APPENDIX A

WELL PURGE LOGS AND SOIL GAS LOGS (NOVEMBER 2014)

(Included on CD)

APPENDIX B

TABULATED WATER-LEVEL DATA

(Included on CD)

APPENDIX C

TABULATED FIELD PARAMETERS FOR GROUNDWATER

(Included on CD)

APPENDIX D

LABORATORY ANALYTICAL REPORTS
(NOVEMBER 2014)

(Included on CD)

APPENDIX E

COMPREHENSIVE DATA SUMMARY IN EXCEL FORMAT

(Included on CD)

APPENDIX F

GEOTRACKER CONFIRMATION SHEETS

(Included on CD)

APPENDIX G

DATA VALIDATION REPORTS

(Included on CD)

APPENDIX H

MONITORED NATURAL ATTENUATION STATISTICAL ANALYSIS RESULTS

(Included on CD)

APPENDIX C

LETTER FROM MARIN COUNTY DEPARTMENT OF ENVIRONMENTAL HEALTH SERVICES

Majors, Shawn M

From: McMullen, Dave <DMcMullen@marincounty.org>
Sent: Monday, September 21, 2015 3:36 PM
To: Majors, Shawn M
Cc: Callow, Scott
Subject: Hamilton AFB

Hello Sean,

I had a chance to talk to Scott Callow about a statement from our dept. as well as archive data.

Here is the statement:

County of Marin's Environmental Health Services is responding to a request for information from Sean Majors, Battelle Corporation, regarding the feasibility of ever installing a drinking water well in the area of the former Hamilton Air Force Base.

Based on historic use as an air force base, known groundwater contamination from military use as well as a leaking Underground Storage Tank at the fuel station, our department does not plan to issue water well drilling permits in the area in the future.

As far as archival records for future inquiries were are requesting a copy of your final report from you as we don't currently have a substantial amount of info on this.

If you haven't done so already, Scott recommends contacting the Regional Water Board's Ralph Lambert ralambert@waterboards.ca.gov for more information.

Thank you,

COUNTY OF MARIN

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APPENDIX D

SUMMARY OF MODEL DEVELOPMENT AND RESULTS

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D.1 INTRODUCTION

This appendix presents an evaluation of MTBE fate and transport in groundwater at Former Underground Storage Tank (UST) Site 957/970 at the Department of Defense Housing Facility (DoDHF) Novato in Novato, California. The purpose of the evaluation is to predict the time required for MTBE concentrations throughout the plume to fall below the California maximum contaminant level (MCL) of 13.0 µg/L under monitored natural attenuation (MNA) conditions. This appendix includes four primary sections: (1) MTBE background information, (2) the conceptual site model (CSM), (3) the description of the numerical groundwater flow and MTBE transport model and associated transport predictions, and (4) a summary of the evaluation.

D.2 MTBE BACKGROUND

This section presents MTBE background information, including a general description of MTBE use in fuel and MTBE fate and transport in the environment.

D.2.1 MTBE Use in Fuel

MTBE was used as a fuel oxygenate and octane booster in gasoline beginning in 1979. Initial MTBE concentrations were roughly 5% by volume. In response to amendments to the Federal Clean Air Act in 1990, MTBE concentrations were increased to 11% in most gasoline sold in California after October 1992 (Rhodes and Verstuyft, 2001). In 1996, over 95 percent of the gasoline used in California was blended with MTBE. The remainder was blended with ethanol, ethyl *tert*-butyl ether (ETBE), or tertiary amyl methyl ether (TAME) (California Air Resources Board [CARB], 1998). Although MTBE was effective as a fuel oxygenate, spills of MTBE-blended fuel (e.g., from leaking USTs) resulted in significant environmental impacts due to the toxicity of MTBE. The problem was exacerbated by the greater mobility and persistence of MTBE in the subsurface relative to other fuel compounds (e.g., benzene, toluene, ethylbenzene, and xylenes) (EPA, 2008). Due to increasing environmental and health concerns, the use of MTBE in gasoline in California was phased out by the end of 2003.

D.2.2 MTBE Fate and Transport

D.2.2.1 Sorption

MTBE is relatively mobile in the subsurface, only sorbing weakly to soil. For MTBE, the organic carbon partition coefficient (K_{oc}), a measure of the tendency for organic chemicals to sorb to soil, is approximately 10 mL/g. This is considerably less than the K_{oc} values of BTEX compounds: the K_{oc} for benzene is 85 mL/g, the K_{oc} for toluene is 166 mL/g, the K_{oc} ethylbenzene is 520 mL/g, and the K_{oc} values for individual xylene isomers (i.e., m-, p-, and o-xylene) range from 24 to 540 mL/g (Hazardous Substances Data Bank [HSDB], 2013). MTBE contamination in groundwater is thus more mobile than is BTEX contamination, and releases of MTBE-blended fuel in the subsurface therefore typically result in MTBE plumes that extend further downgradient than do the associated BTEX plumes.

D.2.2.2 Volatilization

MTBE has a high vapor pressure and will therefore readily volatilize from non-aqueous phase liquid (NAPL) above the saturated zone. However, MTBE has a low Henry's law constant and will therefore tend to remain in soil moisture and groundwater (American Petroleum Institute [API], 2007), rather than volatilizing into the air phase.

D.2.2.3 Degradation

Initial studies on the biodegradation of MTBE reported negative results (Fiorenza, et. al., 2002). However, MTBE and its intermediate degradation product, *tert*-butyl alcohol (TBA), have since been reported to biodegrade in both *in situ* and ex-situ studies, under a wide range of aerobic and anaerobic geochemical conditions, and examples of MTBE biodegradation are geographically widespread (API, 2007).

A literature survey (British Environmental Agency, 2002) concluded that MTBE anaerobic first-order degradation rates at hydrocarbon-contaminated sites range from 0.0035 to 0.00035 day^{-1} (a half-life of 0.54 to 5.4 years). The rate of degradation can vary significantly from site to site, and in some cases no biodegradation is observed (EPA, 2008).

Groundwater containing MTBE commonly has low dissolved oxygen because preferential biodegradation of other fuel components consumes oxygen. Slow field degradation of MTBE may reflect the rate of re-aeration of the groundwater. In field experiments, aerobic degradation rate constants of 0 to 0.007 day^{-1} (corresponding to no degradation to half-lives as short as 100 days) have been reported (EPA, 2008). In the laboratory, reported aerobic rate constants range from 0.07 to 0.001 day^{-1} (corresponding to half-lives of 10 to 700 days) (EPA, 2008).

The presence of TBA in MTBE-contaminated groundwater may indicate MTBE degradation because MTBE may be metabolized to TBA under both aerobic and anaerobic conditions (API, 2007). However, TBA has been used in parts of the United States as a fuel oxygenate and/or octane booster. In addition, TBA is a chemical intermediate of MTBE synthesis and can thus be present in trace amounts in fuel-grade MTBE. Therefore, the mere presence of TBA is not sufficient to infer MTBE degradation.

Available information indicates that TBA has not been used as a fuel oxygenate and/or octane booster in California (CARB, 1998). Additionally, TBA was not known to be used as of 2003 as a significant gasoline additive in the United States (DeVaull et al., 2003).

Due to the higher aqueous-phase solubility of TBA than MTBE, even trace quantities of TBA in fuel-grade MTBE can result in TBA concentrations that are comparable to MTBE concentrations in contaminated groundwater (Ellis, 2001).

D.2.2.4 Plume Sizes/Stability

A study conducted by BP Amoco of 45 MTBE plumes found a mean plume length of 140 ft using the 10 μg/L contour (Reisinger, et al., 2000). Using well-specific time series data, the authors determined that 4.4% of the MTBE plumes were expanding, 6.6% were stable, and 89% were contracting. Thus, nearly all (95%) of this large sample of MTBE plumes were stable or contracting.

A recent API technical bulletin (API, 2012) surveyed MTBE plume length and stability from a series of studies comprising over 400 gasoline release sites in multiple states. The survey found that MTBE plumes tend to stabilize at relatively short lengths (i.e., 90% less than 540 ft). Additionally, 75-90% of the MTBE plumes evaluated were stable or contracting at the time of the studies (approximately calendar year 2000).

D.3 CONCEPTUAL SITE MODEL

A detailed CSM of the site is presented in Battelle (2007) and is summarized in this section. This CSM integrates geologic, hydrogeologic, and contaminant data, and serves as the foundation for the present analysis of MTBE fate and transport at the site.

D.3.1 Regional Geology

The site lies within the Coast Range geomorphic province of northern California, which is characterized by subparallel mountain ranges, alluviated intermontane valleys, and active northwest-oriented strike-slip faults. Surface geology includes Quaternary sediments consisting of Bay Mud, alluvium, and colluvium that overlie Cretaceous Franciscan bedrock. The Franciscan bedrock is generally hard, massive, and slightly fractured. In several upland areas that surround the site, the Franciscan bedrock outcrops and forms isolated hills (e.g., Ammo Hill and Reservoir Hill).

D.3.2 Site Geology

At the site, an alluvial unit consisting of clays, silts, sands, and gravels, directly overlies a bedrock valley. In the upgradient area of the plume, boring logs indicate that the alluvial unit is highly heterogeneous, consisting of interfingered deposits of clay, silt, sand, and gravel. In the leading edge area of the plume, the alluvial unit consists of more homogeneous, discrete layers of sandy, silty, and clayey material. In this area, sand tends to immediately overlie the Franciscan bedrock. In turn, clayey materials (comprising the Bay Mud unit) tend to overlie the sands. In the Landfill 26 area, the alluvial unit is further overlain by a landfill refuse layer and cap material.

The uppermost bedrock unit at the site is the Franciscan Formation, a blue-gray, fine- to medium-grained sandstone. It has been slightly altered by metamorphism, sealing its primary porosity (U.S. Army Corps of Engineers [USACE], 1998). The sandstone is often weathered and fractured, creating secondary porosity, and the fractures are commonly filled by either calcite or silica material. The mapped top of bedrock elevation (Figure D-1) reveals a bedrock valley beneath the site. This valley is narrow in the UST source areas and broadens moving northward. The bedrock outcrops on the east side of the bedrock valley, forming Reservoir Hill. North of the leading edge of the plume, the bedrock also outcrops in the middle of the valley, forming Ammo Hill (Figure D-1). Bedrock is encountered at approximately 15 ft below ground surface (bgs) in the former UST source areas. The depth to bedrock increases moving northward, with bedrock encountered north of State Access Road at depths greater than 30 ft bgs.

D.3.3 Hydrogeology

The primary water-bearing zone at the site is the alluvial unit. Groundwater flow is generally from south to north (Figure D-2). Flow gradients are generally steeper in the southern portion of the plume area where the alluvial unit is thinner vertically and narrower west-to-east due to the structure of the bedrock valley. Flow gradients lessen to the north where the alluvial unit thickens and broadens, again due to the bedrock topography. The bedrock outcrop at Ammo Hill north of the plume leading edge causes groundwater flow in the alluvial aquifer to diverge to the northwest and northeast. Thus, the bedrock topography exerts significant control on groundwater flow in the area.

Groundwater recharge in the alluvial aquifer originates primarily from precipitation. In addition, significant groundwater flux is believed to occur from portions of the alluvial aquifer that are upgradient

of the site. Groundwater in the alluvial unit is unconfined in the southern portion of the plume and confined by the Bay Mud in the northern portion of the plume.

As noted in Section 0, metamorphism has reduced the primary porosity of the Franciscan bedrock at the site and the bedrock fractures are commonly filled by either calcite or silica material. As a result, the Franciscan Formation is not believed to be a significant source or transmitter of groundwater at the site. A handful of bedrock wells exist at the site, with water levels similar to those observed in adjacent alluvial wells. During sampling, the bedrock wells yield low water volumes, consistent with the belief that the bedrock is not a significant source or transmitter of groundwater at the site.

Hydraulic conductivity values in the alluvium from slug test data range from 0.4 ft/day to 20.7 ft/day.

