Site Characterization Report
for
Site No. 2016

Prepared for

United States Navy
Roosevelt Roads Naval Station

Ceiba, Puerto Rico

Contract No. N62470-95-D-6007
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Prepared by

CH2MHILL

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List of Acronyms

bls	below land surface
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
CFR	Code of Federal Regulations
DRO	Diesel Range Organics
ft/day	feet per day
ft/ft	feet per foot
HVC	hydrocarbon vapor content
mg/Kg	milligrams per kilogram
mg/L	milligrams per Liter
msl	mean sea level
NAVSTA	U.S. Naval Station
OVA	Organic vapor analyzer
PAH	Polynuclear Aromatic Hydrocarbons
ppm	parts per million
PREQB	Puerto Rico Environmental Quality Board
QA/QC	Quality Assurance/Quality Control
QRA	Qualitative Risk Assessment
RCRA	Resource Conservation and Recovery Act
SC	Site Characterization
SVE	Soil Vapor Extraction
TEG	Transglobal Environmental Chemistry
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
USCS	Unified Soil Classification System
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
µg/L	micrograms per Liter

Executive Summary

CH2M HILL conducted a site characterization (SC) for former underground storage tank (UST) Site 2016 located in Vieques, an island located due east of the Roosevelt Roads U.S. Naval Station (NAVSTA Roosevelt Roads), Ceiba, Puerto Rico. Site 2016 is the former location of a 550-gallon waste oil UST. The UST was used to store waste oil generated from vehicle maintenance activities that take place in Building 2016. The purpose of the SC was to assess the horizontal and vertical extent of potential impacts from the UST on soil and groundwater at Site 2016. The SC investigation consisted of the installation of soil borings and monitoring wells, the collection and analysis of soil and groundwater samples, and aquifer testing.

Five soil borings and three monitoring wells were installed at Site 2016. Soil and groundwater samples collected from the soil borings and monitoring wells were sent to a laboratory for analysis. Permanent monitoring well locations were selected based on analytical results from soil and groundwater samples collected from the five soil borings. Monitoring well top-of-casing elevation and depth-to-water measurements also were collected to determine the groundwater flow direction at Site 2016. Two slug tests (aquifer tests) were performed to determine the hydraulic conductivity of the surficial aquifer. Results of the slug tests revealed that the soils beneath Site 2016 have a low hydraulic conductivity (ranging from 0.6 feet per day [ft/day] to 2.2 ft/day).

Laboratory analytical data showed that total petroleum hydrocarbons (TPH) were detected in the soil sample from the 45 to 47 foot interval in soil boring 2016-SB-1 at a concentration of 42,000 milligrams per kilogram (mg/kg), which is above the Puerto Rico Environmental Quality Board (PREQB) target level of 100 mg/kg for this constituent. This soil sample is located in the source area, adjacent to the former UST. No free product was detected in any of the monitoring wells installed during this investigation. The dissolved concentration of benzene detected at monitoring well 2016-MW1 is 17 micrograms per liter (µg/L) which exceeds the PREQB target level of 5 µg/L for that compound. Dissolved concentrations of Toluene, Ethylbenzene, Xylenes, Total Recoverable Petroleum Hydrocarbons (TRPH), TPH (diesel, gasoline, and motor oil range organics), and polynuclear aromatic hydrocarbons (PAHs) were not identified above laboratory method detection limits.

A qualitative risk assessment (QRA) was conducted to assess potential exposure pathways at the site. Based on the results of the QRA, the small amount of petroleum impacted media at Site 2016 is not a threat to human health and the environment due to the depth at which petroleum impacts were noted and because of the lack of complete exposure pathways.

Based on the information obtained from the field investigation and laboratory analytical data, CH2M HILL recommends that no corrective measures (no further action) be implemented at Site 2016. Natural biodegradation processes are expected to reduce the levels of contaminants detected in soil boring 2016-SB-1/MW-1.

SECTION 1

Introduction

Pursuant to Contract Number N62470-95-D-6007-CTO-076, CH2M HILL was authorized by the United States Navy to conduct a site characterization (SC) investigation of underground storage tank (UST) 2016 (Site 2016) located in Vieques, an island located due east of the United States Naval Station Roosevelt Roads. The objective of the SC investigation was to evaluate the degree and extent of potential impacts from petroleum products to the soil and groundwater at Site 2016. This report presents a summary of the work completed, results of the SC field investigation, and remediation recommendations.

1.1 Site Location

Site 2016 is located in Vieques, an island located east of the United States Naval Station Roosevelt Roads (NAVSTA Roosevelt Roads) (Figure 1-1). The approximate location of Site 2016 is 18° 08′ 00″ latitude and 65° 31′ 00″ longitude. The area of interest for this SC investigation is located on the north west corner of Building 2016. The area of interest is a grassy area with an unpaved driveway that is part of the vehicle maintenance department of the base contractor. A topographic map of the study area, depicting the relief of the site, is presented as Figure 1-2.

1.2 Site Background

According to information provided by the United States Navy, Site 2016 is the former location of a 550-gallon, single-wall, steel waste-oil underground storage tank (UST). The piping system associated with the UST consisted of single wall steel pipes. The UST was installed in 1970 to store waste oil generated from vehicle maintenance activities that take place in Building 2016.

As part of the UST removal activities conducted at Site 2016, soil samples collected and submitted for laboratory analysis detected Total Petroleum Hydrocarbons concentrations ranging from 568 to 1790 milligrams per kilogram (mg/kg). United States Navy personnel indicated that no accidental spills associated with the UST at Site 2016 had occurred at the site.

1.3 Previous Investigations

No previous SC investigations have been conducted at Site 2016. The United States Navy requested that a SC investigation be conducted at Site 2016 to evaluate the degree and extent of potential impacts from petroleum products to the soil and groundwater at Site 2016.

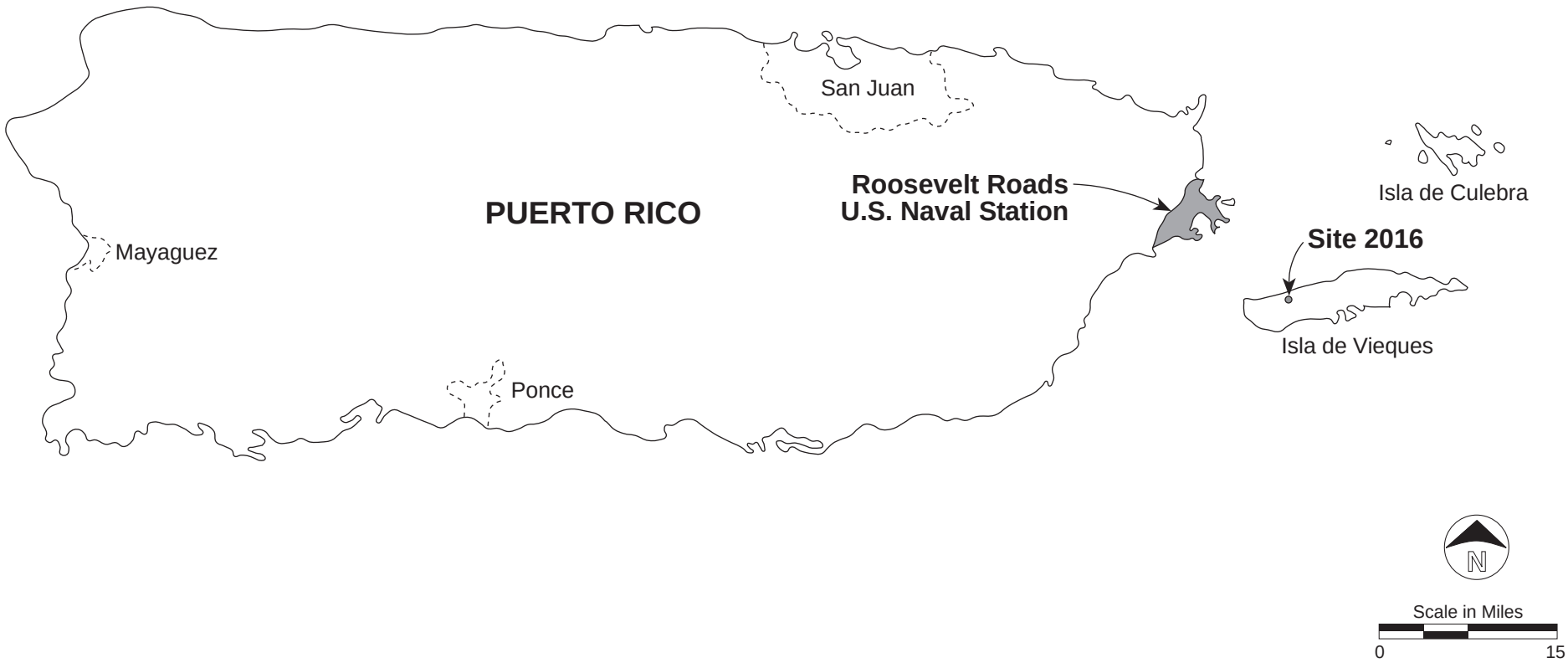

FIGURE 1-1
Site Location Map

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FIGURE 1-2
Topographic Map - Site 2016
Roosevelt Roads U.S. Naval Station
Isla De Vieques, Puerto Rico

Scale in Feet
0 1500 3000

N

USGS Quad Map:
Isla De Vieques,
Puerto Rico - 1982

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1.4 Project Objectives

The main objective of CH2M HILL's SC investigation was to assess the horizontal and vertical extent of soil and groundwater impacted by the 550-gallon, single-wall, steel UST and associated single wall, steel piping that was removed at Site 2016. The SC investigation consisted of the installation of soil borings and monitoring wells, and by collecting and analyzing soil and groundwater samples.

To support analytical data and potential contaminant transport mechanisms, in-situ permeability tests were performed to determine the hydraulic conductivity characteristics of the surficial aquifer. Groundwater flow direction and gradients were also calculated from the groundwater elevation data and permeability test results.

