This concentration was exceeded only once during the LTM (ME01).

4. Exceedances of the PAL for PAHs and 4,4'-DDT are sporadic (no trends are observed).

5. Since changing the sampling depth of the sediment samples (December 2009/January 2010), numerous statistically significant increasing trends have been observed for SVOCs at SED09-10 and SED09-11. While concentrations at SED09-10 have increased dramatically between ME 30/31 and ME 32, most concentrations are now relatively stable at these higher concentrations; no apparent trends are demonstrated though only limited data is currently available (i.e., ME-33 through -39). Furthermore, comparable concentrations were reported for most parameters in samples collected during ME-04; concentrations decreased dramatically in samples post ME-04 and then remained stable until ME-32. Therefore, the increase in SVOCs is likely due to changes in the depth of the sampling (from 2 to 3 feet bgs to 2 to 6 inches bgs) and is not indicative of long-term, continued migration of contamination from the landfill to the shoreline.

6. Sediment collected within the constructed wetlands is generally static in that no (or very little) deposition or erosion occurs. This is because the geosynthetic cap and underlying fabric on the revetment wall prevent erosion, migration and subsequent deposition of soils in the constructed wetlands (though some exceptions occur in the northern portion of the landfill where the geosynthetic cap is absent and no revetment wall is present).

3.5.2.4 Spatial Analyses of Long-Term Trends for Groundwater, Piezometers and Sediment

Spatial analyses of long-term trends for groundwater, piezometers and sediments were performed in order to correlate the various trends for the different media and to further determine if contamination is migrating to the offshore. Several VOCs such as acetone, chloromethane, 2-butanone, and carbon disulfide have been detected in groundwater, piezometers and sediment samples during the course of the LTMP. However, there is limited evidence only of CVOCs (the primary contaminants at Site present in groundwater at Allen Harbor Landfill) in sediment samples collected during the LTMP. Vinyl chloride and TCE have been detected in SED09-08, which is downgradient from the MW09-20 location and collocated with P09-08.

Figures 3-17 and 3-18 present a spatial analysis of statistical trends for select CVOCs.

The following conclusions were determined from site data from ME 01 through ME 39 –

1. Statistical trend analyses indicate that no trends or decreasing trends account for most of the trends observed for the LTM data for monitoring well, piezometer, and sediment samples. Upward trends only account for, at most, approximately 20 percent of all trends observed. In some cases, the increasing trends were determined for chemicals that do not exceed PALs or the observed upward trend was due to changes in sampling positions (depths).

2. Only data for two monitoring wells demonstrated upward trends for constituents that also exceeded their PALs (MW09-09S and MW09-21D); however, these upward trends appear to be a consequence of continued ethene degradation at wells within the well clusters that demonstrate downward trends for the parent compound.

3. Significant exceedances to PALs for CVOCs occur at MW09-20I with only upward trends for degradation by-products.

4. The spatial distribution of the data and the lack of increasing concentration trends in sediments/piezometers strongly suggest that no significant migration of CVOCs from the landfill to the constructed wetlands is occurring.

3.5.2.5 Landfill Gas

Landfill gas samples are collected from five passive landfill gas vents located in the center of the landfill during each monitoring event (ME01 through ME 39). The samples are analyzed for the presence of VOCs, SVOCs, total petroleum hydrocarbons (TPH), and methane, per the approved LTMP (and revisions). Analytical results for the landfill gas samples (reported on a per volume basis) are converted to a mass flow rate using the density of each gas and the air flow rate measured during sampling, then compared to PALs (presented as chemical emission rates). No exceedances of PALs have ever been reported for the gas vent samples collected during the LTM.

In Appendix D, graphs depicting concentration trends are presented for any chemical detected at least once in samples collected during ME 01 through ME 39. Frequencies of detections tables are also included in Appendix D.

3.5.2.6 Shellfish

In December 2007, the Navy collected shellfish samples in the P09-01, P09-09, and P09-10 areas along the landfill shoreline. This was the first shellfish sampling event conducted since the inception of the LTMP because this was the first time sufficient quantities and sizes of shellfish occurred. Two samples of ribbed mussels were collected from the P09-01 area and two samples were collected from the P09-09/10 area. In addition, reference samples were collected from Fishing Cove in Wickford, Rhode Island, and from the shoreline of Prudence Island, located in Narragansett Bay, to evaluate the anthropogenic background levels of contamination present in similar marshy areas within or adjacent to Narragansett Bay. The Navy continued to collect shellfish (ribbed mussels) samples annually from 2008 through 2011 at these locations. Samples were typically collected in late spring/early summer to coincide with the spawning season. Additionally, in 2010 when a sufficient population and size of ribbed mussels were observed, shellfish samples were also collected near P09-07 and P09-08. Shellfish samples were analyzed for SVOCs, PAHs, pesticides, PCB homologs, metals, and percent lipids. Shellfish tissue sampling data were normalized by dividing the analytical result in µg/kg (for SVOCs, PAHs, pesticides, PCB homologs) or in mg/kg (for metals) by the percent lipids content of the organisms.

There are no PALs for shellfish samples collected from the shoreline of Allen Harbor Landfill, therefore on-site shellfish sampling results were compared to the results for the two reference samples. Where concentrations levels in the on-site shellfish samples exceeded those of the reference samples, sampling results were compared to data collected from similar locations during the RI in 1995. Table 3-4 is a summary of analytes detected during annual 2007 through 2011 sampling events at Allen Harbor Landfill and the reference locations.