Graphs of water level versus time were constructed for site monitoring wells (Attachment K1; on disc only) to assess water level fluctuations and to develop calibration targets for the groundwater flow model. These hydrographs reveal that groundwater elevations fluctuate by several feet seasonally, with higher groundwater elevations evident during the late winter and early spring months, corresponding to the regional rainy season. The June 2007 water level data were selected as model calibration targets because of a combination of (1) excellent site coverage (i.e., high number of wells measured versus other events), (2) water levels near the central tendency for each well based on hydrograph inspection, and (3) lack of anomalous measurements during this event. The June 2007 potentiometric surface is presented in Figure D-3.

D.3.4 MTBE History and Distribution at the Site

D.3.4.1 Timeline and Sources

MTBE contamination at the site originates from past releases of MTBE-blended fuel at former USTs 957 and 970. Currently, MTBE-impacted groundwater extends approximately 3,300 ft downgradient and north of the former southernmost source area associated with UST 970 (Figure D-4). The leading edge of the MTBE plume broadens as groundwater flow bifurcates around Ammo Hill.

Both USTs 957 and 970 were in operation from the mid-1970s to the early 1990s. As noted in Section 0, MTBE began to be used as a fuel oxygenate and octane booster in gasoline in 1979 and was phased out by the end of 2003. Thus, MTBE releases at USTs 957 and 970 may have occurred as early as 1979. Early site investigations identified significant MTBE impacts in the source areas as early as 1996. Monitoring wells installed progressively further northward had identified impacts in the leading edge area by roughly 1998 to 2000. Therefore, the MTBE travel time from the source areas to the leading edge was at most about 20 years (1979 to 2000) and may have been less depending upon the timing of the initial MTBE releases from USTs 957 and 970.

Continuing sources of MTBE contamination are not present in the plume area due to removal of the USTs and subsequent treatment in the UST source areas. Source area treatment included an air sparge and soil vapor extraction (SVE) system active from June 1998 to October 1999 in and downgradient of the UST 970 area. Subsequently, a biosparge system was active from September 2002 to March 2005 (continuously) and March 2006 to January 2009 (pulsed) in and downgradient of the UST 957 area.

D.3.4.2 Aqueous-Phase MTBE Plume

The current (November 2013) MTBE plume is presented in Figure D-4. The MTBE plume and MTBE trends over time are discussed in detail in Sections 2 and 3, respectively, of the main body of this report. The MTBE plume may be preferentially following a streambed channel that is suspected to have existed in the bedrock valley at the site. The centerline of the MTBE plume tends to mimic the centerline of the bedrock valley.

A key feature in the development and calibration of the model detailed in this appendix is the observed stability of the MTBE plume along the line depicted in Figure D-5. Upgradient of this line, similar MTBE impacts have been observed at monitoring wells screened at varying depths, with maximum concentrations along the plume centerline consistently in the hundreds of µg/L. In addition, the plume has migrated relatively quickly and steadily through the wells in this area. Historical sampling data indicate that MTBE arrived at IT-GMP-15, IT-PZ-9, IT-GMP-17, and IT-GMP-18 (located south to north along the plume centerline in the leading edge area) in 1998, 1998, 2000, and 2004, respectively. Following initial impact, MTBE concentrations in each of these wells increased steadily to the hundreds of µg/L over a period of four to six years (Figure D-5).

Given the concentration trends and timing of impacts in these wells, significant MTBE impacts would have been expected by the present at wells downgradient of the line in Figure D-5. However, little to no MTBE impacts have been observed at these sentry wells. At IT-GMP-19, approximately 200 ft downgradient of IT-GMP-18, MTBE was detected at low levels (0.4 µg/L) upon initial sampling in early 2005. Over the nearly nine-year period since, concentrations have increased marginally to less than 10 µg/L. Slightly further downgradient, MTBE has not been detected at IT-MW-81S (sampled from 2001 through 2012) and IT-MW-81D (sampled from 2001 through 2013). The recent air sparge treatment in the leading edge area occurred upgradient of IT-GMP-18 and years after the impacts in the wells noted above (IT-GMP-15, IT-PZ-9, IT-GMP-17, and IT-GMP-18); thus, the observed stability of the plume is independent of the air sparge system.

To the west of the plume centerline, the data are similar. Upgradient of the line in Figure D-5, MTBE arrived at monitoring well MW-M13 in 2000, with concentrations steadily increasing to about 100 µg/L within six years. Similar concentrations are observed at the co-located deeper well, MW-M13D, since sampling commenced there in 2005. Downgradient of MW-M13 and the line depicted in Figure D-5, MTBE was detected at low levels (0.4 µg/L) at monitoring well MW-M28 upon initial sampling in late 2005. Over the eight-year period since that time, concentrations at MW-M28 have only reached less than 1 µg/L.

Thus, the concentration versus time data on the upgradient side of the line indicate quick migration with consistent concentration patterns (i.e., in each well, concentrations steadily increase from initial impact to hundreds of µg/L over a four- to six-year period). On the other hand, data downgradient of the line indicate little to no impact and, where impacts are detected, insignificant concentration increase over a period of eight to nine years. Thus, the plume appears to be stable along the line indicated in Figure D-5. This is consistent with literature data indicating that the vast majority of MTBE plumes are presently stable to contracting (Section 0).

In some settings, apparent stability of this sort could be caused by a plume bypassing the downgradient sentry wells due to poor vertical placement of the sentry well screens. In this instance, however, the relatively uniform vertical distribution of contamination upgradient of the front (with maximum impacts in most wells in the hundreds of µg/L, regardless of screened interval) suggests that the sentry wells downgradient of the front (IT-GMP-19, IT-MW-81S, IT-MW-81D, and MW-M28) are unlikely to be bypassed by the plume due to the vertical location of their screens. Three of these wells (IT-GMP-19, IT-MW-81S, and MW-M28) are screened shallow, at depths similar to a number of upgradient impacted wells, including IT-GMP-18, IT-GMP-17, and MW-M13. One of these wells (IT-MW-81D) is screened

deeper, at a depth similar to a number of upgradient impacted wells, including LEA-MW1 through LEA-MW5. Thus, the data indicate that the plume is not bypassing the sentry wells but, rather, is stable at the line upgradient of the sentry wells indicated in Figure D-5.

It is also possible that the MTBE plume could follow preferential flowpaths and bypass the monitoring well network, moving primarily to the northeast and passing between IT-MW-81D/IT-MW-81S and MW-86S/MW-86D. However, slightly downgradient of these wells, MTBE had not been detected at wells IT-EW-91-03, IT-MW-88S/IT-MW-88D, and IT-EW-91-06 as of the most recent sampling in 2011. The Navy is currently coordinating with USACE to receive any recent monitoring data that may be available for these and other downgradient USACE wells. If such data reveal no significant MTBE impacts as expected, additional weight would be added to the argument that the plume is stable along the extreme leading edge.

Although the hydraulic gradient and therefore the groundwater flow velocity decrease through this area due to a thickening and broadening of the saturated alluvium, this alone is insufficient to account for the observed plume stability (as indicated by initial attempts to history-match the concentration trends over time in this area using the contaminant transport model, discussed subsequently in Section 0). The observed stability of the MTBE plume front is believed to be primarily attributable to a combination of enhanced MTBE degradation and increased sorption in this area. The former may be due to increased DO through this area of the aquifer, which could result from higher DO levels in focused recharge, including runoff from Landfill 26. The latter may be due to increased organic carbon in this area of the aquifer arising from geologic heterogeneity.

D.3.4.3 MTBE Degradation

Studies discussed in Section 0 indicate that MTBE degradation rates are highly variable from site to site. Available site-specific MNA data presented in Section 3 of the main text of this document indicate that MTBE degradation is occurring in at least some portions of the plume.

D.3.4.4 MTBE Sorption

As discussed in Section 0, MTBE is relatively mobile in the subsurface, only sorbing weakly to soil. Sorption of contamination to aquifer material is typically represented as an equilibrium process characterized by the distribution coefficient (K_d). In this approach, the sorbed- and dissolved-phase concentrations are assumed to be in equilibrium, and the sorbed-phase concentration divided by the dissolved-phase concentration is the equilibrium K_d. Site- and contaminant-specific K_d values may be determined experimentally. In addition, K_d values for organic compounds may be estimated based on the amount of organic carbon in the aquifer matrix because organics sorb predominantly to organic carbon in the subsurface. In the latter case, K_d is generally taken as the product of the organic carbon fraction in the matrix (f_{oc}) and the organic carbon partition coefficient (K_{oc}).

K_{oc} is a chemical-specific property available from literature. For MTBE, the K_{oc} is approximately 10 mL/g (HSDB 2013). Organic carbon fraction data are available for the sediments in the southern half of the site. Twenty-one measurements were performed for soil samples from 18 boreholes, with a median f_{oc} of 0.0011 kg/kg, or 0.11%. Together with a K_{oc} of 10 mL/g, this yields a K_d of 0.01 mL/g.

Aquifer effective porosity and bulk density also affect the degree of MTBE sorption. An effective porosity of 0.2 (unitless) and a dry bulk density of 1.5 g/cm^3 are reasonable values for heterogeneous alluvial materials (Argonne National Laboratory, 2013). From these values for K_d, effective porosity, and

dry bulk density, an MTBE transport retardation factor of 1.1 (unitless) may be calculated ($R_f = 1 + K_d*\rho_b/\eta_e$, where R_f is the retardation factor, ρ_b is dry bulk density and η_e is effective porosity). The retardation factor is the factor by which contaminant movement is slowed relative to groundwater flow due to sorption onto the subsurface matrix. Thus, given the values for the above aquifer properties (f_{oc}, ρ_b, η_e), MTBE transport at the site is slowed very little relative to groundwater flow.

D.3.5 Conceptual Site Model Summary

The site geology consists of an alluvial unit underlain by a bedrock valley. In the southern, upgradient area of the plume, boring logs indicate that the alluvial unit is highly heterogeneous, consisting of interfingered deposits of clay, silt, sand, and gravel. In the northern leading edge area of the plume, the alluvial unit consists of more homogeneous, discrete layers of sandy, silty, and clayey material. The bedrock valley underlying the alluvial unit is generally oriented north-south, with the bedrock valley wall outcropping on the east side of the site to form Reservoir Hill. Bedrock also outcrops to the north of the site in the middle of the valley to form Ammo Hill. The depth to bedrock generally increases moving from south to north.

The primary water-bearing zone at the site is the alluvial unit. Groundwater flow is from south to north (Figure D-2). Flow gradients are generally steeper in the southern portion of the plume area where the alluvial unit is thinner vertically and narrower west-to-east due to the structure of the bedrock valley. Flow gradients lessen to the north where the alluvial unit thickens and broadens, again due to the bedrock topography. The bedrock outcrop at Ammo Hill north of the plume leading edge causes groundwater flow in the alluvial aquifer to diverge to the northwest and northeast. Thus, the bedrock topography exerts significant control on groundwater flow in the area.

MTBE contamination at the site originates from past releases of MTBE-blended fuel at former USTs 957 and 970, which were in operation from the mid-1970's to the early 1990's. Currently, MTBE-impacted groundwater extends approximately 3,300 ft downgradient and north of the former southernmost source area (UST 970) (Figure D-4). The leading edge of the MTBE plume broadens as groundwater flow bifurcates around Ammo Hill. Continuing sources of MTBE contamination are not present in the plume area due to removal of the USTs and subsequent treatment in the UST source areas.

A key feature in the development and calibration of the model detailed in this appendix is the observed stability of the MTBE plume along the line depicted in Figure D-5. Upgradient of this line, similar MTBE impacts have been observed at monitoring wells screened at varying depths, with maximum concentrations along the plume centerline consistently in the hundreds of µg/L. In addition, the plume has migrated relatively quickly and steadily through the wells in this area. Given the concentration trends and timing of impacts in these wells, significant MTBE impacts would have been expected by the present at wells downgradient of the line in Figure D-5. However, little to no MTBE impacts have been observed at these sentry wells.