In addition to evaluating the potential presence of contamination from the former UST, a qualitative risk assessment (QRA) was completed to evaluate potential impacts from site related compounds to human health and the environment.

Five (5) soil borings and three (3) monitoring wells were installed at Site 2016 to meet the project objectives. Soil and groundwater samples collected from the soil borings and monitoring wells installed during this investigation were submitted to Transglobal Environmental Geochemistry (TEG) for laboratory analysis.

SECTION 2

Field Investigation

The SC for Site 2016 occurred between August 4 and August 24, 1998. Assessment activities consisted of the installation of soil borings and monitoring wells, the collection of soil and groundwater samples, and aquifer testing. Soil samples were collected at two-foot intervals and were screened in the field with an organic vapor analyzer (OVA). Groundwater and soil samples were sent for laboratory analyses. Lithologic data were collected during the installation of monitoring wells and soil borings. Soil boring lithologic logs, monitoring well construction diagrams, and in-situ permeability testing results are included in Appendices A, B, and C, respectively.

2.1 Drilling

This section describes soil boring and monitoring well installation activities. Drilling activities at the site were initiated after NAVSTA personnel cleared utilities within the limits of the study area. Field decontamination, air monitoring, OVA screening, well construction and development procedures are included in Appendix D. Table 2-1 summarizes the contents of Appendix D. The standard operating procedures were presented in the Final Work Plan and Health and Safety Plan (CH2M HILL, 1998).

TABLE 2-1
Summary of Appendix D
Site 2016 - Roosevelt Roads Naval Station UST Site Characterization

Appendix D Subsection	Contents
D-1	Utility Location/Dig Permit
D-2	Equipment Decontamination Procedures
D-3	Air Monitoring Procedures
D-4	OVA Field Screening Methodology
D-5	Monitoring Well Construction Procedures
D-6	Monitoring Well Development Procedures

2.1.1 Soil Boring Procedures

To determine and delineate the extent of petroleum-impacted soils, five (5) soil borings (2016-SB1 through 2016-SB5) were conducted. Soil borings were advanced to 4 feet below land surface (bls) with a post hole digger prior to using the drilling rig. Soil samples were then collected continuously in 2-foot intervals to a depth of 20 feet bls and continued in 5-foot intervals and terminated when water was encountered at approximately 45 feet bls. The surficial soils encountered at Site 2016 were described in accordance with the Unified Soil

Classification System (USCS) and the Munsell soil color chart. Appendix A contains the soil boring lithologic logs.

2.1.2 Soil Field Screening and Sampling

Soil samples were collected using stainless steel split spoons until the water table was encountered. The samples were placed in 16-ounce glass jars, covered by a sheet of aluminum foil, and securely capped. Approximately five minutes were allowed to elapse before the headspace in the jars was analyzed with a Model 128 Foxboro OVA. The methodology used to conduct OVA screening is described in Appendix D-4. The OVA screening results, summarized in Table 2-2, indicate that 16 of the 72 soil samples screened produced detectable vapors. Of those 16 samples, 12 samples had net hydrocarbon vapor content (HVC) concentrations above 100 parts per million (ppm), all of which occurred in the source area. The net HVC concentrations ranged from non-detect to greater than 1,000 PPM. Methane vapor concentrations ranged from non-detect to 50 PPM.

Select soil samples (based on field observations and OVM readings) were collected for laboratory analysis. The screening process involved a 24-hour turn around time from sample delivery on selected samples to confirm contamination delineation. Soil samples collected from the soil borings were analyzed by TEG of Puerto Rico. Since the USTs under investigation were used to store waste oil, the selected laboratory analysis included: Benzene, Toluene, Ethylbenzene, and Total Xylenes (BTEX) by EPA Method 8020, Total Recoverable Petroleum Hydrocarbons (TRPH) by Environmental Protection Agency (EPA) Method 418.1; and Total Petroleum Hydrocarbons (TPH) by EPA Method 8015M for Gasoline Range Organics (GRO), Diesel Range Organics (DRO), and motor oil (OIL).

EPA Method 418.1 was initially used as the standard site soil contamination screening method until CH2M HILL was informed by the TEG laboratory that, based on experience, TRPH (EPA Method 418.1) has a tendency to give false positives in certain soil types commonly found in Puerto Rico. Once this was known, the standard screening method was changed to EPA Method 8015M for contamination delineation.

Two soil samples from each soil boring were selected for laboratory analysis. The general interval used for soil sample collection was 4 to 6 feet bls and 43 to 45 feet bls. Section 4 presents laboratory analytical data.

2.1.3 Groundwater Field Screening

At the time of the soil boring installations, the depth to water across Site 2016 was approximately 45 feet bls (Appendix A). At selected boreholes, after water was encountered, a new Teflon® bailer was placed in the water table and a water sample was collected. This was performed to delineate the extent of the groundwater contamination prior to the installation of the monitoring wells.

Groundwater from the soil borings was analyzed for by EPA Method 8020, and TPH by EPA Method 8015M for DRO, GRO, and OIL. Based on the laboratory analytical data and field observations, all soil borings outside the source area, were determined to be in areas of groundwater contamination below PREQB levels. Two soil borings away of the source area were converted to monitoring wells (2016-MW2 and 2016-MW3). Groundwater samples obtained from the source soil boring 2016-SB1 had concentrations of TPH GRO that exceeded the PREQB target level of 50 milligrams per liter (mg/L). The source well (2016-

MW1) was installed in the area of the removed UST location. The groundwater analytical results reported by TEG are summarized in Table 2-3.

TABLE 2-2
Organic Vapor Analysis of Soil
Site 2016 - Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

Sample Designation	Date Sampled	Sample Depth (ft BLS)	Total Organic Vapors (ppm)	Total Methane Vapors (ppm)	Total Petroleum Hydrocarbon Vapors (ppm)
2016-SB1	8/11/98	0-2	<1	na	<1
	8/11/98	2-4	<1	na	<1
	8/11/98	4-6	<1	na	<1
	8/11/98	6-8	<1	na	<1
	8/11/98	8-10	40	12	28
	8/11/98	10-12	20	<1	20
	8/11/98	12-14	>1000	30	>970
	8/11/98	14-16	>1000	50	>950
	8/11/98	16-18	>1000	18	>982
	8/11/98	18-20	400	<1	400
	8/11/98	23-25	>1000	20	>980
	8/11/98	28-30	>1000	25	>975
	8/11/98	31-33	>1000	20	>980
	8/11/98	33-35	580	20	560
	8/11/98	35-37	>1000	<1	>1000
	8/11/98	40-42	>1000	5	>995
	8/11/98	45-47	>1000	15	>985
	8/11/98	47-49	>1000	30	>970
2016-SB2	8/4/98	0-2	<1	na	<1
	8/4/98	2-4	<1	na	<1
	8/4/98	4-6	<1	na	<1
	8/4/98	6-8	<1	na	<1
	8/4/98	8-10	<1	na	<1
	8/4/98	10-12	<1	na	<1
	8/4/98	12-14	<1	na	<1
	8/4/98	14-16	<1	na	<1
	8/4/98	16-18	<1	na	<1
	8/4/98	18-20	<1	na	<1
	8/4/98	23-25	<1	na	<1
	8/4/98	28-30	<1	na	<1
	8/4/98	33-35	<1	na	<1
	8/4/98	38-40	3	1	2
	8/4/98	43-45	4	1	3
2016-SB3	8/5/98	0-2	<1	na	<1
	8/5/98	2-4	<1	na	<1
	8/5/98	4-6	<1	na	<1
	8/5/98	6-8	<1	na	<1
	8/5/98	8-10	<1	na	<1
	8/5/98	10-12	<1	na	<1
	8/5/98	12-14	<1	na	<1
	8/5/98	14-16	<1	na	<1
	8/5/98	16-18	<1	na	<1
	8/5/98	18-20	<1	na	<1
	8/5/98	23-25	<1	na	<1
	8/5/98	28-30	<1	na	<1

TABLE 2-2 (CONTINUED)
Organic Vapor Analysis of Soil
Site 2016 - Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

Sample Designation	Date Sampled	Sample Depth (ft BLS)	Total Organic Vapors (ppm)	Total Methane Vapors (ppm)	Total Petroleum Hydrocarbon Vapors (ppm)
2016-SB4	8/6/98	0-2	<1	na	<1
	8/6/98	2-4	<1	na	<1
	8/6/98	4-6	<1	na	<1
	8/6/98	6-8	<1	na	<1
	8/6/98	8-10	<1	na	<1
	8/6/98	10-12	<1	na	<1
	8/6/98	12-14	<1	na	<1
	8/6/98	14-16	<1	na	<1
	8/6/98	16-18	<1	na	<1
	8/6/98	18-20	<1	na	<1
	8/6/98	23-25	<1	na	<1
	8/6/98	28-30	<1	na	<1
2016-SB5	8/7/98	0-2	<1	na	<1
	8/7/98	2-4	<1	na	<1
	8/7/98	4-6	<1	na	<1
	8/7/98	6-8	<1	na	<1
	8/7/98	8-10	<1	na	<1
	8/7/98	10-12	<1	na	<1
	8/7/98	12-14	<1	na	<1
	8/7/98	14-16	<1	na	<1
	8/7/98	16-18	<1	na	<1
	8/7/98	18-20	<1	na	<1
	8/7/98	23-25	<1	na	<1
	8/7/98	28-30	<1	na	<1
	8/7/98	33-35	<1	na	<1
	8/7/98	38-40	<1	na	<1
	8/7/98	45-47	<1	na	<1

na = Not Analyzed - No sample to analyze or low total organic vapor concentrations
NA = Not Available - Methane and total organic vapor concentrations exceed instrument range
BLS = below land surface
ppm = parts per million

TABLE 2-3
Summary of TEG Soil Boring Groundwater Screening Analytical Results
Site 2016 - Roosevelt Roads Naval Station UST Site Characterization