The shellfish tissue data collected during 2007 through 2011 indicate that SVOCs, pesticides, and metals are present in ribbed mussels at levels generally comparable to the two reference stations used for this study. However, the concentrations of PAHs and PCBs exceeded the levels detected in the reference samples, especially those reported for shoreline locations ET09-03 and ET09-06. At these two locations, when the exceedances of reference concentrations occur, the concentrations reported for the Allen Harbor shoreline samples are generally approximately two times the concentrations of the reference area samples. In 2011, concentrations of PAHs did not exceed the reference sample concentrations; however, PCBs concentrations in the shoreline samples still exceeded those reported for the reference area samples.

Since the PAHs and PCBs from ribbed mussel sampling results were higher than the reference locations, the results were compared to shellfish samples collected during the marine ERA from the same areas of the site. These comparisons indicate that these chemicals are generally present at lower concentrations than reported for samples collected in the mid-1990s, prior to the completion of the remedy. With the exception of total PCBs at ET09-03 (concentrations are comparable to 1995 results), in 2009, sample results at the three other locations are approximately one-half of the 1995 concentrations. Sample results from the six locations in 2010 and four locations in 2011 were also approximately one-half of 1995 concentrations (with the exception of low PAHs in ET09-06 in 2010). Samples collected at ET09-07 and ET09-08 represented the first occurrence of shellfish in this portion of the constructed wetland; concentrations in the 2010/2011 samples are significantly lower than those reported for samples collected in 1995.

Although Allen Harbor shoreline shellfish tissue concentrations are greater than those reported for reference area samples, current shellfish tissue concentrations are significantly lower than pre-remedy, site-specific concentrations. This strongly suggests that the current remedy is protective of shellfish within the constructed wetland and is controlling the migration of landfill constituents such that there is no further degradation of the shellfish population inhabiting the landfill shoreline. Concentrations of chemicals of concern have decreased since construction of the wetlands.

In Appendix D, graphs depicting concentration trends are presented for any chemical detected at least once in samples collected during the 2007 through 2011 monitoring events. No trends were observed for most all data where enough data was available for analyses. Only the upward trend reported for arsenic was statistically significant; this was observed at all landfill *and* reference locations. Frequencies of detections tables are also included in Appendix D.

3.5.2.7 Annual Landfill Settlement Surveys

Landfill settlement surveys are completed annually by inspecting up to 26 monitoring wells, five gas vents, and six locations each along the revetment wall, breakwater structure, and constructed wetland. The objective of the annual survey is to monitor changes in elevation at various locations throughout the landfill and evaluate whether they are significant enough to suggest that the integrity of the remedy is at risk. The Final *Remedial Action Operations and Long-Term Management Plan for Allen Harbor Landfill* established a benchmark of 6 inches of differential settlement over 100 linear feet for the purpose of identifying potential areas of excessive settlement. Based on the evaluation of survey data collected since 1999, there are no areas on the landfill cap that exceed this benchmark, indicating that the integrity of the landfill liner is not likely to have been impacted by differential settlement. A summary of landfill settlement survey data collected during the LTMP is provided in Appendix D of the March 2012 Long-Term Monitoring Report – 2009 and 2010 (Tetra Tech).

3.5.2.8 Evaluation of Potentially Stressed Vegetation Area

The constructed wetlands area lies between a stone revetment wall and breakwater structure that separates the wetlands from Allen Harbor. The wetlands were constructed in the late 1990s as part of the selected remedy for Site 09. During this time, smooth cordgrass (*Spartina alterniflora*) was planted along approximately 1,400 feet of the eastern edge of the landfill. A potentially stressed vegetation area was observed within the constructed wetlands along the southeastern edge of Site 09 and downgradient of monitoring well MW09-20I (Figure 3-2). The following subsections summarize the results of several evaluations performed to assess this area.

3.5.2.8.1 Color-Tec® Sediment Field Screening

A field screening-based evaluation was performed in April 2010 to determine whether CVOCs were present in sediments, seeps, and surface water within the stressed area of the constructed wetlands. The intent of this investigation was to estimate the extent of CVOCs in this area and to provide preliminary support for a habitat evaluation.

Sediment samples were collected from 12 locations within the study area and from two background locations. Background locations were in areas adjacent to the stressed portion where vegetation was well established and considered healthy. Two samples were collected from each location at depths of 1 to 3 inches and 12 to 15 inches bgs. These two zones were selected based on the observed or anticipated vegetation root zone. Samples collected from the deeper depths correspond to the maximum anticipated extent of the vegetation root zone for *S. alterniflora*. One surface water sample was collected

from a pool of standing water within the constructed, and two seep water samples were also collected from locations within the survey area.

Screening results indicated the presence of CVOCs at five sediment sample locations along the revetment wall in the survey area and at one background location (also along the revetment wall). All positive Color-Tec® results were modest responses (i.e., slight color changes, a less than 0.5 direct reading on the colorimetric tube) indicating low CVOC detections (less than 10 µg/kg). As a reference, direct colorimetric tube readings of 1.5 and 1.3 on the same tubes resulted in fixed-base laboratory results of less than 100 µg/kg of total CVOCs.

The surface water sample collected also demonstrated a modest response (i.e., a positive reaction with a slight color change, indicating very low concentrations (less than 10 µg/L) of CVOCs. Only one of the two seep water sample (located near P09-08A) was positive for CVOCs with a slight color change, indicating the sample contained very low concentrations (less than 10 µg/L) of CVOCs.

With the exception of one location, all sampling locations along the revetment wall had a low-level positive result from at least one of the sampling depths. More positive results were noted for the sediment samples collected from the deeper sampling zone (i.e., 12 to 15 inches bgs). CVOCs were not detected in any of the samples collected near the center of the constructed wetland. Therefore, based on this preliminary screening, samples collected near the revetment wall, particularly at depth, contain elevated chlorinated concentrations whereas samples collected in the central portion of the constructed wetland did not. Based on the low-level positive detections in the standing surface water and seep samples (March 2010), it is not known whether these low-level detections are due to surface water emanating from the landfill seeps and percolating downward into the sediments or if contaminated groundwater is migrating upward and discharging into the constructed wetland.