It is possible that the MTBE plume could follow preferential flowpaths and bypass sentry wells IT-GMP-19 and IT-MW-81S/IT-MW-81D, moving primarily to the northeast and passing between IT-MW-81D/IT-MW-81S and MW-86S/MW-86D. However, slightly downgradient of these wells, MTBE had not been detected at wells IT-EW-91-03, IT-MW-88S/IT-MW-88D, and IT-EW-91-06 as of the most recent sampling in 2011. The Navy is currently coordinating with USACE to receive any recent monitoring data that may be available for these and other downgradient USACE wells. If such data reveal no significant MTBE impacts as expected, additional weight would be added to the argument that the plume is stable along the extreme leading edge.

Available literature discussed in Section 0 indicate that MTBE degradation rates are highly variable from site to site. Available site-specific MNA data presented in Section 3 of the main text of this document indicate that MTBE degradation is occurring in at least some portions of the plume.

Sorption of MTBE to aquifer material is expected to be relatively low, given that MTBE sorbs weakly to soil and available data indicate that organic carbon in the alluvium at the site is relatively low. However, the observed stability of the MTBE plume at the extreme leading edge suggests that sorption is greater in this area.

D.4 NUMERICAL FLOW AND TRANSPORT MODEL

A numerical groundwater flow and MTBE transport model was constructed to assess future MTBE fate and transport. First, the conceptual model described above was translated into a numerical flow and transport model. Second, the model was used to reproduce key features of the current MTBE distribution. Third, the model was used to predict future MTBE fate and transport to support site decision-making. Each of these three major elements is discussed in the following subsections.

D.4.1 Groundwater Flow Model Development

D.4.1.1 Code Selection

MODFLOW-SURFACT, a proprietary version of USGS MODFLOW, was used for the flow model.

D.4.1.2 Model Grid and Layers

The model grid is presented in Figure D-6. All model cells are 50 feet by 50 feet, and the model dimensions are 4,400 feet by 2,600 feet. The model consists of one layer representing the alluvial aquifer at the site. The bottom of the model was specified using the top of bedrock surface (Figure D-1), and the top of the model was set to the site topography.

D.4.1.3 Boundary Conditions

Bedrock outcrops on the east and west side of the alluvial aquifer and at Ammo Hill were represented as no-flow boundaries in the model (Figure D-6). Inflow on the south end of the model and outflow on the north end of the model were specified using constant head cells with specified heads of 37 ft and 0 ft, respectively. These head values were based upon observed heads in the immediate area of these boundary conditions. Pumping is not expected to occur in the vicinity of these boundaries, so the use of constant heads (which can potentially provide infinite sinks/sources of water) is not problematic in these areas.

D.4.1.4 Hydraulic Conductivity

Based on the conceptual model, horizontal hydraulic conductivity (K_h) values are expected to be in the range of approximately 0.1 to 100 ft/day in the alluvial aquifer. During model calibration, the K_h distribution was adjusted within this range in order to calibrate the flow model.

The vertical hydraulic conductivity (K_v) was set at $0.1*K_h$, consistent with standard groundwater flow modeling practice.

D.4.1.5 Recharge

Recharge in this model is used to represent the net infiltration of precipitation to the saturated zone, minus evapotranspiration. A base recharge value of 2 in/yr was specified throughout the active area of the model, with the exception of the Landfill 26 area. In this area, the recharge was reduced to 0.5 in/yr to reflect the reduction of infiltration due to the landfill cap.

D.4.1.6 Flow Model Calibration

Model calibration is the process of adjusting model input parameters (e.g., hydraulic conductivity and boundary conditions) in order to reproduce field observations (e.g., heads at monitoring wells) with the model. Successful model calibration increases confidence that the model is a reasonable representation of the physical system and can be used to make predictions to support site decision-making.

Site observation data available for calibration of this flow model include monitoring well water level observations discussed in the conceptual model section. The model K_h distribution was systematically adjusted using PEST (Doherty, 2010) until these water level observations at the site were reproduced within the model under steady-state flow conditions. The calibrated K_h distribution is presented in Figure D-7.

To assess calibration, the difference (or residual) between observed head and the simulated head at the corresponding model location is calculated. These head residuals are posted on Figure D-8 and a scatterplot of simulated versus observed heads is provided in Figure D-9. Figure D-8 shows little spatial bias in the head residuals, while Figure D-9 shows little error bias with magnitude of head. For a calibrated model, the mean of the head residuals should be near zero (indicating little overall model bias) and the standard deviation of the residuals divided by the range of head observations should be less than 10% (indicating residuals are generally tightly clustered near zero). The calibration statistics are presented in Table D-1. The mean head residual is -0.15 ft and the standard deviation of the residuals divided by the range of head observations is 2.57%, both indicating acceptable head calibration.

D.4.2 Contaminant Transport Model Development

The flow model described in the preceding section provides the foundation for the contaminant transport model because contaminants are transported advectively with groundwater flow. In addition, the transport model includes representation of physical processes specific to MTBE transport. These are described in the following subsections.

D.4.2.1 Code Selection

The code used for the flow model (MODFLOW-SURFACT) was also used for the contaminant transport model.

D.4.2.2 MTBE Sources

Differing MTBE sources were specified in the model, depending upon the purpose of each model simulation, as follows:

- For the purpose of calibration simulations that attempt to recreate the MTBE travel times from USTs 957 and 970 to the plume leading edge (see Section 0), MTBE releases were represented in the model using a constant concentration source cell at each UST. An MTBE concentration of 500,000 μg/L was used for each of the constant concentration cells, a slightly higher concentration than the maximum observed at the site (240,000 μg/L in November 1996 at 970-MW4, 100 to 200 ft downgradient of the former NEX station and UST 970).
- For the purpose of calibration simulations that attempt to reproduce the migration of the downgradient half of the plume from 2002 to 2010 (see Section 0), continuing MTBE sources were not specified in the model.

- For the purpose of prediction of future transport of the current MTBE plume (see Section 0), continuing MTBE sources were not specified in the model, consistent with the CSM.

D.4.2.3 Initial MTBE Plume

Differing initial MTBE plumes were specified in the model, depending upon the purpose of each model simulation, as follows:

- For the purpose of calibration simulations that attempt to recreate the MTBE travel times from USTs 957 and 970 to the plume leading edge (see Section 0), no initial MTBE plume was specified in the model.
- For the purpose of calibration simulations that attempt to reproduce the migration of the downgradient half of the plume from 2002 to 2010 (see Section 0), the downgradient half of the observed November 2002 MTBE plume was specified in the model.
- For the purpose of prediction of future transport of the current MTBE plume (see Section 0), the observed November 2013 MTBE plume was specified in the model.

D.4.2.4 MTBE Degradation

Available literature discussed in Section 0 indicate that MTBE degradation rates are highly variable from site to site. Available site-specific MNA data presented in Section 3 of the main text of this document indicate that MTBE degradation is occurring in at least some portions of the plume.

MTBE degradation rates were varied during model calibration simulations to attempt to reproduce observed transport timing and patterns. Ultimately, for the purpose of transport modeling, degradation was conservatively assumed not to occur throughout the majority of the plume, with the exception that a first-order degradation rate of 0.69 yr^{-1} (corresponding to a half-life of 1 yr) was specified downgradient of the plume stability front (see line in Figure D-5). The degradation rates developed during model calibration were then used in the prediction of future transport of the current MTBE plume.

D.4.2.5 MTBE Sorption

Sorption of contamination to aquifer material is typically represented as an equilibrium process characterized by the distribution coefficient (K_d). In this approach, the sorbed- and dissolved-phase concentrations are assumed to be in equilibrium, and the sorbed-phase concentration divided by the dissolved-phase concentration is the equilibrium K_d.

Site- and contaminant-specific Kd values have not been determined experimentally for the site. However, the MTBE K_d may be estimated from the product of the organic carbon fraction in the matrix (f_{oc}) and the organic carbon partition coefficient (K_{oc}). As discussed in Section 0, this yields an estimated K_d of 0.01 mL/g for MTBE.

Aquifer effective porosity and bulk density also affect the degree of MTBE sorption. The effective porosity in the model was set at 0.2 (unitless) and the dry bulk density at 1.5 g/cm^3, both reasonable values for heterogeneous alluvial material (Argonne National Laboratory, 2013).

Using these values for K_d, effective porosity, and dry bulk density, an MTBE transport retardation factor of 1.1 (unitless) may be calculated (Section 0). This retardation factor indicates that MTBE transport at the site is slowed very little relative to groundwater flow.

The estimated K_d of 0.01 mL/g was adjusted during model calibration to attempt to reproduce observed transport timing and patterns. Ultimately, a K_d of 0.01 mL/g was specified throughout the majority of the plume, with the exception that a K_d of 0.25 mL/g was specified downgradient of the plume stability front (see line in Figure D-5). This K_d distribution developed during model calibration was then used in the prediction of future transport of the current MTBE plume.

D.4.2.6 MTBE Dispersion

Dispersion is the spreading of contaminants in the saturated zone resulting from a combination of mixing (due to local velocity variations) and diffusion. Dispersion is represented in numerical modeling via specification of the dispersivity parameter(s). For two-dimensional flow and transport, these include the longitudinal dispersivity, and transverse horizontal dispersivity. Site-specific dispersivity data are not available for the study area. Literature values are available, but dispersivity has frequently been shown to be scale-dependent (Schulze-Makuch, 2005), meaning that the appropriate value is proportional to plume size. In an analysis of published longitudinal dispersivity data from 109 authors, an empirical power law was developed relating longitudinal dispersivity to the flow distance for various geologic media (Schulze-Makuch, 2005). Using the power law developed for unconsolidated sediments and a flow distance of 3,300 ft, a longitudinal dispersivity on the order of 10 ft may be estimated. The transverse horizontal dispersivity is typically specified as an order of magnitude less than the longitudinal dispersivity. Thus, for this model, longitudinal and transverse horizontal dispersivities of 10 ft and 1 ft were used.

D.4.2.7 MTBE Transport Model Calibration

As with flow model calibration, MTBE transport model calibration involves adjusting model input parameters (e.g., K_d, degradation, etc.) to reproduce field observations (e.g., observed MTBE concentrations at monitoring wells). Again, successful model calibration increases confidence that the model is a reasonable representation of the physical system and so can be used to make predictions to support site decision-making.

Site observation data available for calibration of this transport model include the MTBE groundwater quality data discussed in the conceptual model section. The primary input parameters adjusted during calibration of the solute transport model were the K_d value for MTBE and the MTBE degradation rate.

Calibration of the solute transport model focused on (1) reproducing travel times from the source areas to the leading edge of the plume and (2) history-matching of MTBE transport in the downgradient half of the plume from November 2002 to November 2010.

The MTBE travel time from the source areas to the leading edge was at most about 20 years (1979 to 2000) and may have been less depending upon the timing of the initial MTBE releases from USTs 957 and 970 (see Section 0). As described in preceding sections, constant concentration cells were specified at each of USTs 957 and 970, and no initial MTBE plume was specified for these simulations. An MTBE concentration of 500,000 μg/L was used for each of the constant concentration cells, a slightly higher concentration than the maximum observed at the site (240,000 μg/L in November 1996 at 970-MW4, 100 to 200 ft downgradient of the former NEX station and UST 970). Using a K_d of 0.01 mL/g and conservatively assuming no degradation, MTBE was predicted to reach the leading edge area in five to ten years at concentrations similar to those observed there. This is consistent with the CSM that the travel time was at most 20 years.

History-matching of MTBE transport in the downgradient half of the plume from November 2002 to November 2010 was then performed. In general, history-matching of MTBE transport during the last 15 years is complicated by the various remedial systems at the site, including:

- an air sparge and soil vapor extraction (SVE) system active from June 1998 to October 1999 in and downgradient of the UST 970 area,
- a biosparge system active from September 2002 to March 2005 (continuously) and March 2006 to January 2009 (pulsed) in and downgradient of the UST 957 area,
- an air sparge system active from December 2010 to December 2011 in the leading edge area.

Modeling the effects of these systems on past MTBE fate and transport would introduce additional variables and uncertainty into model calibration. Consequently, the effects of these remedial systems were sidestepped during the model calibration process by focusing on the northern half of the plume (which is downgradient of the older two remedial systems) and by focusing on the time period prior to operation of the leading edge air sparge system (i.e., prior to December 2010). November 2002 was selected as the starting point for this history-matching effort, as this is a relatively early event with comprehensive monitoring well data coverage.