Sample Number	Method 418.1 TRPH (mg/L)	EPA Method 8015M (DRO) (mg/L)	EPA Method 8015M (GRO) TPH (mg/L)	EPA Method 8015M Motor Oil (mg/L)	EPA Method 8020 Total BTEX (mg/L)
2016 SB-1	930	<25	2,000	<50	<0.30
2016 SB-2	400	<25	<10	<50	<0.30
2016 SB-5	<10	<25	<10	<50	<0.30
PREQB Target Levels	50	50	50	50	NS

Notes:
PREQB = Puerto Rico Environmental Quality Board
TRPH = Total Recoverable Petroleum Hydrocarbon
TPH = Total Petroleum Hydrocarbon
mg/L = Milligrams per Liter
Total BTEX = Sum of Benzene, Toluene, Ethylbenzene, and Xylenes
8015M (DRO) = EPA Method 8015 Diesel range organics
8015M Motor Oil = EPA Method 8015 Motor Oil range organics
8015M (GRO) = EPA Method 8015M Gasoline range organics

2.1.4 Monitoring Well Construction

Three 2-inch-diameter monitoring wells (2016-MW1, 2016-MW2, and 2016-MW3) were installed to define the horizontal extent of potentially impacted groundwater in the vicinity of the former UST. One monitoring well was installed to assess the source area groundwater and two monitoring wells were installed to define the horizontal extent of potentially impacted groundwater in the vicinity of the former UST. The wells were installed under the supervision of CH2M HILL personnel. The well construction materials and equipment were thoroughly decontaminated prior to installation of each well. The development of the wells was accomplished by intermittently surging with a Teflon® bailer and using a peristaltic pump with Teflon® tubing to remove fine-grained sediments. Detailed descriptions of monitoring well construction and development procedures are presented in Appendix D. Table 2-4 summarizes the monitoring well development activities. Monitoring well development logs are included in Appendix E. Table 2-5 summarizes monitoring well completion data. Monitoring well construction diagrams are presented in Appendix B.

TABLE 2-4
Monitoring Well Development Summary
Site 2016 - Roosevelt Roads Naval Station UST Site Characterization

Well	Development Method	Development Completion Date	Approximate Gallons Developed	Number of Well Volumes Developed
2016-MW1	Peristaltic Pump/Bailer	9/10/98	55	42.9
2016-MW2	Peristaltic Pump/Bailer	9/10/98	55	43.4
2016-MW3	Peristaltic Pump/Bailer	9/10/98	55	37.8

TABLE 2-5
Monitoring Well Completion Summary
Site 2016 - Roosevelt Roads Naval Station UST Site Characterization

Well Designation	2016-MW1	2016-MW2	2016-MW3
Date Installed	8/17/98	8/20/98	8/20/98
Total Well Depth (ft, bls)	50	50	50
Type of Completion	Flush	Flush	Flush
Top of Casing Elevation (ft)	99.643	98.392	99.765
Casing Type	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC
Casing Length(s)	2	2	2
Screen Type	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC
Screen Slot Size (in)	0.010	0.010	0.010
Screen Length (ft)	10	10	10
Screen Interval (ft, bls)	40-50	40-50	40-50

Note: All monitoring wells are 2 inches in diameter
Top-of-casing elevations were referenced to the Roosevelt Roads datum
In = inch
ft = feet
msl = mean sea level
bls = below land surface

2.2 In-Situ Permeability Testing

On September 11, 1998, in-situ permeability tests were performed in monitoring wells 2016-MW2 and 2016-MW3. The aquifer hydraulic properties beneath Site 2016 were calculated from the data collected during these tests. The in-situ permeability test procedure consisted of the following steps:

- A depth-to-water measurement was taken to determine static conditions in the well.
- A pressure transducer was placed approximately 1 foot off the bottom of the well. The transducer cable was secured in place with the manhole lid to prevent it from shifting during the test.
- The pressure transducer was connected to the data logger.
- The data logger was programmed for the test. This allowed the data logger to convert the pressure transducer readings to feet of water.
- The water level reference on the data logger is entered as the static water level to represent static conditions.
- The data logger started recording and a volume of potable water was introduced into the well.
- Once the water level returned to within approximately 10 percent of static conditions, the test was stopped.

The in-situ permeability tests results were plotted on semi-logarithmic graphs and analyzed using the Bouwer and Rice method (Bouwer and Rice, 1976). The hydraulic conductivity (K) calculated from the tests ranged from 0.6 feet per day (ft/day) to 2.2 ft/day. The raw data, graphs, and calculations pertaining to the in-situ permeability tests are presented in Appendix C.

2.3 Groundwater Elevation Measurements

The top-of-casing elevations of the three monitoring wells installed at Site 2016 were surveyed by a licensed surveyor and referenced to the NAVSTA Roosevelt Roads datum. On September 11, 1998, depth to water measurements were collected from the top of casing (north side) with an electronic water level probe. Table 2-6 presents depth-to-water and monitoring well elevations. The water level measurements obtained on September 11, 1998, were used to generate a water table elevation contour map (Figure 2-1). As shown on the water table elevation map, the groundwater flow appears to be in a northern direction away from the former UST location.

The ground water gradient (I) and flow velocity (V) were calculated from the K obtained from the in-situ permeability tests and water table elevation data. On September 11, the groundwater gradient was 0.03 feet /foot (ft/ft), while the flow velocity was 0.15 ft/day. The calculations used to determine I and V are presented in Appendix C.

2.4 Groundwater Sampling

On September 11, 1998, water samples were collected from the three monitoring wells. The groundwater samples were transported, on ice, to TEG via laboratory courier. The samples were analyzed by the following EPA methods: 8020 (BTEX); 418.1 (TRPH); TPH by EPA Method 8015M for GRO, DRO, and OIL; and 610 (PAH).

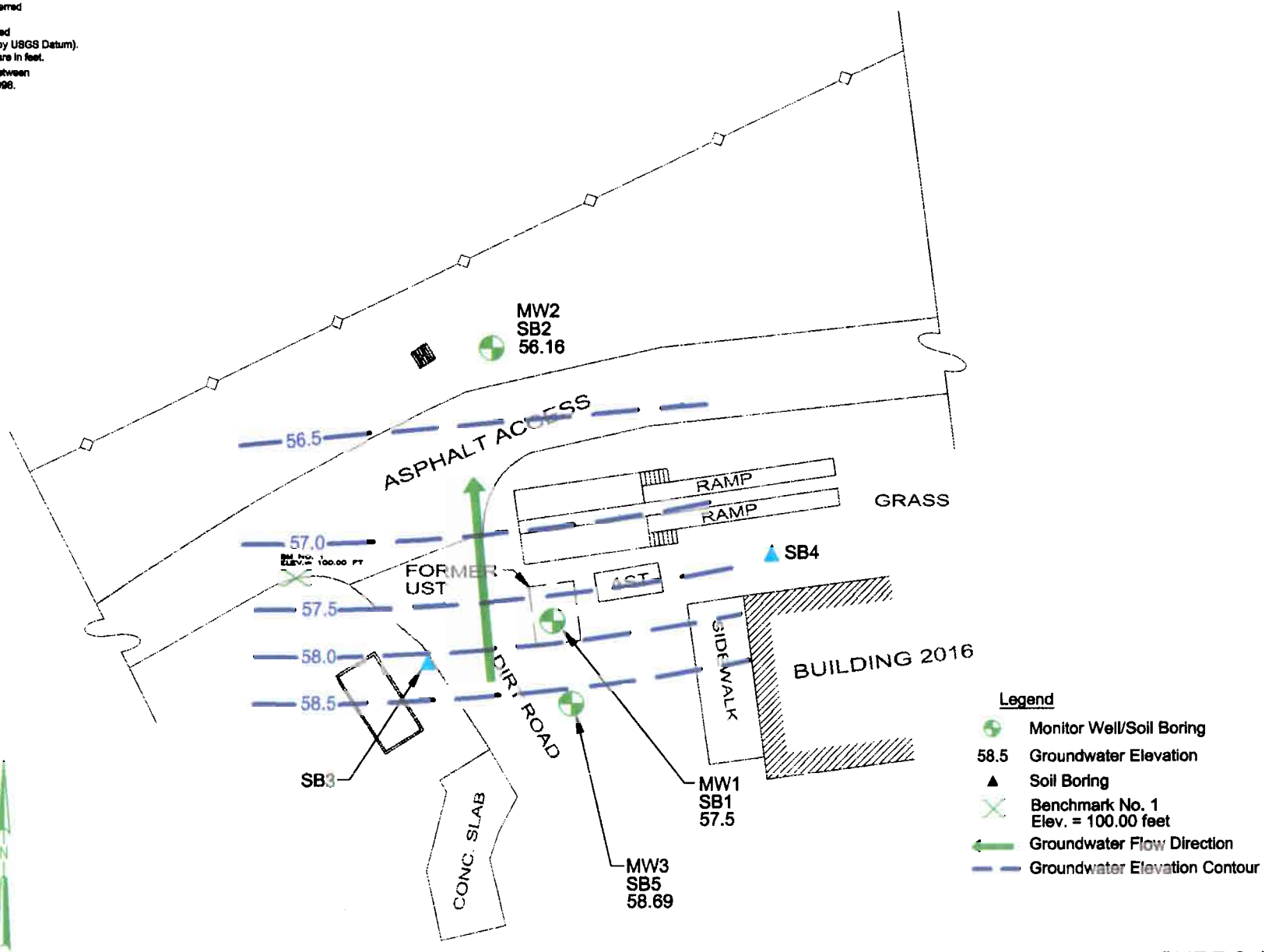
Field blanks, equipment blanks, and trip blanks were collected to ensure that contaminants were not introduced to the water samples before, during, or after sample collection. Groundwater sampling procedures and Quality Assurance/Quality Control (QA/QC) guidelines are detailed in Appendix F. Monitoring well purge and sampling forms are included in Appendix G.