3.5.2.8.2 Habitat Evaluation

A habitat evaluation of the constructed wetlands was conducted in July 2010 to identify possible physical causes of the slow wetland growth (compared to other portions of the constructed wetland) in the stressed vegetation area. The evaluation included an assessment of the soil profile, existing vegetation, and hydrology using the methodology in the United States Army Corps of Engineers 1987 Wetlands Manual.

A wetland scientist inspected conditions within the wetland throughout the course of a normal tidal cycle (July 23). Several established groupings of *S. alterniflora* were observed within the area and occupied 40-percent of the previously unvegetated area. The plants appeared healthy and had well-established networks of rhizomes. Also present were fiddler crabs with active burrows and snails colonizing the plant

and marsh surfaces. A sizable *S.alterniflora* population had become established in the area where the vegetation previously appeared to be stressed or was not present previously.

Soil profiles were examined inside the study area and within the healthy portions of the marsh. These examinations revealed only minor differences in soil structure; such differences would not have a significant impact on normal marsh development.

Surface elevations measured throughout the area to evaluate suitable hydrology (completed as part of annual landfill settlement survey) confirmed that this section of the marsh was within normal ranges for depth and duration of inundation for *S. alterniflora* survival. During the site evaluation, it was noted that the wrack line (debris line) on the revetment wall was higher in the stressed area than anywhere else along the constructed marsh. Navy inspections during storm events indicate that the waves impact directly along this section of the marsh. Consequently, wave erosion during the initial stages of salt marsh development may have adversely impacted vegetative growth of this section of the marsh.

3.5.2.8.3 Spatial Evaluation of Vegetation within the Constructed Wetland

Semi-annual inspections of Site 09 conducted under the LTMP have monitored the progression of the constructed wetlands since 2001. As noted above, observations initially indicated that vegetation within the wetland grew and spread normally, with the exception of an approximately 200 linear foot section near the southern limit (i.e., area approximately centered on P09-07) where vegetation growth had been the slowest (i.e., the stressed vegetation area). Generally, the percent of the constructed wetlands demonstrating a greater than 95-percent vegetative coverage has continually increased since December 2008, and the areas of less robust vegetation coverage have decreased. In addition, where vegetation is absent, there is evidence of fiddler crabs and snails (in additional to ribbed mussels collected during shellfish tissue sampling in 2010). Therefore, although there currently remains a portion of the constructed wetland with stressed vegetation, the area continues to repopulate with biota. Based on observations throughout 2012, the previously identified “stressed area” is now nearly completely vegetated and large amounts of biota are present.

3.5.2.8.4 Color-Tec® Surface Water Field Screening Beyond the Breakwater of the Constructed Wetland

During a seasonal low tide event in October 2012, a field screening-based evaluation was performed to determine whether CVOCs were present in surface water near the breakwater structure downgradient of the former stressed area of the constructed wetlands. The intent of this investigation was to estimate the extent of CVOCs in this area and to provide preliminary support for piezometer and shellfish sampling also conducted in this area.

Surface water samples were collected at near low tide conditions; locations sampled were approximately within 10, 25 and 50 feet of the breakwater structure, between the piezometers P09-07 to P09-08 to P09-12. Samples were collected at the harbor floor (i.e., at the surface water/sediment interface.

Screening results were negative for all sampling locations. While no fixed-base laboratory samples were submitted for surface water at any of the sampling locations, the Color-Tec® screening methodology has been used to effectively conduct environmental investigations along the shoreline of Site 07. [Screening level results for the Site 07 surface water investigation were confirmed by fixed-base analytical data; very low concentrations (less than 3 µg/L) of CVOCs were detected during the Site 07 investigation]. The screening results for the Site 09 surface water investigation will be compared to results for piezometer and shellfish samples collected within the same area.

3.5.2.9 Summary of Data Review

The data collected to date during the LTMP support the conclusions of the RI/FS that formed the basis for the ROD signed in 1997 by the Navy and EPA, and concurred with by RIDEM. The long-term monitoring data indicate that groundwater continue to pose an unacceptable risk to human health if used for drinking or showering. Shallow groundwater data from the shoreline piezometers indicate that the VOC plume in shallow groundwater at the site extends into the off-shore area to the south of the landfill (likely near to the Allen Harbor side of the breakwater structure), but that groundwater does not transport significant concentrations of landfill constituents into near-shore sediments. The analysis of landfill gas samples indicates that VOCs, SVOCs, petroleum hydrocarbons, and methane are being released from the landfill at rates that are below state criteria.

3.5.3 Site Inspection

This section summarizes routine LTMP site inspection activities and the site inspection performed specifically for this five-year review.

3.5.3.1 LTMP Site Inspections

Site inspections are conducted quarterly/semi-annually at Allen Harbor Landfill in conjunction with each long-term monitoring event. During the inspection, each monitoring well is checked to ensure that it is locked, labeled, and in good condition. Observations are noted on a monitoring well inspection form that is included in Appendix A of the long-term monitoring results/data reports. The site inspection also includes an on-site verification of the effectiveness of land use controls by observing land use conditions

(presence of buildings and level of recreational use at the site) and evidence of groundwater extraction wells.

Review of site inspection forms completed during the LTMP indicates that all wells are locked and properly labeled. Land use control inspections performed during the LTMP have not detected any evidence of water supply wells or new construction at the site (see references).