In initial simulations for the history-matching effort, MTBE was consistently predicted to migrate much farther downgradient by 2010 than was observed. This is directly related to the observation that the MTBE plume front is stable along the line depicted in Figure D-5 (Section 0). Although site potentiometric maps typically indicate that the hydraulic gradient decreases across this line, this alone is insufficient to account for the observed plume stability, as indicated by initial history-matching attempts. The observed stability is believed to be primarily attributable to a combination of enhanced MTBE degradation and increased sorption downgradient of the line depicted in Figure D-5 (Section 0). Enhanced degradation may be due to increased DO through this area of the aquifer, which could result from higher DO levels in focused recharge, including runoff from Landfill 26. Increased sorption may be due to increased organic carbon in this area of the aquifer arising from geologic heterogeneity.

Both increased degradation rates and increased sorption were incorporated into the flow and transport model in this area in order to reproduce the observed contaminant transport patterns in the area from 2002 to 2010. Using a K_d of 0.25 mL/g and an MTBE first-order degradation rate of 0.69 yr^{-1} (corresponding to a half-life of 1 yr) downgradient of the line in Figure D-5, the observed November 2010 MTBE distribution in the downgradient half of the plume was able to be reproduced with the model (Figure D-10). Upgradient of the plume stability line (i.e., in the majority of the plume area), the K_d was maintained at 0.01 mL/g and MTBE was conservatively assumed not to degrade, as in the previous history-matching of MTBE transport from the source areas to the leading edge.

These successful transport model calibration steps increase confidence that the model is a reasonable representation of the physical system and so can be used to make predictions to support site decision-making.

D.4.3 Prediction of Future MTBE Fate and Transport

Using the calibrated flow and transport model, the current MTBE plume was modeled forward in time to predict the time until the MTBE MCL will be met throughout the plume. Consistent with the site conceptual model, continuing MTBE sources were not specified in this forward simulation. The November 2013 MTBE plume was used to specify initial concentrations in the model for this simulation. Otherwise, model transport parameters were identical to those used in the calibrated transport model (Section 0). In particular, MTBE was conservatively assumed not to degrade, except in the area downgradient of the plume stability front, where an MTBE first-order degradation rate of 0.69 yr^{-1} (corresponding to a half-life of 1 yr) was specified. A K_d of 0.01 mL/g was used in the majority of the model area, and a K_d of 0.25 mL/g was used downgradient of the plume stability front. Under these

baseline conditions, model simulations predict that maximum MTBE concentrations will decrease to the MTBE MCL in approximately 15 years (Figure D-11).

In addition to this baseline simulation, sensitivity simulations were executed to predict the time until the MTBE MCL will be met using decreased MTBE degradation and sorption in the area where the plume is currently observed to be stable. In this area, the K_d was reduced from 0.25 mL/g to 0.1 mL/g and the MTBE first-order degradation rate was decreased from 0.69 yr^{-1} to 0.069 yr^{-1} (corresponding to a half-life increase from 1 yr to 10 yr). Upgradient of the plume stability line, the K_d was maintained at 0.01 mL/g and MTBE was conservatively assumed not to degrade, as in the baseline simulation. For these transport parameters, model simulations predict that plume stability is no longer maintained (contrary to current observations) and the MTBE MCL will be met in 20 to 25 years (Figure D-12).

D.5 SUMMARY AND RECOMMENDATIONS

D.5.1 Summary

This appendix presents an evaluation of MTBE fate and transport in groundwater at Former UST Site 957/970 at DoDHF Novato in Novato, California. The primary focus of the evaluation is to predict the time required to achieve the California MTBE MCL of 13.0 µg/L under MNA conditions. The following sections summarize the CSM and the numerical flow and transport model developed from the CSM.

D.5.1.1 Conceptual Site Model

The site geology consists of an alluvial unit underlain by a bedrock valley. In the southern, upgradient area of the plume, boring logs indicate that the alluvial unit is highly heterogeneous, consisting of interfingered deposits of clay, silt, sand, and gravel. In the northern leading edge area of the plume, the alluvial unit consists of more homogeneous, discrete layers of sandy, silty, and clayey material. The bedrock valley underlying the alluvial unit is generally oriented north-south, with the bedrock valley walls outcropping on the east sides of the site, forming Reservoir Hill. Bedrock also outcrops to the north of the site in the middle of the valley, forming Ammo Hill. The depth to bedrock generally increases moving from south to north.

The primary water-bearing zone at the site is the alluvial unit. Groundwater flow is from south to north (Figure D-2). Flow gradients are generally steeper in the southern portion of the plume area where the alluvial unit is thinner vertically and narrower west-to-east due to the structure of the bedrock valley. Flow gradients lessen to the north where the alluvial unit thickens and broadens, again due to the bedrock topography. The bedrock outcrop at Ammo Hill north of the plume leading edge causes groundwater flow in the alluvial aquifer to diverge to the northwest and northeast. Thus, the bedrock topography exerts significant control on groundwater flow in the area.

MTBE contamination at the site originates from past releases of MTBE-blended fuel at former USTs 957 and 970, which were in operation from the mid-1970s to the early 1990s. Currently, MTBE-impacted groundwater extends approximately 3,300 ft downgradient and north of the former southernmost source area (UST 970) (Figure D-4). The leading edge of the MTBE plume broadens as groundwater flow bifurcates around Ammo Hill. Continuing sources of MTBE contamination are not present in the plume area due to removal of the USTs and subsequent treatment in the UST source areas.

The MTBE plume is observed to be stable along the line indicated in Figure D-5 (see discussion in Section 0). Upgradient of this line, similar MTBE impacts have been observed at monitoring wells screened at varying depths, with maximum concentrations along the plume centerline consistently in the hundreds of µg/L. In addition, the plume has migrated relatively quickly and steadily through the wells in this area. Given the concentration trends and timing of impacts in these wells, significant MTBE impacts would have been expected by the present at wells downgradient of the line in Figure D-5. However, little to no MTBE impacts have been observed at these sentry wells.

D.5.1.2 Numerical Flow and Transport Model

The CSM summarized above was used as the framework for developing the flow and transport model. The flow and transport model includes one layer, representing the unconsolidated deposits at the site. Thus, the bottom of the model corresponds to the top of weathered bedrock. The groundwater flow

model was calibrated under steady-state flow conditions to observed June 2007 water levels. Two phases of history-matching were then performed with the contaminant transport model: reproduction of travel times from the source areas to the plume leading edge and reproduction of contaminant transport patterns in the northern half of the plume from 2002 to 2010. During the latter transport model calibration step, MTBE degradation and sorption were increased north of the line at the leading edge of the plume in Figure D-5, in order to successfully reproduce the observed plume stability in this area from 2002 to 2010. Successful execution of these flow and transport model calibration steps lends confidence to the use of the model to predict future contaminant transport.

The calibrated flow and transport model was then used to predict future MTBE transport, starting with the November 2013 MTBE plume. Model simulations predict that maximum MTBE concentrations will decrease to the MTBE MCL in approximately 15 years (Figure D-11). Sensitivity simulations were also conducted using decreased MTBE degradation and sorption in the area where the plume is observed to currently be stable. Under these simulations, plume stability is no longer maintained (contrary to current observations) and the predicted time to achieve the MTBE MCL is increased to 20 to 25 years (Figure D-12).

D.5.2 Recommendations

The Navy is currently coordinating with USACE to receive any recent monitoring data that may be available for USACE monitoring wells downgradient of the MTBE plume. Data through 2011 for these wells are presently available to the Navy and indicate no MTBE impacts. If more recent data reveal no significant MTBE impacts as expected, additional weight would be added to the argument that the plume is stable along the extreme leading edge.

D.6 REFERENCES

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Table D-1. Groundwater Flow Model Calibration Statistics

Head Calibration Statistic	Value
Residual Mean (ft)	-0.15
Absolute Residual Mean (ft)	0.69
Residual Standard Deviation (ft)	0.93
Sum of Squares (ft^2)	99.49
Root Mean Square Error (ft)	0.94
Minimum Residual (ft)	-2.41
Maximum Residual (ft)	3.37
Number of Observations	112
Range in Observations (ft)	36.2
Residual Standard Deviation / Range in Head Observations	2.57%
Absolute Residual Mean / Range in Head Observations	1.91%
Root Mean Square Error / Range in Head Observations	2.60%
Residual Mean / Range in Head Observations	-0.41%