TABLE 2-6
Water Table Elevation Data
Site 2016 - Roosevelt Roads Naval Station UST Site Characterization

Well Designation	Elevation of Top of Casing (ft, RRD)	September 11, 1998	
		Depth to Water (ft)	Water Level Elevation (ft, RRD)
2016-MW1	99.64	42.14	57.50
2016-MW2	98.39	42.23	56.16
2016-MW3	99.76	41.08	58.68

NOTE: Top-of-Casing elevations referenced to msl
RRD: Roosevelt Roads Datum

General Notes:
1) The horizontal control are referred to an arbitrary system.
2) The vertical control are referred to a mean sea level system (by USGS Datum).
3) All distances and elevations are in feet.
4) The survey was performed between September and October of 1998.



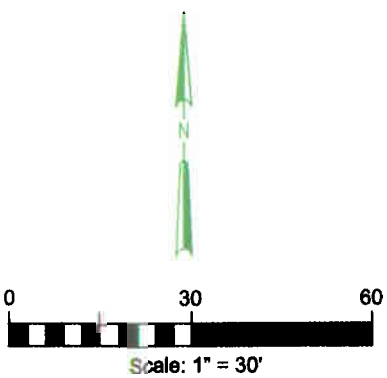


FIGURE 2-1
Groundwater Flow Direction, September 11, 1998
Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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SECTION 3

Site Geology/Hydrogeology

3.1 Regional Geology

The geology of NAVSTA Roosevelt Roads consists of a sequence of intrusive and extrusive volcanic and volcaniclastic lithologies of lower Cretaceous age (M'Gonile, 1979). Much of the U.S. Naval Base is underlain by the Daguoa Formation, which is characterized by interbedded volcanic breccia, lava, subordinate volcanic sandstone, and crystal tuff (M'Gonile, 1979). The Daguoa Formation has an irregular surface and is encountered at various depths across the NAVSTA Roosevelt Roads (BBL, 1994). The Daguoa formation pinches out in the northern part of the NAVSTA Roosevelt Roads giving way to the Fajardo formation. The Fajardo formation is made up of thin-bedded tuffaceous siltstone and sandstone of lower Cretaceous age (Briggs and Aguilar-Cortez, 1980). The largest hills [approximately 300 feet above mean sea level (msl)] and ridges consist of the Daguoa Formation. The hills are flanked by Quaternary and Holocene fanglomerate and swamp deposits. Quaternary alluvium, slopewash, and fanglomerate deposits compose the broad low-lying areas of NAVSTA Roosevelt Roads (BBL, 1995).

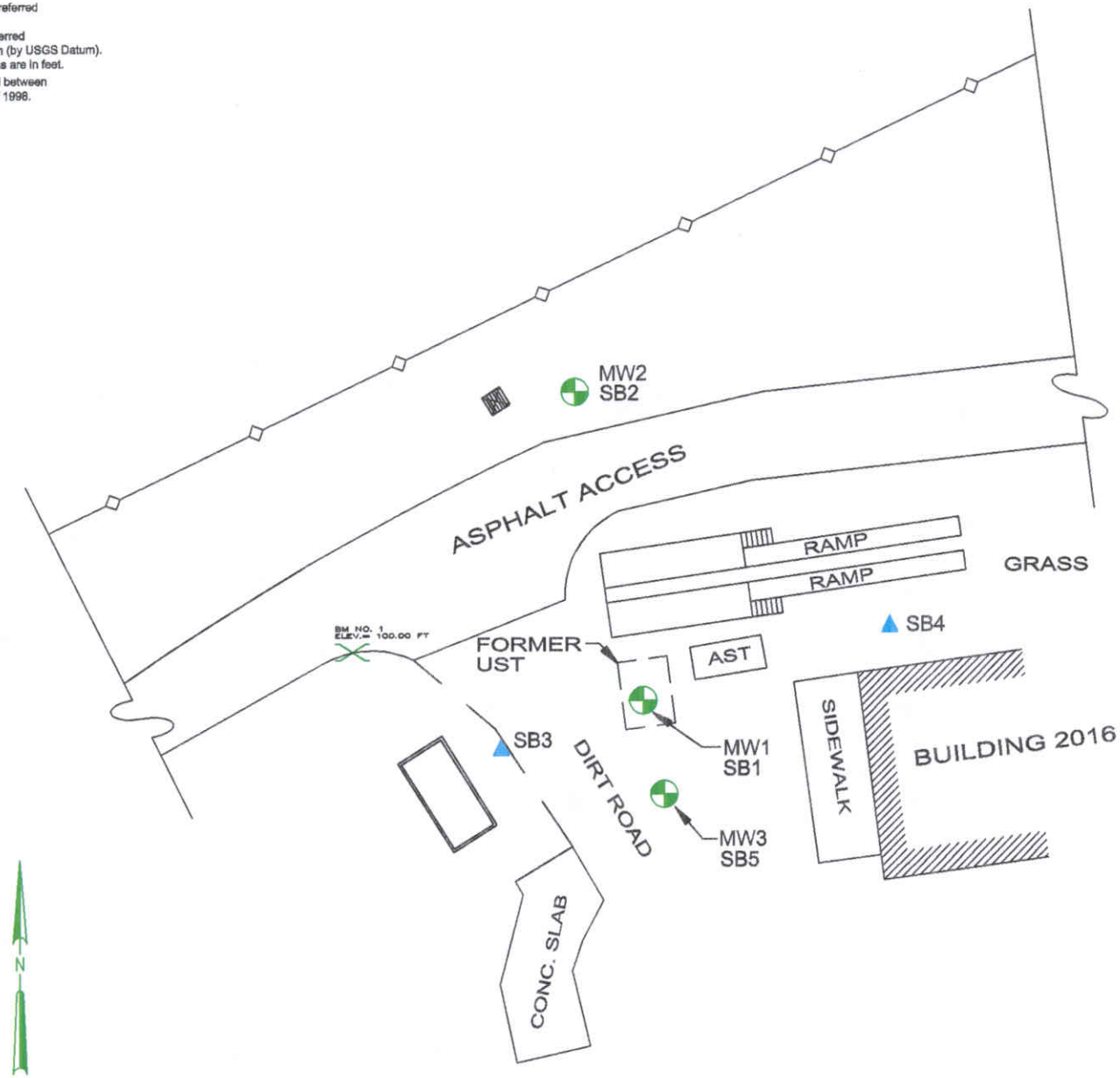
Puerto Rico is surrounded and associated with many Caribbean islands. NAVSTA Roosevelt Roads occupies approximately two thirds of the island of Vieques which is located southwest of Puerto Rico. The geology is generally the same as eastern area of the main island, which NAVSTA Roosevelt Roads occupies.

3.1.1 Site Geology

The soil samples collected during the installations of soil borings and monitoring wells were used to describe the site geology. Lithologic descriptions are included within the soil boring logs and monitoring well construction diagrams which are presented as Appendices A and B, respectively.

As seen in Figure 1-3, Site 2016 lies near rolling topography (approximately 20 to 40 feet above msl) underlain by the Daguoa Formation. Beneath Site 2016, silt and clay from highly weathered volcanic rock are encountered. The colors of encountered lithologies were primarily brown, dark greenish gray, yellowish red, and brownish yellow. The colors of the soils were determined using the Munsell soil color system. The colors observed are characteristic of the weathering and oxidation or reduction of iron-rich volcanic rock. These sediments generally possess high plasticity when moist are very hard when dry, and are not easily crumbled under hand pressure. The locations of monitoring wells and soil borings are provided as Figure 3-1. Locations of the geologic cross-sections are provided in Figure 3-2 and the geologic cross-sections are presented in Figures 3-3 and 3-4. The cross-sections are based on the lithologies observed during the installation of soil borings and monitoring wells for the SC.

General Notes:
1) The horizontal control are referred to an arbitrary system.
2) The vertical control are referred to a mean sea level system (by USGS Datum).
3) All distances and elevations are in feet.
4) The survey was performed between September and October of 1998.



Legend
- Monitor Well/Soil Boring
- Soil Boring
- Benchmark No. 1 Elev. = 100.00 feet

0 30 60
Scale: 1" = 30'