3.5.3.2 Tetra Tech Site Inspections

Tetra Tech has performed site inspections during each of the monitoring events conducted since the last five-year review (March 2008). The inspections include a site walkover and annotation of conditions. Inspections are frequently performed in order to document changes that occur due to increased public use of the property/parcel. Photographs from the site inspections are included in Appendix C.

The site inspections typically begin at the southwestern corner of the landfill near the south drainage swale and then proceeds along the exterior perimeter of the landfill. Groundwater monitoring wells and passive landfill gas vents are inspected as they were encountered. Key observations recorded during each of the site inspections include:

- Condition of the stone drainage channels located in the southeastern corner and northern portion of the landfill
- Condition of the stone revetment
- Condition of the landfill cap
- Condition of access road on landfill (used by contractors during monitoring events)
- Condition of breakwater structure
- Condition of monitoring wells and gas vents
- Condition of created wetland
- Condition of “Warning” signs
- Condition of vegetation within cap and across the site
- Condition of wooden fence (including railings and gate)
- Any other adverse conditions encountered.

Based on the inspections, repairs are either made during this or planned accordingly for future events (e.g. wooden rails need to be ordered and shipped to site).

3.6 TECHNICAL ASSESSMENT

3.6.1 Question A: Is the remedy functioning as intended by the decision documents?

The review of long-term monitoring data, risk assumptions, site inspections, land use control inspections, and ARARs indicates that the remedy is functioning as intended by the ROD. The evaluation presented in this section includes a discussion of the performance of the remedy versus the objectives stated in the ROD.

Surface Soil. The RAOs stated in the ROD for surface soil include a) the prevention of human and terrestrial animal exposure to contaminants in surface soil and b) the prevention of offsite migration of surface soil and surface soil constituents through overland runoff. The remedial actions taken to address these objectives were the construction of the RCRA cap and soil cap over the landfill surface and the construction of the shoreline revetment. These actions prevent exposure to surface soils by human and terrestrial ecological receptors and prevent erosion of landfill materials into the shoreline environment, respectively. These site features are inspected by the Navy semi-annually, as required by the ROD, to ensure their continued integrity and effectiveness. While minor issues such as surface rutting and intrusive vegetation have been identified during inspections, they have been remedied and have not impacted the integrity of the landfill cap, drainage swales, or revetment.

Subsurface Soil. The RAOs stated in the ROD for subsurface soil include a) reduction in leachate generation and b) reduction or elimination in surface erosion and exposure of fill materials along landfill shoreline.

The evaluation of water level data collected during the LTMP suggests that the cap is impeding the infiltration of rainwater through the unsaturated zone, which reduces the generation of leachate (Tetra Tech, 2012a). A qualitative comparison of on-site groundwater levels to those observed at the nearest USGS monitoring well suggests water levels in monitoring wells located outside of the capped area (i.e. MW09-02S, MW09-24S, and MW09-25S) correlate more closely to the off-site well than water levels measured in wells located within the capped area, indicating that water levels within the cap respond differently to seasonal variations in precipitation than wells located beyond the limits of the cap. These data, along with the evaluation of landfill survey data indicating the integrity of the cap is intact, provide evidence to support a reduction in leachate generation since construction of the remedy.

Erosion of and exposure to fill materials located along the landfill shoreline has been mitigated by the removal of debris and construction of the stone revetment. Semi-annual inspections of the revetment have indicated only minor displacement of stones, occasional vegetative growth (which has been removed), and minimal erosion at the toe of the slope presumably resulting from a concentrated runoff

from the edge of the landfill cap. None of these issues has negatively impacted the integrity or effectiveness of the revetment.

Groundwater. The remedial action objective stated in the ROD for groundwater was to prevent human exposure to contaminants in deep groundwater. The Navy has performed land use control inspections at least annually at Allen Harbor Landfill to verify that no water supply wells are constructed on the site. Based on the findings of these inspections, there is no exposure to contaminated groundwater.

Sediment. The RAOs stated for sediment in the ROD include a) minimizing risks from marine ecological exposure to contaminants in sediment and b) controlling potential future sediment contamination from landfill constituents. To evaluate risks along the shoreline associated with site contamination, sediment sampling results are compared against the site-specific Shoreline Risk Monitoring and Remediation Goal (RG) Values that were developed for the protection of aquatic, terrestrial, and human health exposure pathways. Site-specific RG Values were developed for zinc, total Aroclors, and 4,4'-DDE based on the conclusions of a harbor-wide study presented in a report titled *Preliminary Remediation Goals (PRGs) for NCBC Allen Harbor Landfill (Site 09)* (SAIC, 1998). These site-specific values, together with Effect Range Median values (September 1999), represent the PALs for sediment along the Allen Harbor Landfill shoreline.

The evaluation of long-term monitoring data collected during the first 39 events of quarterly monitoring indicates exceedances of PALs in sediment samples are infrequent, with the exception of PCBs in SED09-01 (Table 3-3 and Appendix D). Remedial actions along the shoreline (i.e. sediment removal and wetland construction) have reduced contaminant levels below PALs for all locations except SED09-01 and sediments are not being re-contaminated by landfill constituents.

Wetlands. The RAOs stated in the ROD for wetlands include a) controlling potential future contamination of wetlands from landfill constituents and b) improving the quality of existing wetlands and creating new wetlands along the landfill shoreline.

The evaluation of piezometer and sediment sampling data indicates that, in general, the remedial action is controlling the migration of landfill contaminants into the wetlands. The principle VOCs detected in water samples collected from piezometers are daughter product CVOCs (cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride) and benzene in monitoring wells located along the southern shoreline of the landfill (P09-08 and P09-10). Over the past several years, concentrations in piezometer samples are at or near long-term lows and there are no increasing trends for any CVOCs. Additionally, changes in the sampling locations of the piezometers with respect to the landfill did not result in changes

in concentrations or trends. Exceedances of PALs in sediment samples collected from the constructed wetland (SED09-02 through SED09-08) are infrequent.