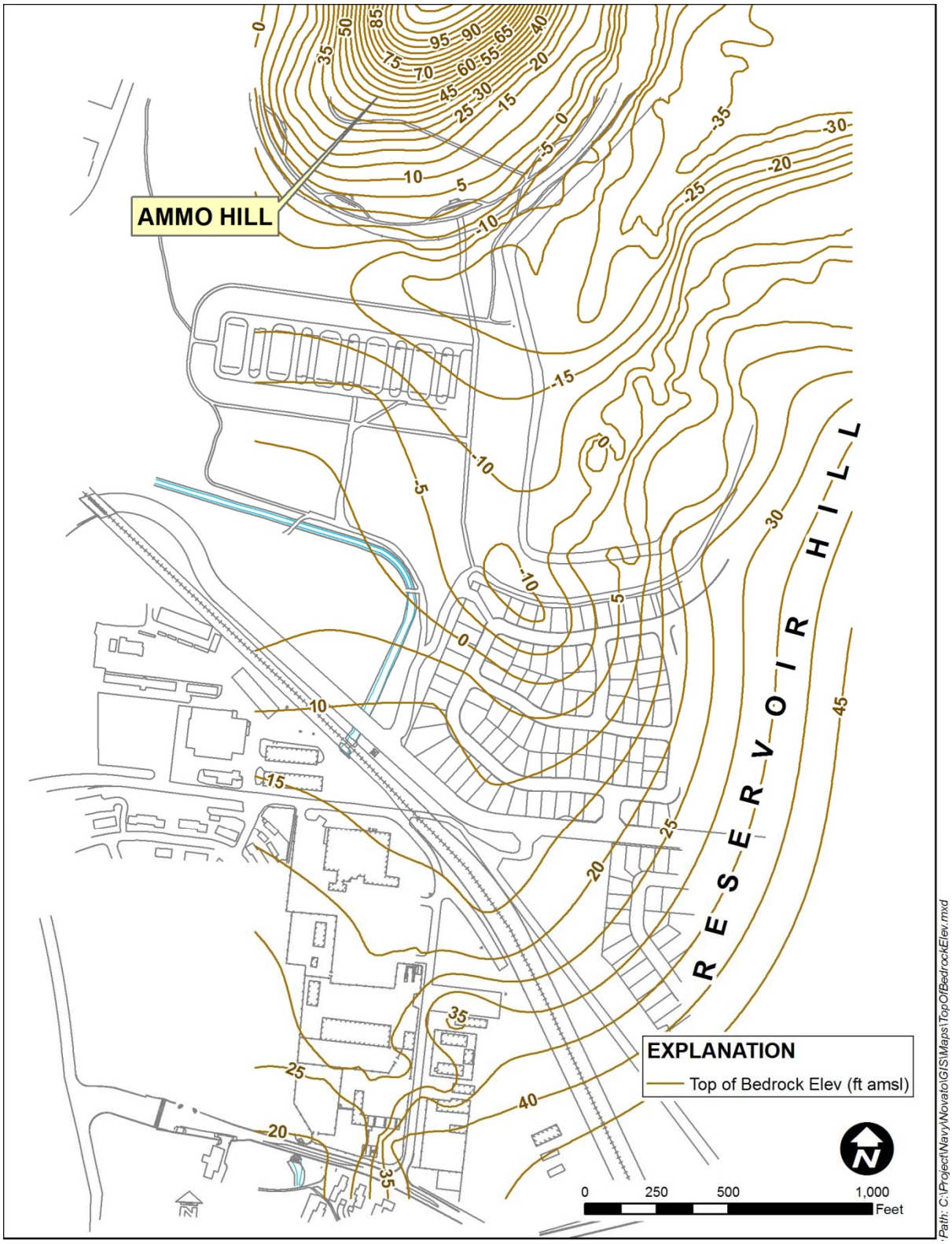

Figure D-1. Top of Bedrock Elevation

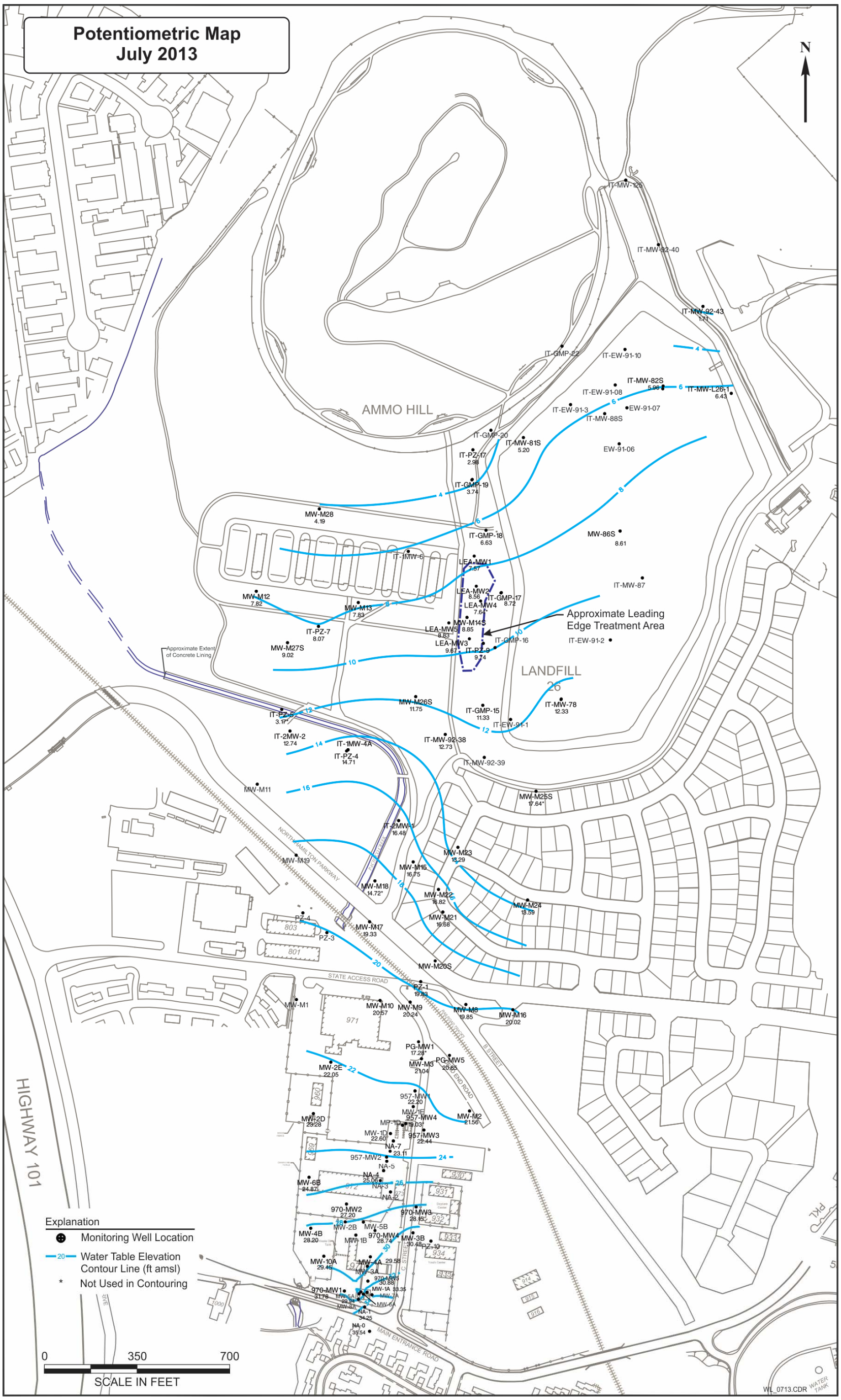

Figure D-2. July 2013 Potentiometric Surface

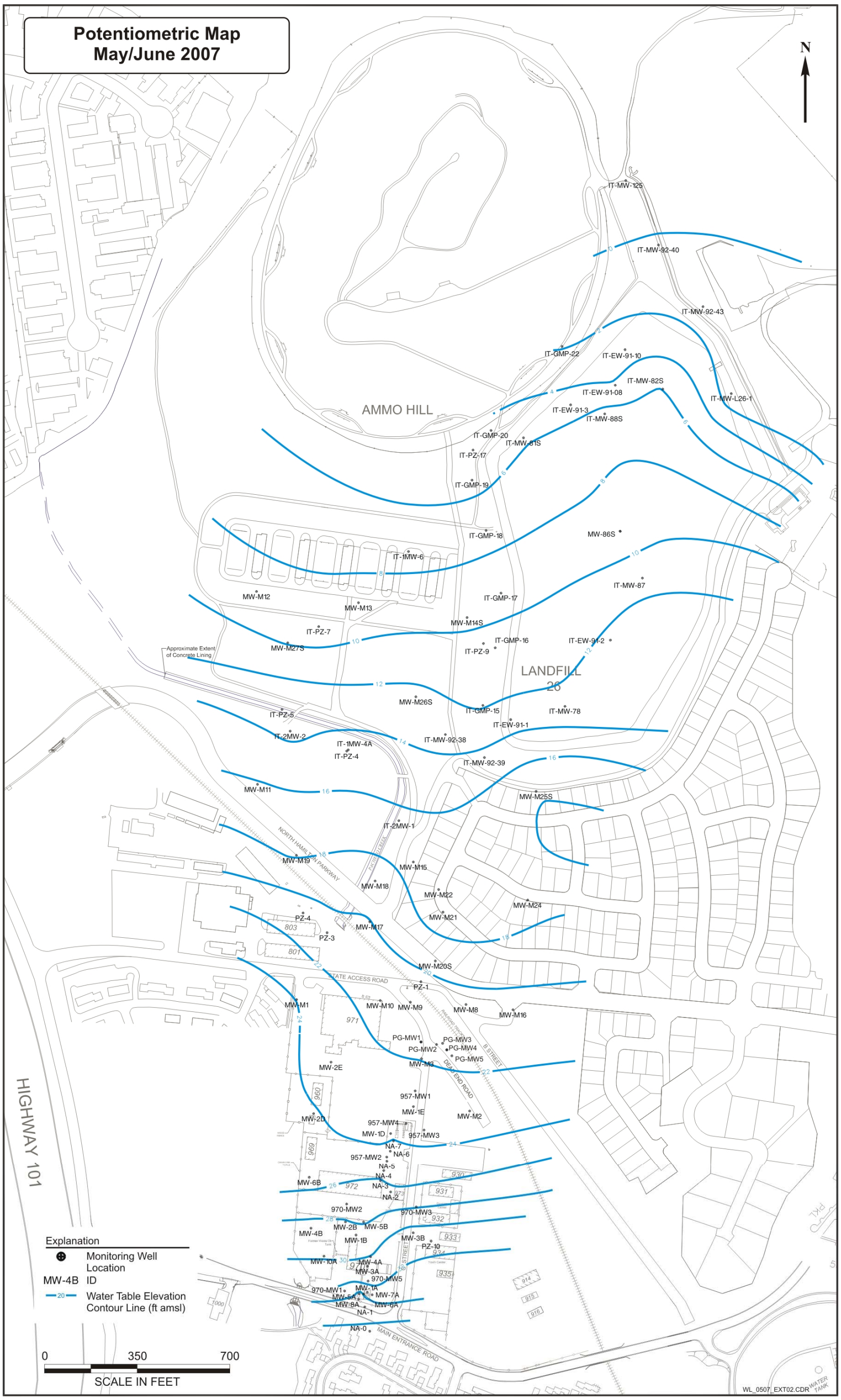

Figure D-3. June 2007 Potentiometric Surface

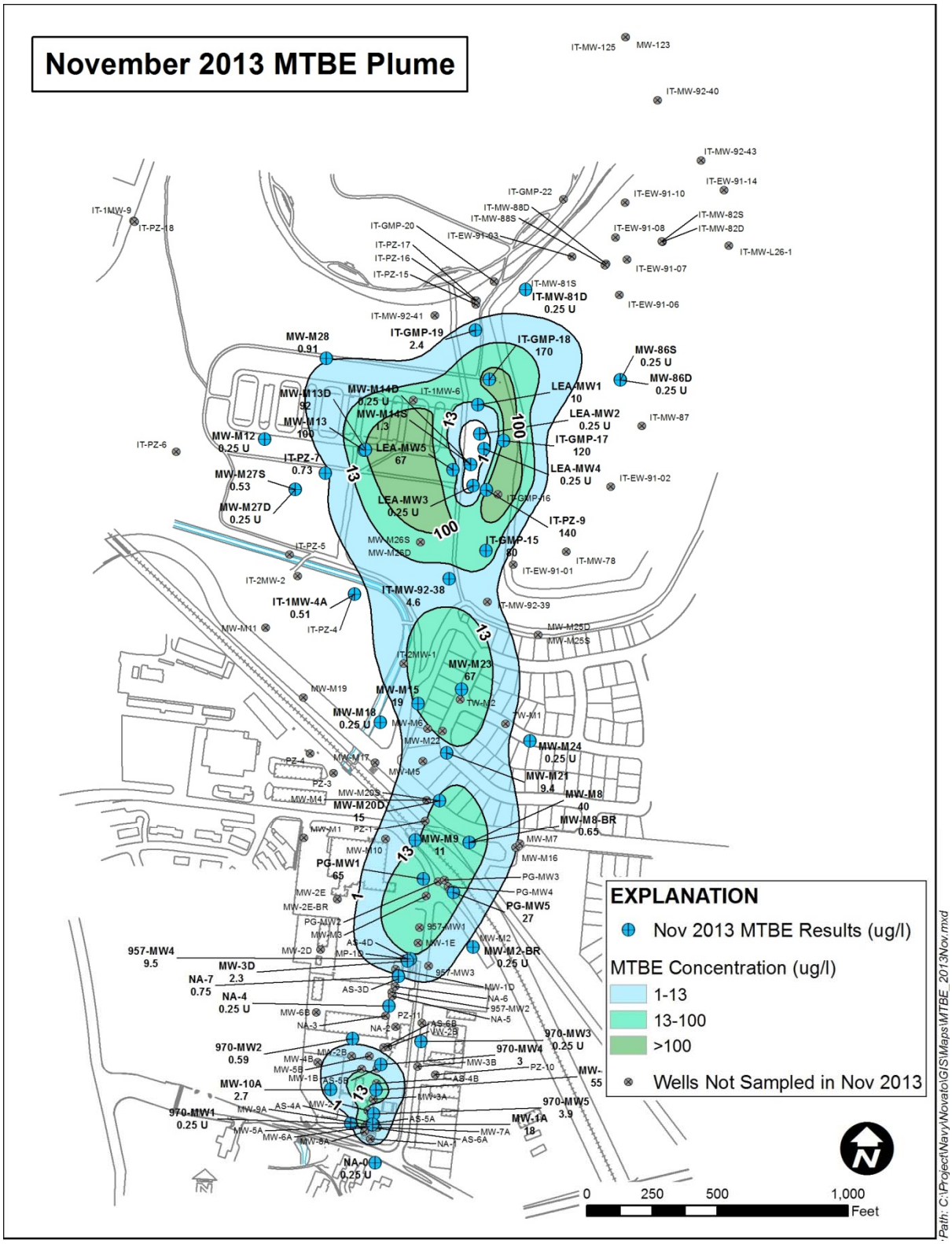

Figure D-4. November 2013 MTBE Plume