FIGURE 3-1
Soil Boring and Monitor Well Locations
Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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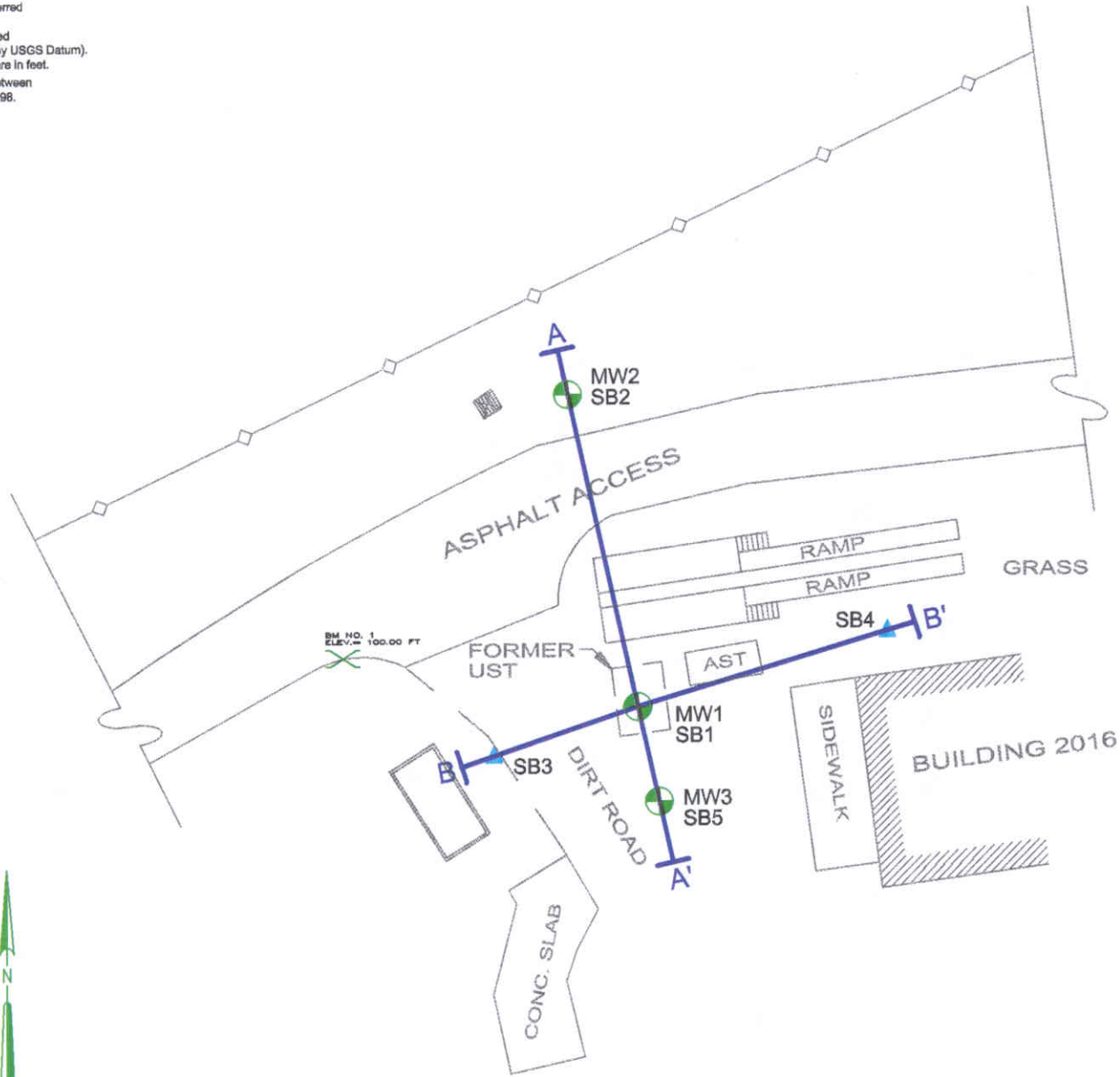
General Notes:
1) The horizontal control are referred to an arbitrary system.
2) The vertical control are referred to a mean sea level system (by USGS Datum).
3) All distances and elevations are in feet.
4) The survey was performed between September and October of 1998.



Legend

- Monitor Well/Soil Boring
- Soil Boring
- Benchmark No. 1 Elev. = 100.00 feet

N

0 30 60

Scale: 1" = 30'

FIGURE 3-2

Location of Geologic Cross Sections

Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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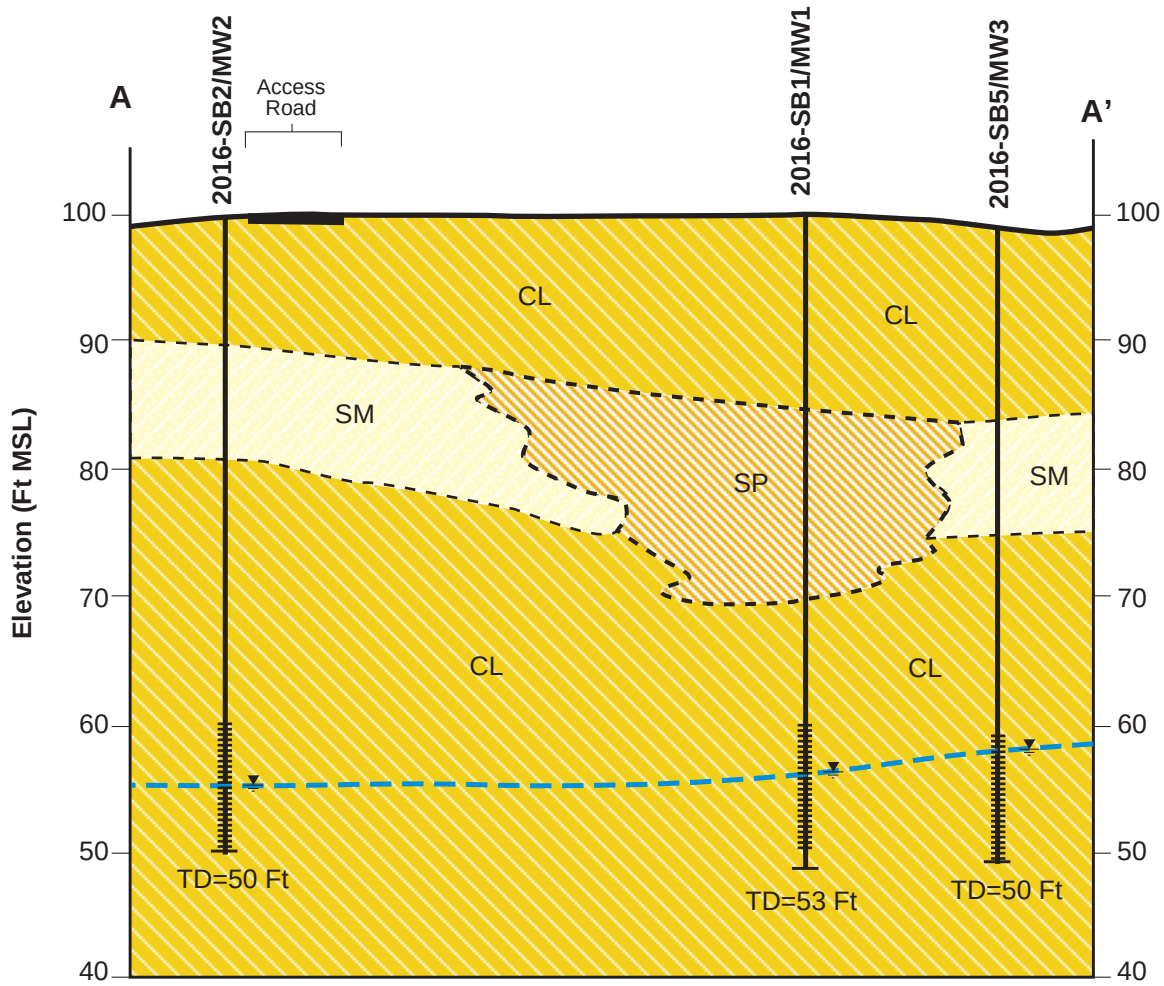

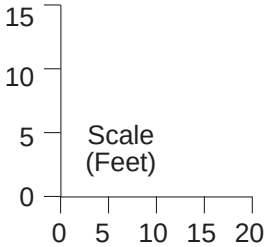

Legend

SM	Silty Sand		Monitor Well Screen Interval
CL	Sandy Clay		Soil Boring Total Depth
SP	Poorly Sorted Sand		Groundwater Level Elevation
TD	Total Depth	FT MSL	Feet Above Mean Sea Level

FIGURE 3-3
Geologic Cross-Section A-A'
Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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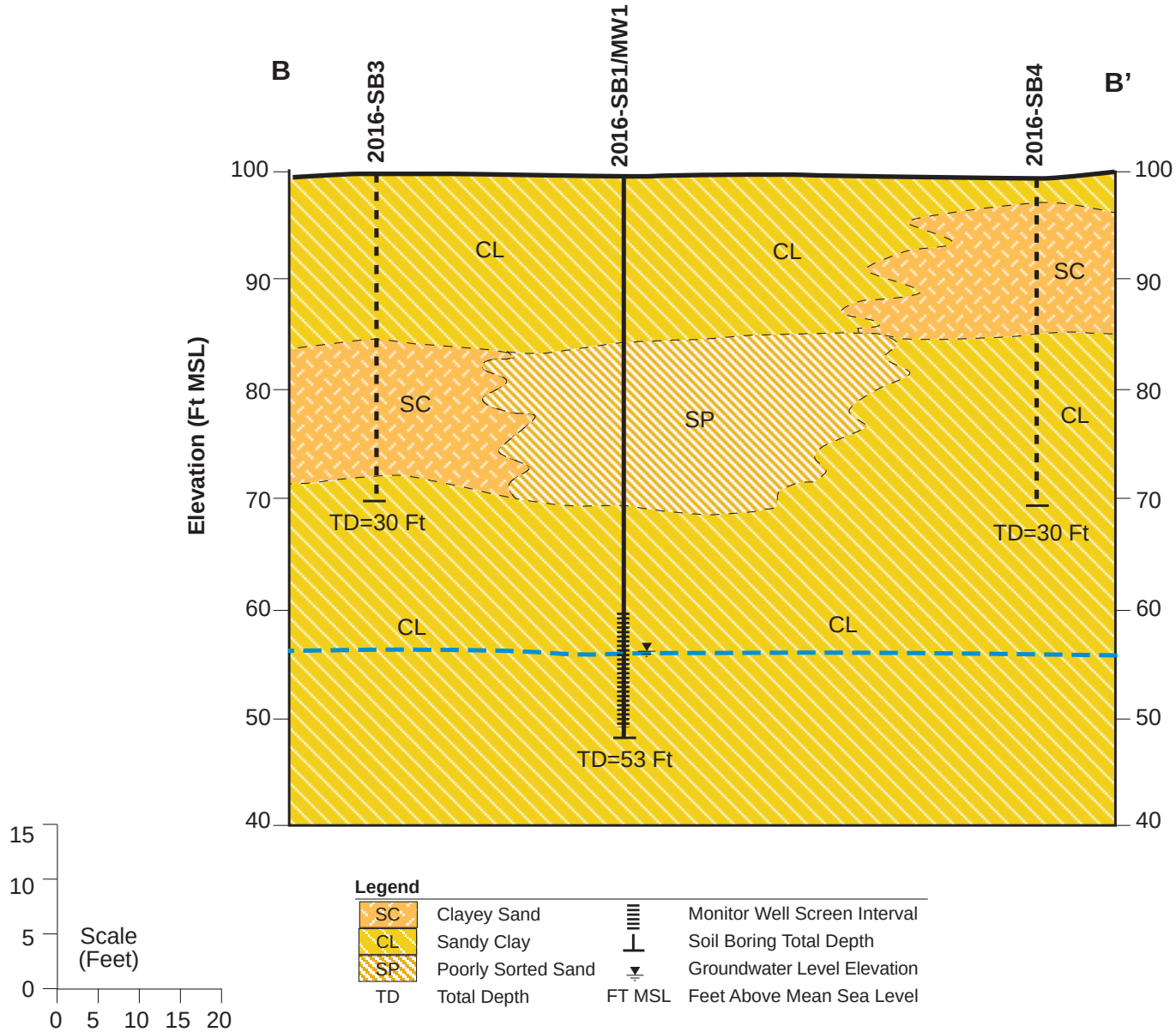

FIGURE 3-4
Geologic Cross-Section B-B'
Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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3.2 Site Hydrogeology

Site 2016 is underlain by a potentially semi-confined surficial aquifer system, which is composed of plastic clays. Water was encountered at the site at depths of 50 feet below land surface (bls); however, the water levels stabilized at depths of approximately 42 feet bls after a period of time.