Wetland inspections have been conducted semi-annually as part of the LTMP for Allen Harbor Landfill. Inspections include an evaluation of the enhanced wetland areas located to the north of the site and the constructed wetland located to the east of the landfill. With few exceptions, these wetland areas are populated with abundant vegetation and are minimally impacted by invasive species. Presently, only minimal areas devoid of vegetation occur in the southern most portions of the constructed wetland; the lack of vegetation in these areas is likely due to dead grass/vegetation accumulation (accumulates during high tides and/or storm events) and/or wave action during storms rather than stresses related to landfill constituents.

During wetland inspections, several ospreys (*Pandion haliaetus*) and double-crested cormorants (*Phalacrocorax auritus*) were observed on poles near the constructed wetland. Two American egrets (*Casmerodius albus*) were observed in the natural marsh south of the constructed wetland. A belted kingfisher (*Megaceryle alcyon*) was observed on a pole near the enhanced wetland. All are predators of fish and/or shellfish and appear to be benefiting from the food sources provided by Allen Harbor, the constructed wetland, the enhanced wetland, and other tidal marshes fringing Allen Harbor (Tetra Tech, 2007p).

Shellfish. The RAOs stated in the ROD for shellfish include a) controlling potential future contamination of shellfish from landfill constituents and b) preventing or minimizing human ingestion of shellfish from the landfill shoreline containing site-related contaminants above health advisory concentrations.

The comparison of shellfish sampling data collected during 2007 to 2011 to reference sample results and data (from the same species) collected during the RI in 1995 from similar locations indicates that the remedy is controlling contamination of shellfish from landfill constituents. There are three signs present along the landfill shoreline notifying trespassers and the public of the state-imposed shellfishing ban that is in place for Allen Harbor. All three signs are in good condition. However, over the past few years, limited evidence of shellfish harvesting has been noted. While it is not known where the shellfish originated from (Site 9 or Site 7), it should be assumed that they were obtained from somewhere within Allen Harbor or along the Narragansett shoreline where shellfishing is not prohibited. Further actions to inform/notify the public of the shellfish ban in Allen Harbor are currently being considered.

3.6.2 Question B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

Changes in Standards and TBCs: ARARs and TBCs considered during preparation of the ROD were reviewed to determine changes in standards since the last five-year review. There have been no changes to currently relevant ARARs with the exception of monitoring criteria.

According to the ROD for Allen Harbor Landfill, long-term monitoring of groundwater, sediment, landfill gas, and shellfish quality were to be performed to evaluate the protectiveness of the remedy. Sampling results are compared to project action limits which were established to evaluate protectiveness. These are discussed in the following paragraphs.

- Groundwater quality was to be monitored using USEPA Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and State Groundwater Quality Standards listed in Table 1 of RIDEM's Rules and Regulations for Groundwater Quality. The current USEPA MCLs are presented in EPA's Drinking Water and Health Advisory Table (USEPA, April 2012) and the State Groundwater Quality Standards were updated in March 2005. The groundwater monitoring criteria were presented in Table 8-2A of the *QAPP for the Long Term Monitoring Plan for Site 09* (EA, 2001b and 2003b). A comparison of the old and current groundwater monitoring criteria indicates that there have been no changes in the groundwater monitoring criteria for Site 09 (ecological screening levels for the primary VOCs detected in the groundwater plumes Site 09) since the last review (Table 3-5). Additionally, aquatic RSLs were reviewed by Tetra Tech in 2010 and determined that they were appropriate for all three sites with VOCs discharging to marine waters (no changes to RSLs were identified).

- Sediment quality was to be monitored using site-specific RGs and the ecological Effects Range Median (ERM) values determined by Long et al. and published in 1995 (Environmental Management, Volume 19, 1995). The sediment monitoring criteria were presented in Table 8-2B of the *QAPP for the Long Term Monitoring Plan for Site 09* (EA, 2001b and 2003b). The ERM values have not been changed since 1995 and, therefore, the protectiveness of the remedy for sediment has not been impacted.

- Landfill gas was to be monitored using chemical-specific RIDEM Allowable Emission Rates. The landfill gas monitoring criteria were presented in Table 8-2D of the *QAPP for the Long Term Monitoring Plan for Site 09* (EA, 2001b and 2003b). RIDEM air toxics emissions rates were updated in July 2007 and are presented in RIDEM's Air Pollution Control Regulation No. 22. The values for some chemicals may have changed, therefore it may be necessary to update Table 8-2D of the *QAPP for Long-Term Monitoring for Site 09.*

- Table 8-2C of the *QAPP for the Long Term Monitoring Plan for Site 09* (EA, 2001b and 2003b) lists chemicals to be monitored in shellfish. No PALs for shellfish are provided in the table. Future evaluations of shellfish sampling data will include the comparison of multiple rounds of data to identify concentration trends.

Changes in Exposure Pathways: Since the construction of the multimedia cap, and based on the review of the long-term monitoring data, there have been no changes at the site that would have resulted in new exposure pathways to human or ecological receptors.

Changes in Toxicity and Other Contaminant Characteristics: There have been no changes in human health toxicity criteria that would impact the monitoring criteria. The toxicity factors (i.e., CSFs and RfDs) used in the human health risk assessment for Site 09 were obtained primarily from IRIS or other sources (e.g., HEAST) in 1995. The toxicity factors for some contaminants of concern at Site 09 have changed since that time. The most noticeable of these are changes in toxicity criteria for beryllium 1,1-DCE, PCE, TCE,PCBs, and naphthalene.