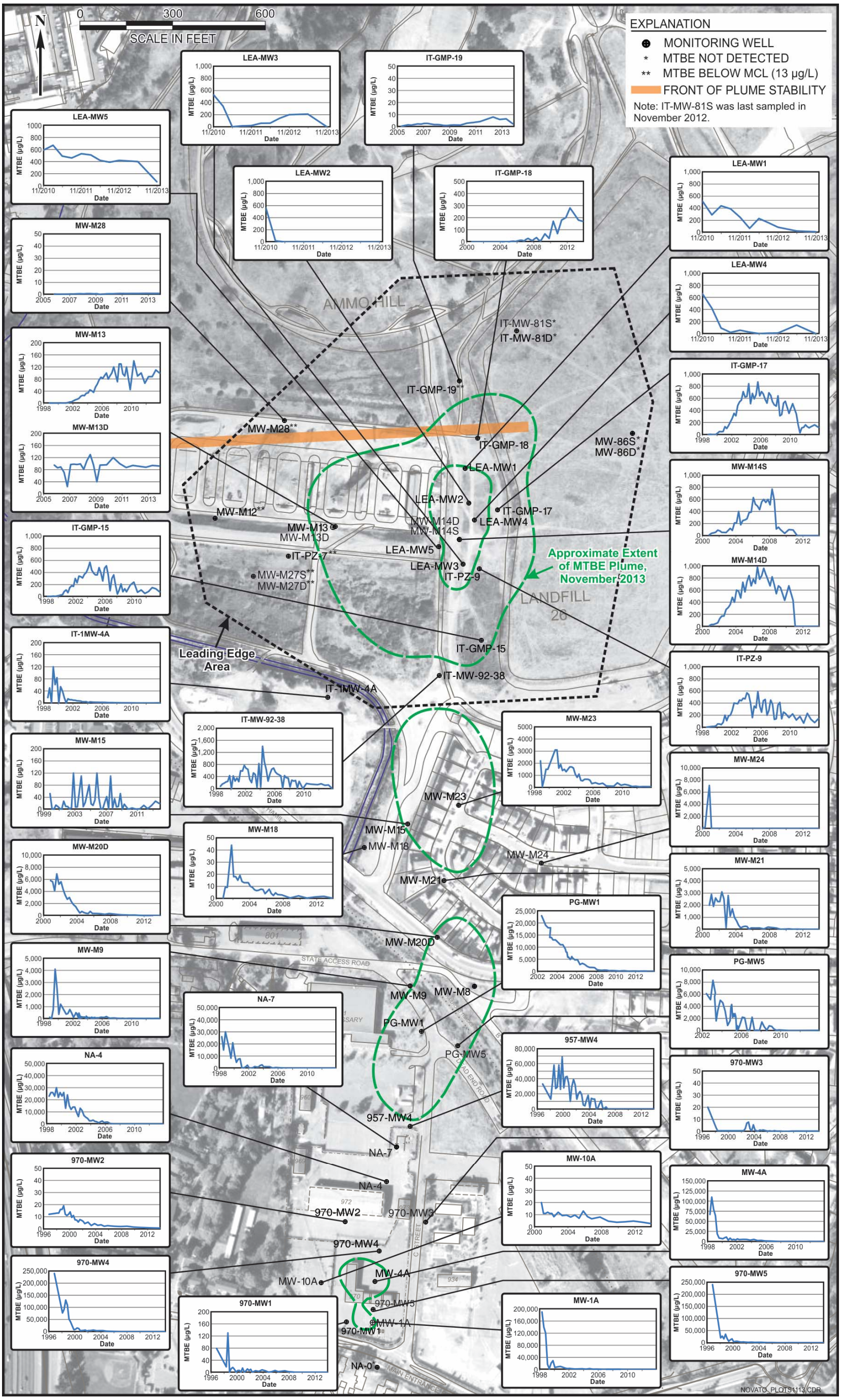

Figure D-5. Concentration vs. Time Trends for Wells Sampled in November 2013

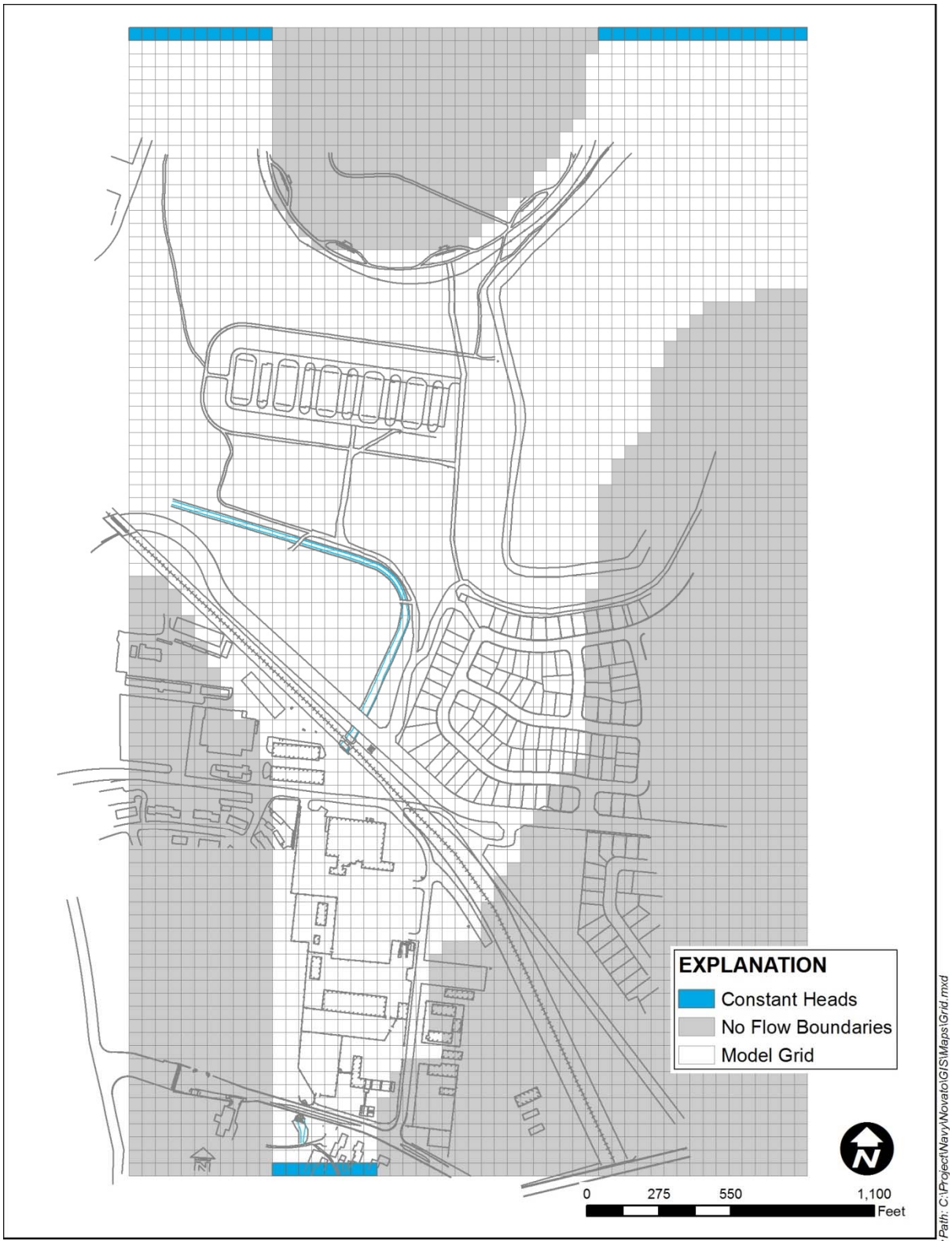

Figure D-6. Numerical Model Grid and Boundary Conditions

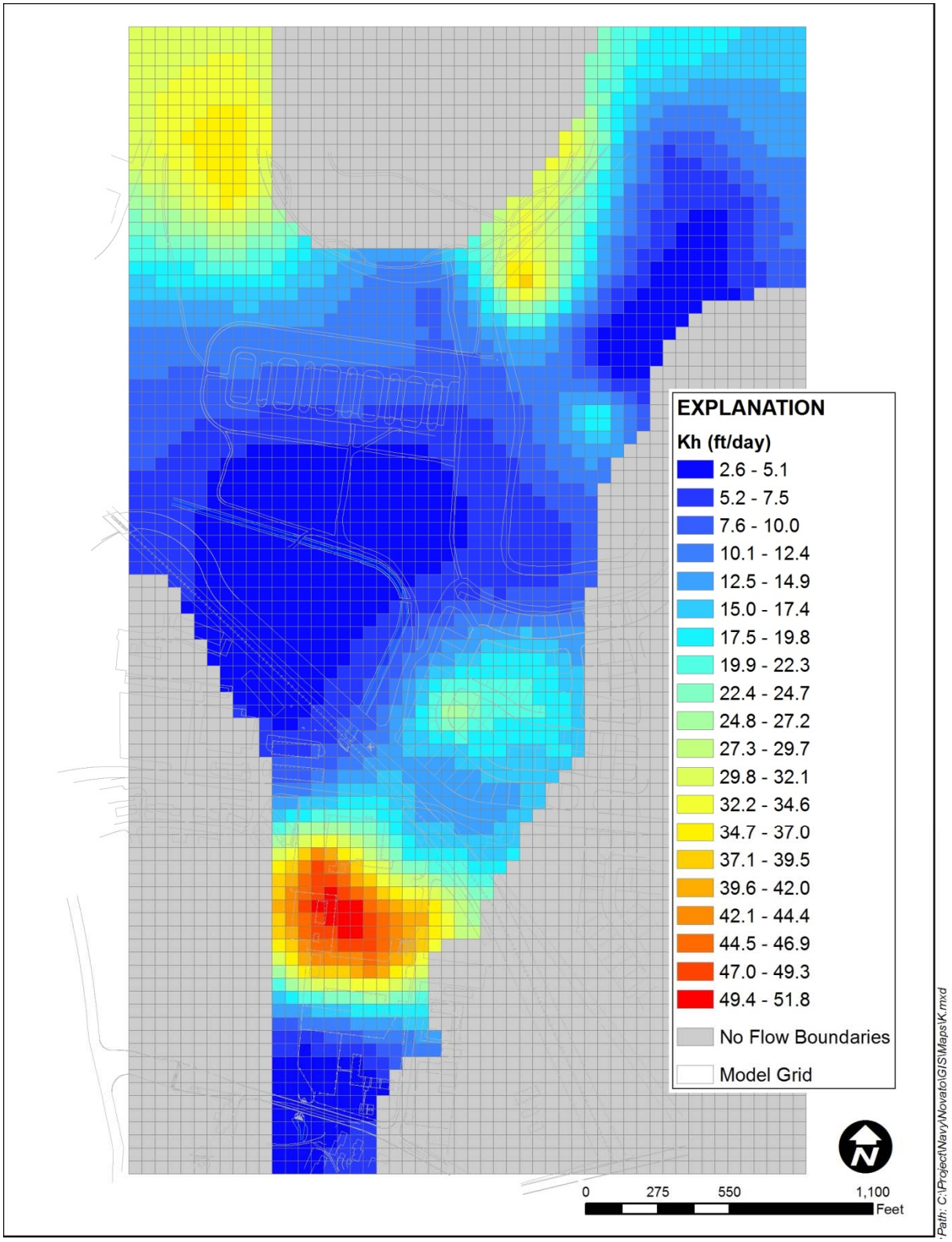

Figure D-7. Calibrated Hydraulic Conductivity Distribution