Groundwater flow at Site 2016 is controlled by elevation differences between adjacent hills and the gentle sloping topography. Groundwater flow at Site 2016 appears to be in a northern direction (see Figures 2-1 and 2-2) away from the former UST. The plasticity of the subsurface material indicates that water is present in the pore spaces; however, the specific yield (ratio of the volume of water that drains from a sample under gravity to the total volume of the sample) is very low. Generally, the subsurface material would expect to display low hydraulic conductivity in all directions. There can be features in the clays, like cracks or thin sand lenses, which can contribute to higher hydraulic conductivity in the areas where the in-situ permeability tests were performed. A presentation of the in-situ permeability test results and hydraulic conductivity values are presented in Appendix C.

SECTION 4

Laboratory Analytical Results

4.1 Soil Analytical Results

Analytical results for total petroleum hydrocarbons (TPH) were used to approximate the maximum horizontal and vertical extent of potentially impacted soil by hydrocarbons. TPH soil contamination detected at Site 2016 is limited to one soil boring (2016-SB1), located in the source area. Soil analytical results are summarized in Table 4-1 and shown in Figure 4-1. TPH contamination for the gasoline range organics (42,000 mg/kg) and motor oil range organics (2,400 mg/kg) was detected in the soil sample collected from 45 - 47 feet below land surface at soil boring 2016-SB1. These concentrations exceed the PREQB target level of 100 mg/kg for TPH.

Although PREQB does not have any standards for BTEX in soils, the samples were analyzed to characterize individual constituents. Ethylbenzene and total xylenes were detected at concentrations of 0.24 mg/kg and 6.7 mg/kg respectively in the soil sample collected from 45 - 47 feet below land surface at soil boring 2016-SB1. Complete laboratory analytical results of samples collected by CH2M HILL personnel are presented in Appendix H.

Soil quality assurance/quality control (QA/QC) analytical results are summarized in Table 4-2.

Soil analytical results were used to determine disposal methods for the drill cuttings. Based on analytical results, drill cuttings from soil borings 2016-SB2, SB3, SB4, and SB5 from Site 2016 were classified as non-hazardous and spread on-site in the vicinity of the former UST. Drill cuttings from soil boring 2016-SB1 were drummed and disposed of properly after analytical analyses.

4.2 Groundwater Analytical Results

Groundwater laboratory analytical results from monitoring wells at Site 2016 are summarized in Table 4-3. As summarized in Table 4-3, the dissolved concentration of benzene detected at monitoring well 2016-MW1 is 17 micrograms per liter (ug/L). This concentration exceeds the PREQB target level of 5 ug/L. The summary also shows that dissolved concentrations of Toluene, Ethylbenzene, Xylenes, TRPH, TPH (DRO and GRO, and OIL), and PAHs were not detected above laboratory method detection limits. PREQB defines groundwater to be contaminated if it contains benzene concentrations above 5 ug/L, total BTEX concentration above 50,000 ug/L, or TRPH and TPH concentrations above 50 milligrams per liter (mg/L).

As it is summarized in Table 4-3 and depicted in Figure 4-2, the groundwater samples analyzed do not exceed the PREQB target levels except for benzene at monitoring well 2016-MW1.

Summaries of the QA/QC laboratory analytical results are presented in Table 4-4. The soil, groundwater, and QA/QC laboratory analytical reports are provided in Appendix H.

TABLE 4-1
Summary of TEG Laboratory Soil Analytical Results
Site 2016, Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

Soil Boring	**Date Sampled**	**TEG Laboratory**			
		EPA Method 8015M (GRO) TPH (mg/kg)	**EPA Method 8015M (DRO) TPH (mg/kg)**	**EPA Method 8015M Motor Oil (mg/kg)**	**EPA Method 8020 Total BTEX (mg/kg)**
2016-SB-1 (4-6')	8/4/98	<10	<25	<50	<0.30
2016-SB-1 (45-47')	8/10/98	42,000	<25	2,400	7.04
2016-SB-2 (4-6')	8/4/98	<10	<25	<50	<0.30
2016-SB-2 (43-45')	8/19/98	<10	<25	<50	<0.30
2016-SB-3 (4-6')	8/5/98	<10	<25	<50	<0.30
2016-SB-4 (4-6')	8/6/98	<10	<25	<50	<0.30
2016-SB-5 (4-6')	8/7/98	<10	<25	<50	<0.30
2016-SB-5 (45-47')	8/13/98	<10	<25	<50	<0.30
PREQB UST Target Levels		100	100	100	NS

Notes:

PREQB	=	Puerto Rico Environmental Quality Board
TPH	=	Total Petroleum Hydrocarbons
Total BTEX	=	Sum of Benzene, Toluene, Ethylbenzene, and Xylene Concentrations
mg/kg	=	Milligrams per Kilogram
NS	=	No Standards in Puerto Rico
UST	=	Underground Storage Tanks
NC	=	Not Collected

EPA = Environmental Protection Agency

8015M (GRO) = EPA Method 8015M Gasoline Range Organics

8015M (DRO) = EPA Method 8015M Diesel Range Organics

NA = Not analyzed

8015M Motor Oil = EPA Method 8015M Motor Oil Range Organics

General Notes:
1) The horizontal control are referred to an arbitrary system.
2) The vertical control are referred to a mean sea level system (by USGS Datum).
3) All distances and elevations are in feet.
4) The survey was performed between September and October of 1998.

EPA Method	Laboratory Detection Limit
BTEX (8020)	0.05 - 0.15 mg/kg
Total Btex	0.30 mg/kg
TPH DRO (8015M)	25.0 mg/kg
TPH GRO (8015M)	10.0 mg/kg
TPH OIL (8015M)	50.0 mg/kg

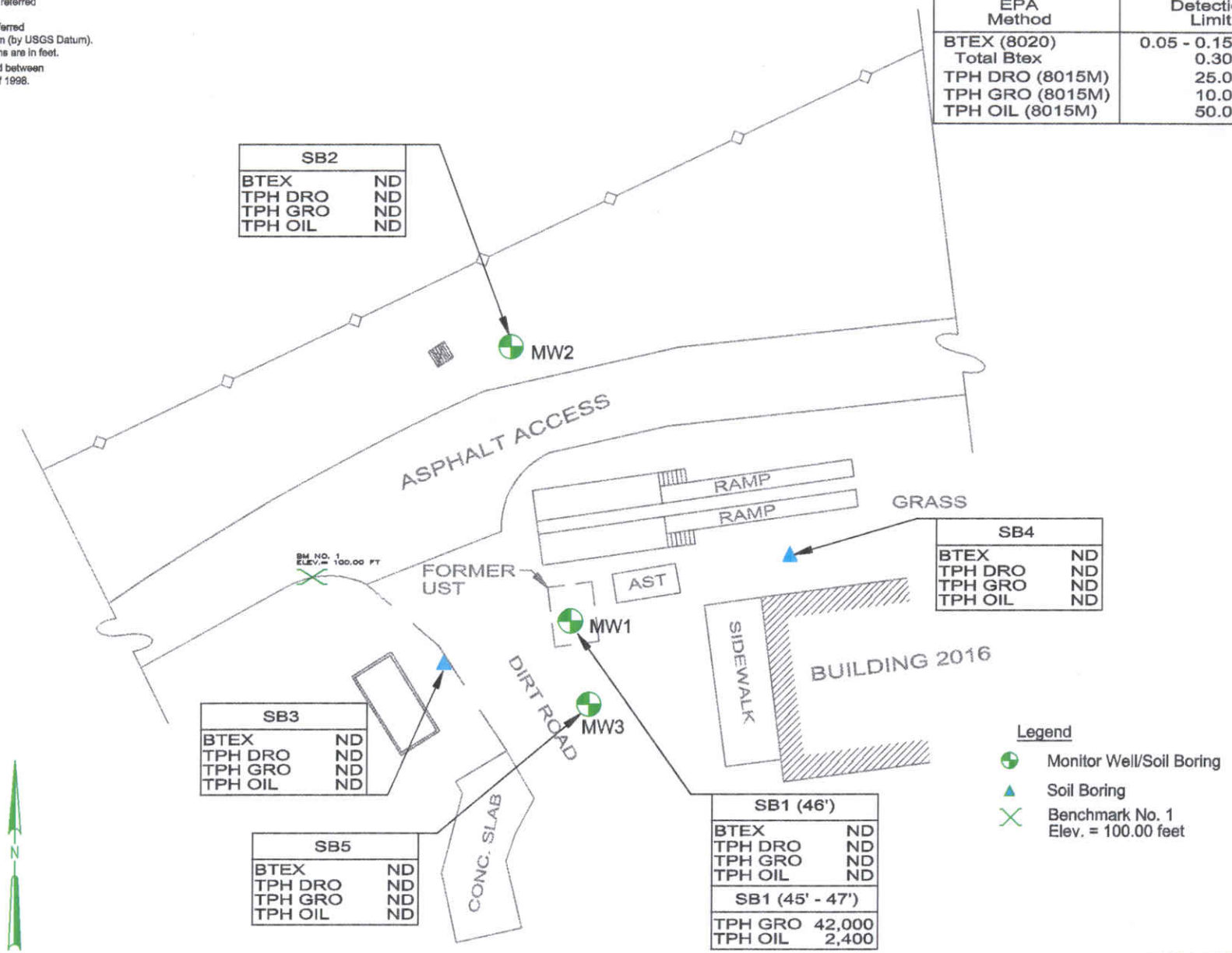

FIGURE 4-1

Soil - BTEX and TPH Analytical Results

Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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TABLE 4-2
Summary of Soil QA/QC Analytical Results
Site 2016, Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