- Beryllium and 1,1-DCE are no longer classified as carcinogens for the oral route of exposure by the USEPA. Therefore, the risks calculated for these chemicals today would be significantly less than the risks presented in the risk assessment prepared for the remedial investigation report.

- The CSFs currently recommended by the USEPA for PCE and TCE have increased by an order of magnitude or more since 1995. In addition TCE is now considered to be a mutagenic chemical. Therefore, the risks calculated for these COCs would increase. However, these changes would not alter the results and conclusions of the risk assessment and do not affect the protectiveness of the remedy.

- The CSF for PCBs used in the risk assessment is approximately 4 times greater than the value currently used. Therefore, the risks calculated for PCBs in soil, sediment, surface water, and shellfish in the risk assessment may be overestimated. However, the risks calculated for PCBs in soil, sediment, and surface water were $1x10^{-6}$ or less and risks for shellfish were greater than $1x10^{-3}$. Therefore, the results of the risk assessment would not be significantly affected by use of the current CSF for PCBs.

- The current inhalation RfD for naphthalene is more conservative than the value used in the risk assessment, thus the risks for construction workers may be underestimated by approximately two orders of magnitude. However, the Hazard Quotient (HQ) for inhalation of naphthalene was 0.00001 and would still be well below the USEPA acceptable level of one, if the current RfD value were used.

A comparison of toxicity criteria values from the RI to current toxicity values is provided on Table E-4 of Appendix E. A comparison of exposure factors used in the Site 09 risk assessment with currently used values is provided on Table E-5 of Appendix E.

Changes in Screening Criteria: When the risk assessment for Site 09 was conducted in 1996, the 1995 USEPA Region 3 RBCs were used as the basis of the COPC screening criteria, in accordance with Region I policy. In 1999, Region I recommended that the Region 9 PRGs be used for screening instead of the Region 3 RBCs. In 2008 the Region 9 PRGs were discontinued and replaced with the USEPA Regional Screening Levels (RSLs). Some RSLs are based on different exposure assumptions and are generally lower than the Region 3 RBCs. For example, the Region 3 RBCs for soil are based on ingestion route of exposure only, but the RSLs are based on the combined effects of ingestion, dermal contact, and inhalation routes of exposure. Consequently, the differences in the values of RSLs and PRGs can be significant. For example, the industrial RBC for naphthalene used in the risk assessment for Site 09 was 82,000 mg/kg but the current RSL for industrial soil is 18 mg/kg. If the RSLs were used for soil screening at Allen Harbor Landfill, naphthalene would be selected as a COPC for surface soil and subsurface soils. However, its exclusion as a COPC is not expected to impact the protectiveness of the remedy. A comparison of old versus new screening criteria values is provided on Tables E-10 through E-13 of Appendix E.

Changes in Risk Assessment Methods: There have been several changes in HHRA methodology since the Phase III report was finalized in 1998. These changes in themselves would not impact the results of the risk assessment or the protectiveness of the remedy. Among these are:

- The implementation of the USEPA's Dermal Guidance (RAGS-Part E) which was finalized in July 2004 (http://www.epa.gov/oswer/riskassessment/ragse/index.htm). The risk assessment for Site 09 evaluated risks for dermal contact with soil, sediment, surface water, and groundwater. Based on several USEPA guidance documents published in 1993 and 1994, risks for dermal contact with carcinogenic PAHs were not evaluated in the risk assessment. Dermal contact with arsenic in soil and sediment was also not evaluated in the risk assessment. The 2004 dermal guidance recommends evaluation of PAHs and arsenic and this could impact risks for construction workers in soil and risks for recreational users in soil and sediment (see Appendix E). If the risks for construction workers were reevaluated including dermal contact with carcinogenic PAHs and arsenic in soil, total risks for soil would increase from $2x10^{-6}$ to approximately $3x10^{-6}$ for the RME case. The risks for recreational exposure to soil would increase from $4x10^{-5}$ to $5x10^{-5}$ and risks for sediment would increase from $1x10^{-5}$ to $2x10^{-5}$, if an updated evaluation of the dermal contact pathway was

included. These calculations indicate that the results and conclusions of the risk assessment for Site 09 have not been significantly affected by omitting the dermal evaluation of PAHs and arsenic.

Use of the RAGS-Part E guidance would also result in slight changes in some dermal exposure parameters, such as exposed skin surface areas and dermal absorption factors. However, the effect of these changes on the calculated risks would be minimal and would not affect the results and conclusions of the risk assessment for Site 09.

- Calculation of exposure point concentrations (EPCs). EPCs for soil, sediment, and shellfish in the Phase III Human Health Risk Assessment for Site 09 were determined according to the Supplemental Guidance to RAGs: Calculating the Concentration Term (USEPA, May 1992). Using this guidance, risks for the reasonable maximum exposure (RME) were calculated using either the maximum detected concentration or the 95 percent UCL based on a lognormal distribution. New guidance for estimating EPCs was published in the USEPA's *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA, December 2002) (http://www.epa.gov/oswer/riskassessment/pdf/ucl.pdf) and the ProUCL guidance (USEPA, May 2010) (http://www.epa.gov/osp/hstl/tsc/software.htm). The effects of using the new guidance on the Site 09 data are not known. However, because risks for the RME were based on maximum detected concentrations or lognormal 95 percent UCLs, it is unlikely that soil risks were underestimated by using the 1992 guidance.