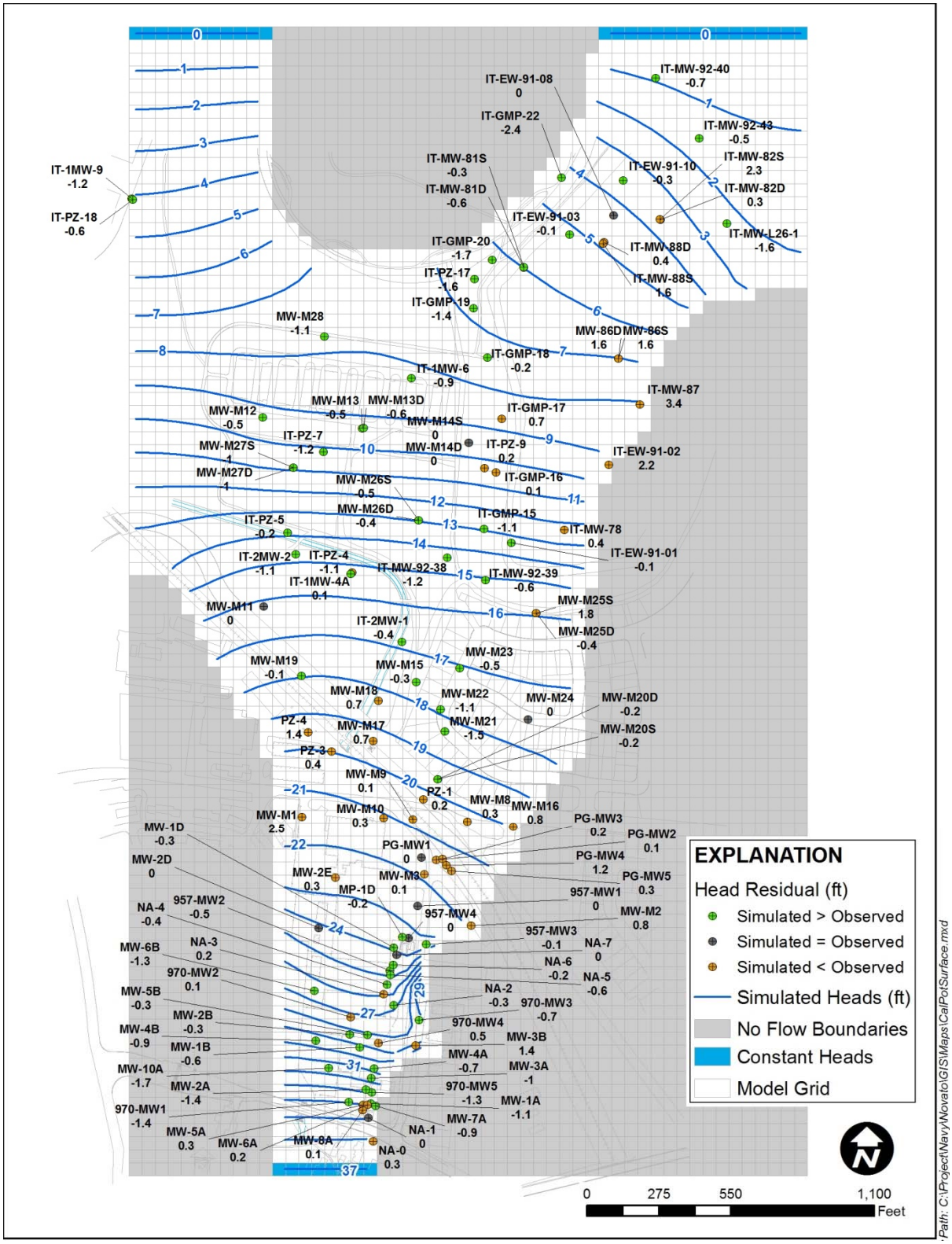

Figure D-8. Calibrated Potentiometric Surface and Head Residuals

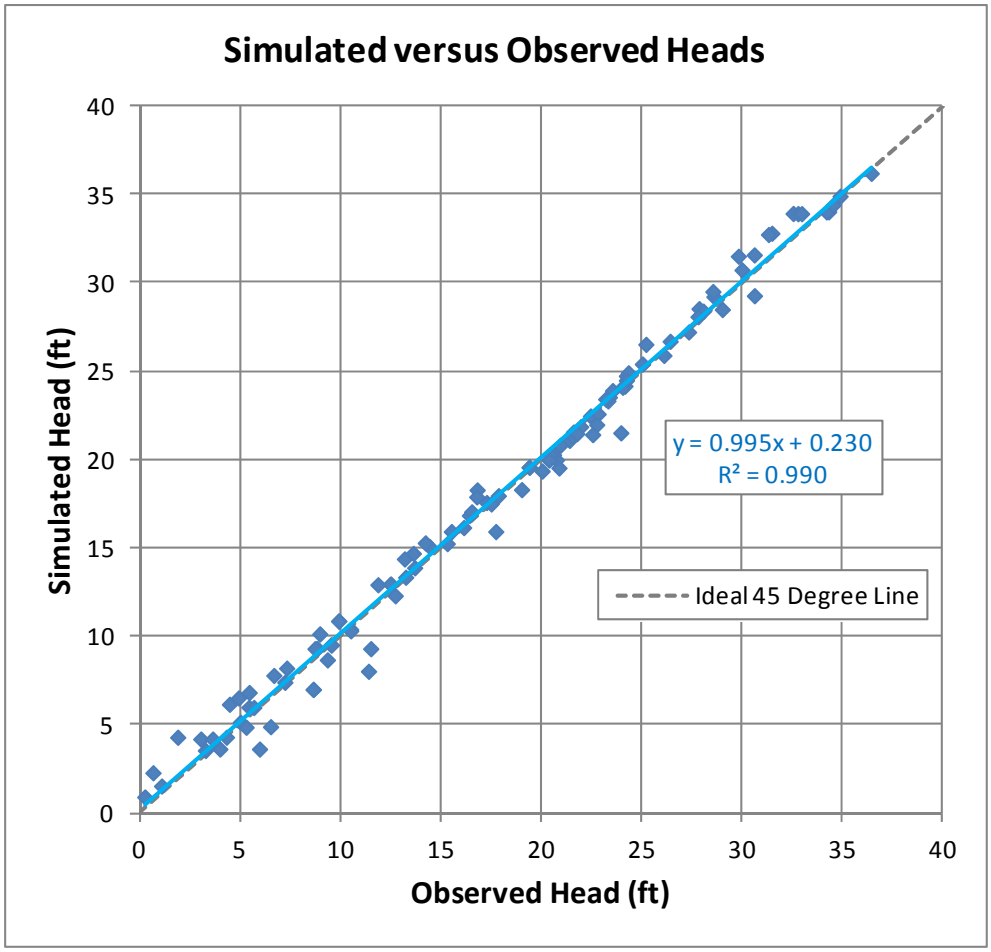

Figure D-9. Scatterplot of Head Residuals

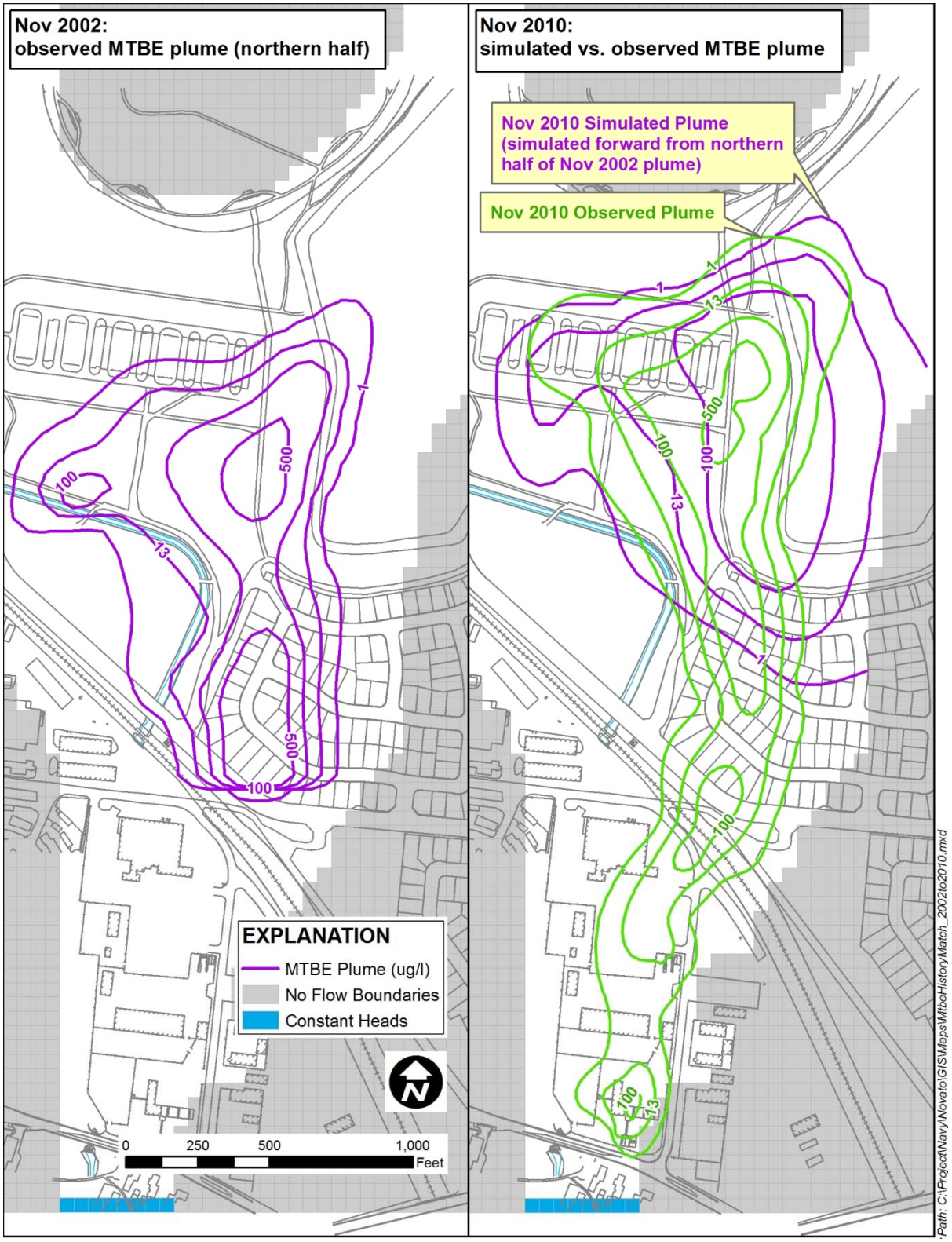

Figure D-10. History-Matching of MTBE Transport in Northern Half of Plume from 2002 to 2010