Sample Name	Date Sampled	Sample Matrix	EPA Method 8015M (GRO) TPH mg/kg	EPA Method 8015M (DRO) TPH mg/kg	EPA Method 8015M Motor Oil mg/kg	EPA Method 418.1 TRPH mg/kg	EPA Method 8020 BTEX mg/kg
2016 DUPE1	8/4/98	Soil	<10	<25	<50	<10	<0.30
			mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**
2016-EQBLK1	8/4/98	Water	<10	<25	<50	<10	<0.30
2016-EQBLK2	8/5/98	Water	<10	<25	<50	<10	<0.30
2016-EQBLK3	8/7/98	Water	<10	<25	<50	<10	<0.30
2016-EQBLK4	8/10/98	Water	<10	<25	<50	<10	<0.30
2016-EQBLK5	8/13/98	Water	<10	<25	<50	<10	<0.30
2016-EQBLK6	8/19/98	Water	<10	<25	<50	<10	<0.30
TRIP BLANK	8/6/98	Water	NA	NA	NA	NA	<0.30
TRIP BLANK	8/11/98	Water	NA	NA	NA	NA	<0.30
TRIP BLANK	8/12/98	Water	NA	NA	NA	NA	<0.30
TRIP BLANK	8/25/98	Water	NA	NA	NA	NA	<0.30
TRIP BLANK	8/20/98	Water	NA	NA	NA	NA	<0.30

Notes:

TPH = Total Petroleum Hydrocarbon
Total BTEX = Sum of Benzene, Toluene, Ethylbenzene, and Xylenes
mg/kg = Milligrams per Kilogram
mg/L = Milligrams per Liter
2016 DUPE1 = Duplicate Sample of 2016-SB-2 (4-6')
2016-EQBLK1 = Equipment Blank – stainless steel spoon
2016-EQBLK2 = Equipment Blank – stainless steel spoon
2016-EQBLK3 = Equipment Blank – stainless steel spoon
2016-EQBLK4 = Equipment Blank – stainless steel spoon
2016-EQBLK5 = Equipment Blank – stainless steel spoon
2016-EQBLK6 = Equipment Blank – stainless steel spoon
EPA = Environmental Protection Agency
8015M (GRO) = EPA Method 8015M Gasoline range organics
8015M (DRO) = EPA Method 8015M Diesel range organics
NA = Not analyzed
8015 Motor Oil = EPA Method 8015M Motor Oil Range Organics

TABLE 4-3
Summary of Groundwater Analytical Results
Site 2016, Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

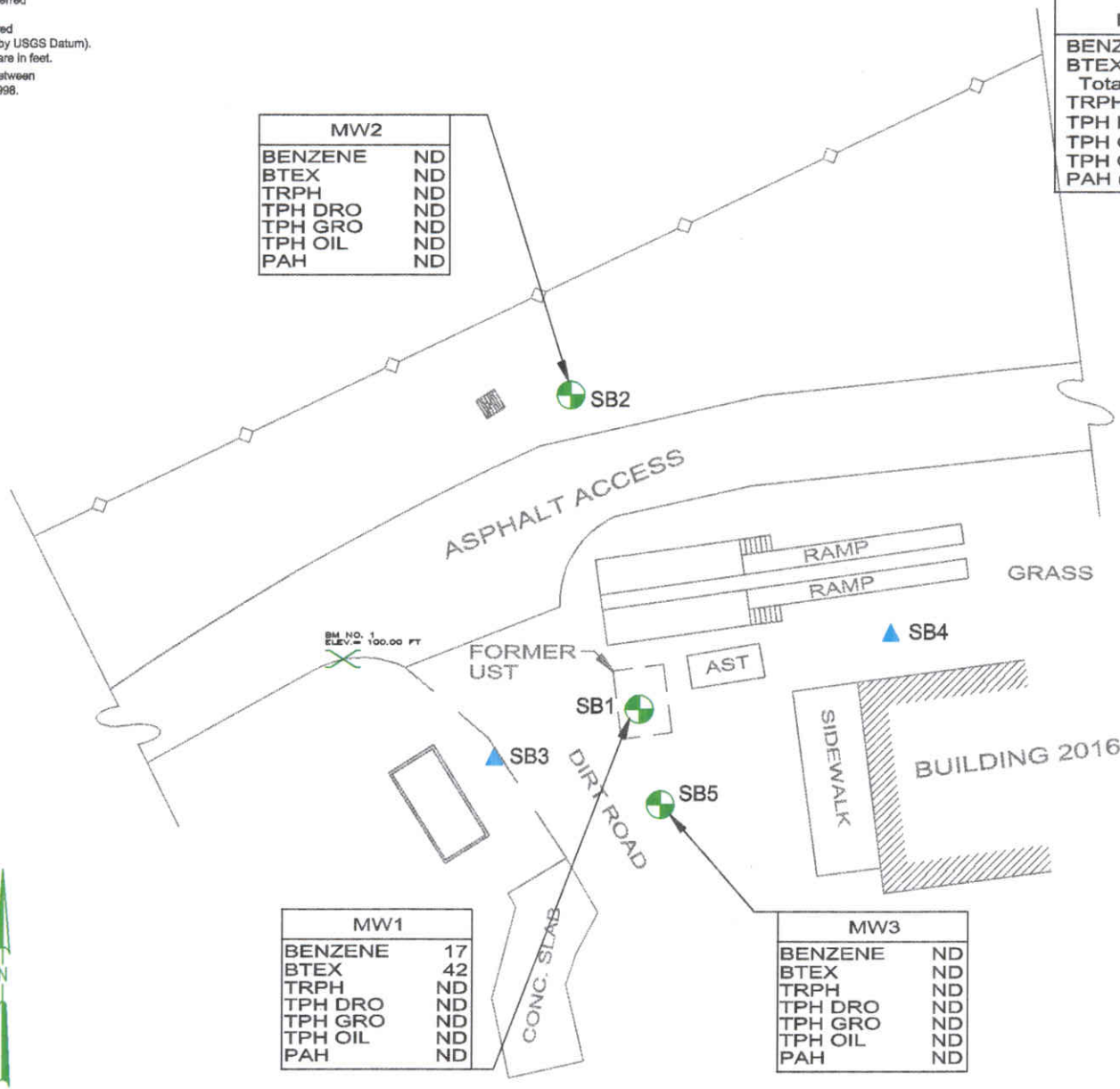
Parameters	**PREBQ Target Levels**	**U.S. EPA MCL**	**2016-MW-1**	**2016-MW-2**	**2016-MW-3**
Date Sampled			**9/11/98**	**9/11/98**	**9/11/98**
Benzene (μg/L)	5.0	1.0	17	<5	<5
Toluene (μg/L)	1,000	1,000	<5	<5	<5
Ethylbenzene (μg/L)	700	700	<5	<5	<5
Total Xylenes (μg/L)	10,000	10,000	<15	<15	<15
Total BTEX (μg/L)	50,000	NS	42	<30	<30
PAH (μg/L)	NS	NS	BDL*	BDL*	BDL*
TRPH (μg/L)	50,000	NS	<10,000	<10,000	<10,000
TPH DRO (μg/L)	50,000	NS	<25,000	<25,000	<25,000
TPH GRO (μg/L)	50,000	NS	<10,000	<10,000	<10,000
TPH Motor Oil (μg/L)	50,000	NS	<50,000	<50,000	<50,000

Notes:

μg/L	=	Micrograms per Liter
PREQB	=	Puerto Rico Environmental Quality Board
Total BTEX	=	Sum of Benzene, Toluene, Ethylbenzene, and Xylenes
PAH	=	Polynuclear Aromatic Hydrocarbon (excluding total naphthalenes)
TRPH	=	Total Recoverable Petroleum Hydrocarbon
NS	=	No Standard
NA	=	Not Collected or Analyzed
MCL	=	Maximum Contaminant Level
BDL	=	Below Detection Levels
*	=	All PAH compounds excluding naphthalenes were below their respective detection limits
US EPA	=	United States Environmental Protection Agency
TPH DRO	=	Total Petroleum Hydrocarbons (Diesel Range Organics)
TPH GRO	=	Total Petroleum Hydrocarbons (Gasoline Range Organics)
TPH Motor Oil	=	Total Petroleum Hydrocarbons (Motor Oil Range Organics)

General Notes:
1) The horizontal control are referred to an arbitrary system.
2) The vertical control are referred to a mean sea level system (by USGS Datum).
3) All distances and elevations are in feet.
4) The survey was performed between September and October of 1998.