- Carcinogens that Act by a Mutagenic Mode of Action. In March 2005, the USEPA provided general direction on implementing the USEPA's 2005 *Guidelines for Carcinogen Risk Assessment (http://www.epa.gov/raf/publications/pdfs/CANCER_GUIDELINES_FINAL_3-25-05.PDF) and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (http://www.epa.gov/cancerguidelines/guidelines-carcinogen-supplement.htm) because of special considerations for carcinogens that act via a mutagenic mode of action (e.g., vinyl chloride and PAHs). This guidance mainly affects risks calculated for children, adolescents, and lifelong residential risks. For Site 09, this could potentially affect risks calculated for residential exposure to vinyl chloride in groundwater, risks for recreational exposure to soil and sediment (by adolescents), and risks for the ingestion of shellfish containing PAHs. The risks calculated for hypothetical residents assumed to be exposed to vinyl chloride in groundwater in the Phase III risk assessment exceeded $1x10^{-2}$. If the new guidance were used, this risk would increase slightly but the results and conclusions of the risk assessment and the remedy for the site would not change. If the new guidance were used to estimate risks for carcinogenic PAHs, the changes in total risk estimates for the media evaluated would be as follows:

- Construction worker exposure to soil – no change
- Recreational exposure to soil – total risk increases from $4x10^{-5}$ to approximately $8x10^{-5}$.
- Recreational exposure to sediment – total risk increases from $1x10^{-5}$ to approximately $4x10^{-5}$
- Ingestion of shellfish – total risk increases from $2x10^{-3}$ to approximately $3x10^{-3}$

As shown above, use of the new guidance for PAHs would result in a slight increase in total risks but would not impact the results and conclusions of the risk assessment and the remedy for the site would not change.

- USEPA's *RAGS Part F, Supplemental Guidance for Inhalation Risk Assessment was published in January 2009* (http://www.epa.gov/oswer/riskassessment/ragsf/index.htm). Use of the RAGS Part F guidance would result in minor changes in the inhalation risks. However, the effect of these changes on the calculated total risks would be minimal and would not affect the results and conclusions of the risk assessment for Site 09.

- At the time the human health risk assessment was prepared USEPA Region I recommended that, for a resident, inhalation exposures to chemicals volatilizing from groundwater be evaluated by assuming that the risks from the inhalation exposure pathway were equal to the risks from ingestion exposure pathway. USEPA Region I now recommends that such inhalation exposures be evaluated using the Andleman method which assumes that 50 percent of the chemical volatilizes from groundwater to indoor air. This change in methodology would result in higher risks from exposures to volatiles in groundwater. However since risks associated with the potential domestic use of the groundwater were already unacceptable, the conclusions of the risk assessment are not affected by the changes in methodology.

- Evaluation of Exposures from Vapor Intrusion. In November 2002 USEPA released the OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (http://www.epa.gov/epawaste/hazard/correctiveaction/eis/vapor.htm). In 2012 USEPA released the Vapor Intrusion Screening Level (VISL) Calculator (http://www.epa.gov/oswer/vaporintrusion/guidance.html#Item6) which provides screening levels for evaluating the potential for risks from vapor intrusion. The concentrations of VOCs in groundwater at Site 09 exceed the screening criteria by several orders of magnitude indicating that unacceptable risks would be predicted for receptors exposed to VOCs via the vapor intrusion pathway. For example the maximum detected concentration of vinyl chloride in the most recent groundwater samples was 7,200 µg/L; this concentration corresponds to a $5x10^{-2}$ cancer risk. The maximum detected concentration of TCE was 370,000 µg/L; this concentration corresponds to a $3x10^{-1}$ cancer

risk. However, the ROD prohibits residential or commercial development of the site or any activity that would compromise the integrity of the landfill cap. Therefore the selected remedy is protective of exposures associated with the vapor intrusion pathway.

Combined Effects of Changes: As discussed above, the individual changes in risk assessment methodology and toxicological data would not, in themselves, affect the results and conclusions of the risk assessment and the remedy for Site 09. However, the cumulative effects of these changes might result in unacceptable risks for some exposure scenarios. A discussion of the potential cumulative effects in presented below (note the discussion below pertains to risks calculated prior to implementation of the remedy).

- **Residential Exposure to Groundwater.** The RME cancer risk for groundwater was $3x10^{-1}$ prior to the remedy. Changes in risk assessment methodology would not significantly affect risk estimates for groundwater. The monitoring criteria for groundwater are USEPA MCLs, which are not risk-based values, and these have not changed. Therefore, the protectiveness of the remedy for groundwater at Site 09 would not be affected by the changes in methodology.

- **Ingestion of Shellfish.** The RME cancer risk for the ingestion of shellfish was $2x10^{-3}$ prior to the remedy. Changes in risk assessment methodology would not significantly affect these risks.

- **Remediation/Construction Worker Exposure to Soil.** The RME cancer risk for the construction worker was $2x10^{-6}$ prior to the remedy. Changes in risk assessment methodology would not significantly affect these risks.

- **Recreational Exposure to Surface Soil.** The RME cancer risk for surface soil was $4x10^{-5}$ prior to the remedy. If the cumulative effects of changes in risk assessment methodology and toxicology were taken into account, the total risk might exceed $1x10^{-4}$. However, the remedy included placement of a soil cap/cover over surface soils, preventing exposure, therefore these changes would not significantly impact the protectiveness of the remedy.

- **Recreational Exposure to Surface Water.** Changes in risk assessment methodology would not significantly affect risks for surface water.

- **Recreational Exposure to Sediment.** The RME cancer risk for sediment was $1x10^{-5}$ prior to the remedy. Risks would increase if the cumulative effects of changes in risk assessment methodology and toxicology were taken into account, but the total risk would likely be less than $1x10^{-4}$. A more rigorous risk analysis would be necessary to evaluate the cumulative effects of the changes, however

the remedy included remediation of sediment and LTMP data indicate that contaminant levels in sediment are protective to both human and ecological receptors, therefore these changes would not significantly impact the protectiveness of the remedy. Further discussion, and a table comparing LTMP sediment data to risk-based concentrations for exposure to sediments, has been included in Appendix E.