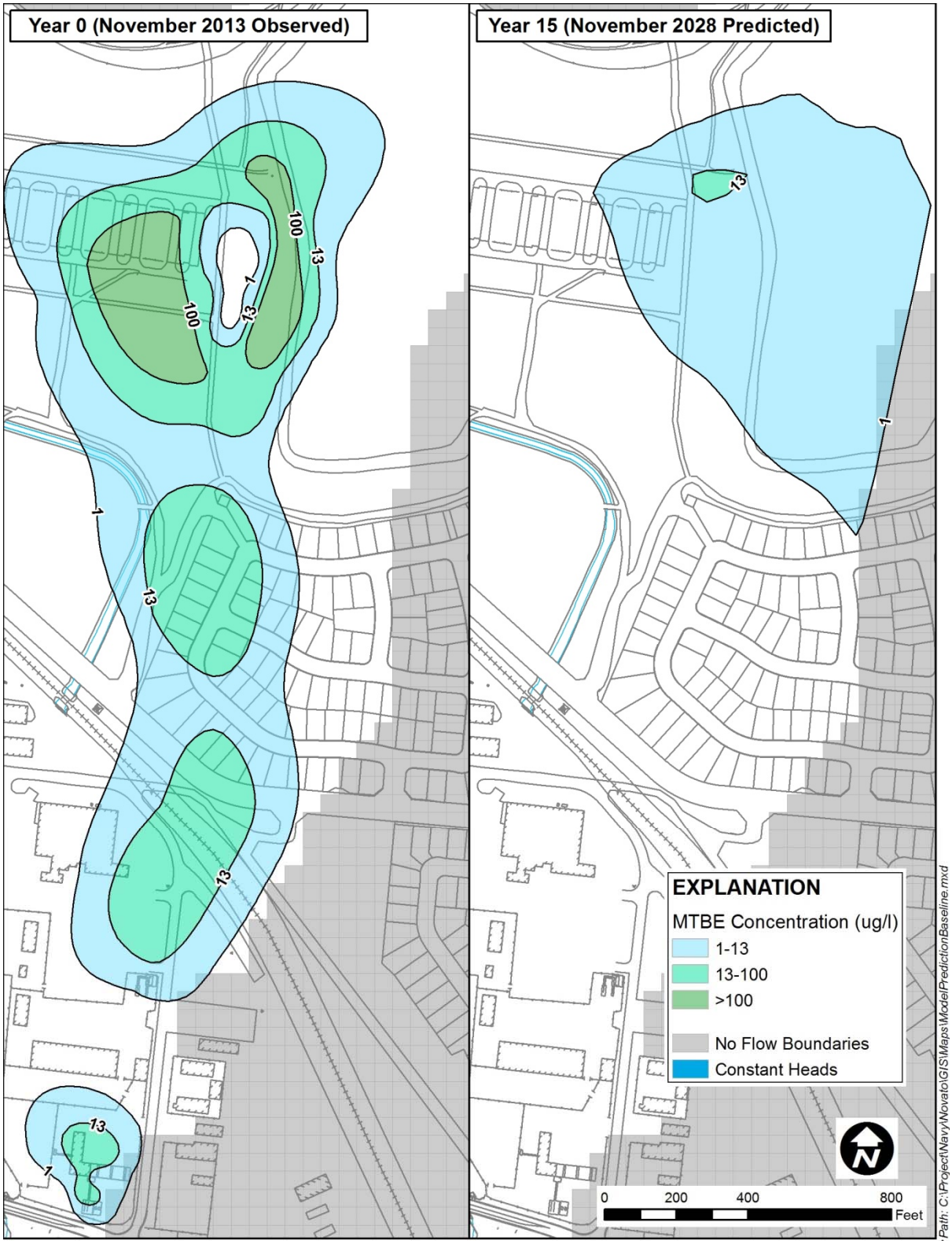

Figure D-11. Predicted MTBE Distribution after 15 Years (November 2028) for Baseline Transport Conditions

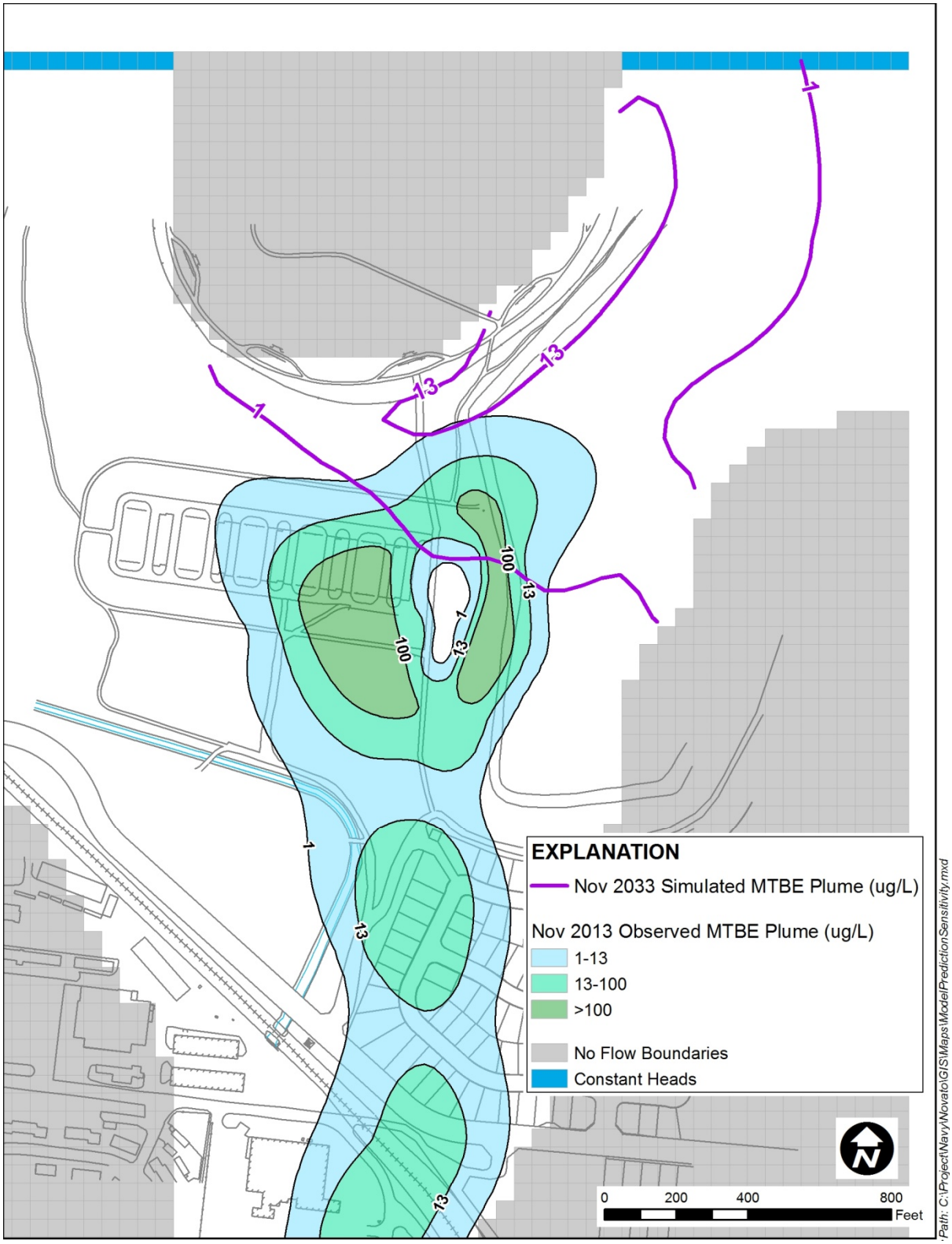

Figure D-12. Predicted MTBE Distribution after 20 Years (November 2033) for Sensitivity Transport Conditions

APPENDIX E

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DRAFT FINAL SITE CLOSURE REPORT, REQUEST FOR NO FURTHER ACTION, FORMER UST SITE 957/970, FORMER DEPARTMENT OF DEFENSE HOUSING FACILITY NOVATO, MARIN COUNTY

Dear Mr. Doctor:

The California Department of Toxic Substances Control (DTSC) has reviewed the subject document (DF Closure/NFA Request), dated 30 March 2016, and has determined it satisfactorily addressed the comments DTSC provided on the DF Closure Report/NFA Request, dated September 2015; therefore, DTSC has no further comments.

However, DTSC notes that per the agreement reached between DTSC, San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), U.S. Environmental Protection Agency - Region 9, and the Naval Facilities Engineering Command in a 09 December 2015 conference, and reiterated in a 04 May 2016 e-mail from Ms. Margarete Beth SFBRWQCB, formal concurrence by the lead agency for California (SFRWQCB) will be provided, if appropriate, after the Hamilton Square soil remediation is complete so that all parcels can be closed at one time.

If you have any questions, please contact me at (916) 255-3714 or email me at Terry.Escarda@dtsc.ca.gov.

Sincerely,

Terry M Escarda

Terry M. Escarda, P.E.
Project Manager/Hazardous Substances Engineer
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cc: See next page.

Printed on Recycled Paper

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May 31, 2016
Geotracker Nos: T0604180127
T0609592161
T0609592162

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Subject: Comments, Draft Final Site Closure Report Request for No Further Action, Former UST Site 957/970, Former Department of Defense Housing Facility, Novato, Marin County

Dear Mr. Doctor:

San Francisco Bay Regional Water Quality Control Board (Regional Water Board) staff has reviewed the *Draft Final Site Closure Report Request for No Further Action, Former UST Site 957/970, Former Department of Defense Housing Facility, Novato, California* (Draft Final NFA), dated March 30, 2016.

Regional Water Board staff offers the following comments:

1. The Draft Final NFA should include an brief explanation as to why the TPHg concentration level in well NA-7 has not decreased since 2006. The concentration level for TPHg in well NA-7 has actually increased to 4,400 µg/L in 2015 from 4,200 µg/L in 2006. Although TPHg concentration levels have decreased overtime from 30,000 µg/L to 4,400 µg/L, the concentration level has basically remained the same during the last 10 years. It appears a hot spot may still exist at that location.
2. Please explain why TPHg analysis was not conducted in monitoring wells MP-1D, MW-1E, and MW-M3, which are located down-gradient of well NA-7.
3. The Draft Final NFA should include figures depicting the TPHg and TPHd concentrations in soil at the UST 970 location or explain why the Draft Final NFA does not include such figures. The NFA includes figures depicting TPHd/g concentrations in soil at the UST 957 area, but not the UST 970 area.

4. Please ensure that each table clearly identifies the UST location for which the data represents. For example, Table 11 presents soil data for the Oil/Water Separator, but it doesn't indicate if it is for the UST 957 area or the UST 970 area.
5. All tables should include the most recent ESL[1] for each contaminant of concern and media (e.g. groundwater, soil) for comparison. Some of the tables include ESLs that do not reflect the most recent ESL value.

If you have any questions, please contact me at (510) 622-2338 or by e-mail at margarete.beth@waterboards.ca.gov.

Sincerely,

Margarete "Maggie" Beth
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[1] http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/esl.shtml

Responses To Comments
Draft Final Site Closure Report
Request For No Further Action Former UST Site 957/970
Former Department Of Defense Housing Facility Novato, Novato, California
July 2016

Comment No.	Comments	Navy Response
San Francisco Regional Water Quality Control Board Comments		
1.	The Draft Final NFA should include a brief explanation as to why the TPHg concentration level in well NA-7 has not decreased since 2006. The concentration level for TPHg in well NA-7 has actually increased to 4,400 µg/L in 2015 from 4,200 µg/L in 2006. Although TPHg concentration levels have decreased overtime from 30,000 µg/L to 4,400 µg/L, the concentration level has basically remained the same during the last 10 years. It appears a hot spot may still exist at that location.	The 2015 TPH-G concentrations in NA-7 of 4,400 µg/L suggest residual TPH-G is present at this location. However, it is important to note that downgradient, well 957-MW4 screened (8-18 ft bgs) in the same interval as NA-7 (10-15 ft bgs) was non-detect, suggesting that the residual TPH-G is not migrating and natural bioattenuation mechanisms are occurring to degrade petroleum-related products and resulting in a low threat to human health and safety and to the environment.
2.	Please explain why TPHg analysis was not conducted in monitoring wells MP-1D, MW-1E, and MW-M3, which are located down-gradient of well NA-7.	These wells were not sampled because MP-1D was abandoned in 2010 and MW-1E and MW-M3 were abandoned in 2013. Figure 5: TPH-G Plume Contour Map (November 2006 and December 2015) and Table 6: TPH-G Concentrations in Groundwater (2006 and 2015) have been updated accordingly.
3.	The Draft Final NFA should include figures depicting the TPHg and TPHd concentrations in soil at the UST 970 location or explain why the Draft Final NFA does not include such figures. The NFA includes figures depicting TPHd/g concentrations in soil at the UST957 area, but not the UST 970 area.	Figures depicting soil TPH-D and TPH-G concentrations in soil at the UST 970 location were not included in the Draft Final NFA because that parcel has been transferred to a private developer and is currently undergoing a remedial action to remove residual COCs in soil at this location by a separate contractor to achieve soil cleanup standards for residential development. Figures depicting the TPH-G and TPH-D concentration in soil at the UST 970 location are available in the *Final Remedial Investigation Report For Former UST Site 957/970 at Department of Defense Housing Facility Novato, California* (Battelle, 2001).
4.	Please ensure that each table clearly identifies the UST location for which the data represents. For example, Table 11 presents soil data for the Oil/Water Separator, but it doesn't indicate if it is for the UST 957 area or the UST 970 area.	The following tables have been updated accordingly. Table 5 lists the locations for each of the monitoring wells. Tables 10, 11, 12 identify UST locations. Tables 13 and 14 list the location in the header. Tables 15 and 16 identify the location in a column.
5.	All tables should include the most recent ESL1 for each contaminant of concern and media (e.g. groundwater, soil) for comparison. Some of the tables include ESLs that do not reflect the most recent ESL value.	All tables have been updated accordingly with the 2016 ESLs.