Note that the above discussion focused on cancer risks because cancer risks would be most affected by the abovementioned changes. Noncarcinogenic risks would not be as greatly affected because the most significant changes were associated with HHRA methodology for the carcinogenic PAHs.

Supporting risk assessment tables and calculations for the analysis presented in this section are found in Appendix E (Risk Assessment Support Documentation).

3.6.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No weather-related events have affected the protectiveness of the remedy, and there is no other information that calls into question the protectiveness of the remedy.

3.6.4 Technical Assessment Summary

Based on the LTM data reviewed and land use control inspections, the remedy at Allen Harbor Landfill is functioning as intended by the ROD. Regular monitoring of groundwater, sediment, and landfill gas is occurring at the locations where exposures to these media are most likely to occur. Shellfish sampling along the landfill shoreline commenced in 2007. Landfill inspections are being performed and documented to verify the integrity of the landfill cap, monitoring wells, gas vents, revetment, wetlands, breakwater, and other remedy features.

Land use restrictions are effectively preventing exposure to groundwater contaminated with VOCs, SVOCs, and metals. The landfill cap components prevent contact with contaminants in surface and subsurface soils. Sediment sampling data indicates that contaminant levels in sediment are within acceptable ranges and are not being re-contaminated by landfill constituents. Landfill gas sampling data indicates that emission rates from gas vents are within acceptable ranges. Shellfish sampling data indicate the remedy is controlling the contamination of shellfish by landfill constituents.

There have been no changes in physical conditions at the landfill that would affect the protectiveness of the remedy. There have been no changes to ARARs or TBC guidance that would impact the

protectiveness of the remedy. However, the RIDEM Allowable Emissions Rates used to evaluate gas vent emissions may need to be adjusted to reflect recent changes to RIDEM Air Resource Regulations.

Minor changes in risk assessment methods and the toxicity of contaminants that have occurred since the last review are not expected to adversely impact the remedy. For certain exposure scenarios (recreational exposure to surface soils and sediment), the calculated total risk associated with exposure to contaminants may have increased above 10E-4 using current risk assessment methods, however the remedial actions taken at the site have addressed these exposures and they do not present a protectiveness concern.

No other information has come to light that could call into question the protectiveness of the remedy.

Statistically-significant (95 percent confidence) increasing concentrations of VOCs have been observed in MW09-09S, MW09-20D, and MW09-21D over the course of the LTMP. These increases are likely due to the vertical or horizontal migration of contaminants within the landfill. Presently, the increase in VOC concentrations in these wells does not present a protectiveness issue since the use of on-site groundwater is prohibited by the land use restrictions. The spatial distribution of the data and the general lack of increasing concentration trends (only few increasing concentration trends are observed) in sediments/piezometers strongly suggest that no significant migration of CVOCs from the landfill to the constructed wetlands is occurring. Additional sampling and trend analysis will be utilized in the future to monitor changes in VOC concentrations in these and other on-site wells to evaluate potential risks associated with groundwater contamination.

Elevated concentrations of CVOCs have been present in shallow groundwater samples collected from piezometer location P09-08 since March 2004, although CVOC contamination was known to exist beyond the landfill shoreline as early as 1997 (EA, 1998c). The reason for the sudden detection of CVOCs in P09-08 during the sixth monitoring event is not clear, however it roughly corresponds with a similar increase in CVOCs detected in piezometers at Calf Pasture Point and the institution of modified shoreline piezometer sampling procedures that were recommended in the first five-year review (the first five-year review questioned the representativeness of samples collected from shoreline piezometers). Nevertheless, further study to delineate the extent of CVOCs in groundwater beneath the Harbor may be appropriate if CVOC concentrations increase from their current levels and unacceptable risks are suspected.

3.7 ISSUES

There were no protectiveness issues identified in this review.

3.7.1 Concerns

The following concerns are identified for Allen Harbor Landfill:

Concern	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
1. LTM program needs to be reviewed/updated, including updating PALs based on new MCLs or EPA RSLs (as appropriate).	N	N
2. LTM ME Data reporting and LTM comprehensive reviews of site data need to be reviewed/updated to ensure appropriate data is shared with BCT in a timely manner to ensure continued protectiveness.	N	N
3. Evaluation of area downgradient and offshore (beyond breakwater) of MW09-20I needs to be completed.	N	N

3.8 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Concern	Recommendations/Follow-Up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Y/N)	
					Current	Future
1.	a) Schedule a DQO meeting to discuss optimization of the LTM program and establish the objectives and scope of the LTM program. b) Prepare a revised Work Plan/SAP for Long-Term Monitoring at Site 09.	Navy	EPA/ RIDEM	7/1/13 11/30/13	N	N
2.	Schedule a DQO meeting to discuss reporting requirements for data reports and a schedule for comprehensive data reviews.	Navy	EPA/ RIDEM	6/1/13	N	N
3.	Prepare a Technical Memorandum based on data collected in offshore area in October 2012 and include evaluation of date through ME 40 with conclusions and recommendations for future long-term sampling.	Navy	EPA/ RIDEM	6/1/13	N	N

3.9 PROTECTIVENESS STATEMENT

The remedy at Allen Harbor Landfill is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through remedy-related institutional controls and a state-enforced prohibition of shellfishing in Allen Harbor. These controls are effectively preventing exposure to site-related contaminants.

In order to verify that the remedy continues to be protective, changes to the LTM program are warranted. The objectives and scope of these changes will be developed through the DQO process, as described in the UFP-QAPP Guidance.

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