EPA Method	Laboratory Detection Limit
BENZENE	5 ug/L
BTEX (8020)	5 - 15 ug/L
Total Btex	30 ug/L
TRPH (418.1)	10.0 mg/L
TPH DRO (8015M)	25.0 mg/L
TPH GRO (8015M)	10.0 mg/L
TPH OIL (8015M)	50.0 mg/L
PAH (610)	0.2 - 0.5 mg/L



MW2	
BENZENE	ND
BTEX	ND
TRPH	ND
TPH DRO	ND
TPH GRO	ND
TPH OIL	ND
PAH	ND

MW1	
BENZENE	17
BTEX	42
TRPH	ND
TPH DRO	ND
TPH GRO	ND
TPH OIL	ND
PAH	ND

MW3	
BENZENE	ND
BTEX	ND
TRPH	ND
TPH DRO	ND
TPH GRO	ND
TPH OIL	ND
PAH	ND

Legend
- Monitor Well/Soil Boring
- Soil Boring
- Benchmark No. 1 Elev. = 100.00 feet

0 30 60
Scale: 1" = 30'

FIGURE 4-2
Groundwater - BTEX, TRPH and PAH Analytical Results
Site 2016, Roosevelt Roads Naval Station, Puerto Rico

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TABLE 4-4
Summary of Groundwater QA/QC Analytical Results
Site 2016, Roosevelt Roads, U.S. Naval Station, Ceiba, Puerto Rico

Parameters	**PREBQ Levels**	**U.S. EPA MCL**	**2016-EQ BLK 7 (Equipment Blank)**	**2016-FB1 (Field Blank)**	**2016-Trip Blank**	**2016-DUPE1**
Date Sampled			**9/11/98**	**9/11/98**	**9/11/98**	**9/11/98**
Benzene (μg/L)	5.0	1.0	<5	<5	<5	<5
Toluene (μg/L)	1,000	1,000	<5	<5	<5	<5
Ethylbenzene (μg/L)	700	700	<5	<5	<5	<5
Total Xylenes (μg/L)	10,000	10,000	<15	<15	<15	<15
Total BTEX (μg/L)	50,000	NS	<30	<30	<30	<30
PAH (μg/L)	NS	NS	BDL*	BDL*	NA	*
TRPH (μg/L)	50,000	NS	<10,000	<10,000	NA	<10,000
TPH DRO (μg/L)	50,000	NS	<25,000	<25,000	NA	<25,000
TPH GRO (μg/L)	50,000	NS	<10,000	<10,000	NA	<10,000
TPH Motor Oil (μg/L)	50,000	NS	<50,000	<50,000	NA	<50,000

Notes:

μg/L = Micrograms per Liter
US EPA = United States Environmental Protection Agency
PREQB = Puerto Rico Environmental Quality Board
Total BTEX = Sum of Benzene, Toluene, Ethylbenzene, and Xylenes
PAH = Polynuclear Aromatic Hydrocarbon (excluding total naphthalenes)
TRPH = Total Recoverable Petroleum Hydrocarbon
NS = No Standard
NA = Not Collected or Analyzed
MCL = Maximum Contaminant Level
BDL* = Below Detection Levels. All PAH compounds excluding naphthalenes were below their respective detection limits
2016-DUPE1 = Duplicate Sample of 2016-MW3
TPH DRO = Total Petroleum Hydrocarbons (Diesel Range Organics)
TPH GRO = Total Petroleum Hydrocarbons (Gasoline Range Organics)
TPH Motor Oil = Total Petroleum Hydrocarbons (Motor Oil Range Organics)
* = Detected Anthracene/Phenanthrene, Pyrene, Benzo (b/k) Fluoranthene and Ideno (1,2,3, cd) Pyrene/DB (ah) Anthracene at concentrations of 0.68 mg/L, 0.47 mg/L, 0.71 mg/L, and 0.67 mg/L, respectively

SECTION 5

Qualitative Risk Assessment

The objective of the Qualitative Risk Assessment (QRA) is to identify the population that is potentially at risk of exposure to chemicals present in, or released from, soil and groundwater at Site 2016. The QRA presents a discussion of exposure pathways and a qualitative evaluation of the magnitude of the risk.

An exposure pathway is described as the route by which a chemical migrates from the contamination source to a potential receptor. To determine the exposure pathway, the chemical of concern, possible transport media, exposure routes (means by which a chemical comes in contact with a biological receptor), and potential receptors are taken into account. The results of the QRA are used to qualitatively determine the risk to human health and environmental receptors from the contaminants found at Site 2016.

5.1 Nature and Extent of Release

Based on field and laboratory data obtained during groundwater sampling, CH2M HILL concluded that dissolved petroleum hydrocarbons in groundwater, with the exception of benzene, are not present at concentrations above PREQB target levels. Laboratory analytical data indicated that soils exceeding PREQB TPH target levels of 100 mg/kg were confined to an area adjacent to the former UST location at Site 2016 at a depth of 45 to 47 feet bls.

5.2 Chemical of Concern

Petroleum contains a large number of compounds. The specific petroleum-based compounds potentially present in groundwater that represent a potential risk to human health and the environment are volatile organic aromatics (consisting of benzene, toluene, ethylbenzene, and xylene), and naphthalene. Toluene, ethylbenzene, xylenes, and naphthalene are non-carcinogenic compounds; benzene is a known human carcinogen. Thus, the qualitative risk assessment will focus on the human health impacts of benzene in the groundwater.

5.3 Exposure Assessment

The exposure assessment examines the potential migratory pathways and the biological receptors affected by the chemical of concern. An exposure assessment also estimates both short and long term assessment in terms of doses by exposure routes.

5.3.1 Human Receptors

Site 2016 is the location of a former UST, which was located in back of Building 2016. The building serves as a vehicle maintenance shop and is inhabited by U.S. Navy Personnel. The potential of human contact with the compounds is considered minimal because:

- The contamination is found in subsurface soils below 45 feet bls
- The soils consist of compacted silt and clay, minimizing the ability of the soils to spread by wind action
- The area is covered by vegetation
- The area has restricted access (i.e., authorized personnel only)

5.3.2 Environmental Receptors

The potential for migration of the chemicals of concern to environmental receptors is minimal because petroleum impacts to subsurface soils and groundwater were localized to one sampling location and were identified at depths approaching 45 feet below grade where groundwater was encountered. The contaminated soils are overlain by clays, which exhibit high plasticity, resulting in low hydraulic conductivity. These clays act as a cap, limiting the ability of contaminated soils to spread by wind action and for water to infiltrate the soil and leach the contaminants into the groundwater system.

Site 2016 is characterized by a gently rolling topography, which slopes away from the adjacent hills. Groundwater appears to be flowing away from the site towards the north. The northern direction of groundwater flow indicates a possible route towards Pasaje De Vieques, located north of the site. This is the only potential environmental receptor for the chemicals of concern.

5.3.3 Exposure Pathways

Exposure pathways are defined as the route compounds follow from an original source to potential receptors. The mechanism by which the population can come into contact with the compound is also evaluated and taken into consideration by the exposure pathways. The following four elements are required to complete an exposure pathway:

- A source and mechanism of release for a compound of concern (e.g., storage tank leak)
- A feasible environmental transport route (e.g., dissolved groundwater constituents)
- An exposure point of potential contact with receptors (e.g., potable well)
- An exposure route allowing receptors to come in contact with the compound(s) (e.g., inhalation of vapors and ingestion of groundwater)

If any of these elements are not present, the exposure pathway is considered incomplete. In Site 2016, the first element (a source/mechanism) has been shown to exist. The second element is also present since benzene was detected above the PREQB target level of 5 μg/L. A discussion of the potential exposure pathways is presented in the following sections.

5.3.4 Groundwater Consumption Pathway

The tropical rain forest (El Yunque) provides the primary source of potable water in eastern Puerto Rico and the island of Vieques. El Yunque is located approximately 5 miles west of NAVSTA Roosevelt Roads. Based on conversations with U.S. Navy personnel, it was determined that the potable water supply for the island of Vieques originated from El Yunque. The island is served potable water by a pipeline from the main island of Puerto Rico. Because of the availability of surface water in Vieques, groundwater is not exploited by the U.S. Navy as a source of potable water; therefore, this pathway is incomplete.

5.3.5 Ingestion Pathway

The only potential ingestion pathway of the chemicals of concern is if excavation or drilling activities was conducted. Workers may be exposed through ingestion of the soils during these activities. Thus, a minor possibility of an ingestion pathway exists at Site 2016. Because site access is restricted, however, this exposure pathway is incomplete under current site conditions.

5.3.6 Inhalation Pathway

The only potential inhalation pathway of the chemicals of concern is if excavation or drilling activities was conducted within the limits of the source area at Site 2016. Workers may be exposed through inhalation of the soils during these activities. Thus, a minor possibility of an inhalation pathway exists at Site 2016. Proposed construction activities, however, require the approval of the U.S. Navy Engineering Command prior to conducting any work at Site 2016. Therefore, this exposure pathway is incomplete under current site conditions.

5.3.7 Risk Evaluation

The QRA results indicate that because of the presence of incomplete exposure pathways, the potential for human contact with the compounds of concern is minimal. As described in this section, each viable exposure pathway is incomplete. The missing elements are either a viable exposure point and/or a viable exposure route. Thus, the chemicals of concern do not present a hazard to personnel who visit, work, or live at the NAVSTA Roosevelt Roads or in the surrounding area.

The QRA also indicates that potential impacts to environmental receptors is minimal since the only dissolved petroleum constituent identified was low levels of benzene in the source area well (2016-MW-1) at a depth of approximately 42 feet bls and appears to be localized to the source area. Groundwater quality down-gradient of Site 2016 is likely to be unaffected by potential release from the former UST making impacts to potential environmental receptors an unlikely scenario.

SECTION 6

Remediation Assessment

This section presents an explanation for the no further action recommendation that has been adopted for both soils and groundwater at Site 2016.

6.1 No Further Action

6.1.1 Soils

The laboratory analytical results indicated that TPH and total BTEX concentrations in the soil were below the PREQB target levels for all samples except 2016-SB-1, which had a TPH concentration of 42,000 mg/kg. However, this soil sample was collected at a depth of 45 to 47 feet bls and is located within the source area, adjacent to the former UST. It is expected that natural biodegradation processes will reduce the concentrations of contaminants identified in this soil boring over time to levels approaching PRQEB targets. Due to the depth of the petroleum impacts identified at this location, the localized nature of this release, and the absence of complete exposure routes, no further action is recommended.

6.1.2 Groundwater

No free product was detected in any of the monitoring wells installed during this investigation. The groundwater samples collected at Site 2016 were below method detection limits for dissolved petroleum hydrocarbon constituents with the exception of 2016-MW-1 which exhibited a benzene concentration of 17 µg/L, which is above the PREQB target level of 5 µg/L for this compound. Since groundwater on-site was encountered at depths ranging from 42 to 45 feet bls and complete exposure routes do not exist at the site, no further action is recommended.

SECTION 7

Conclusions and Recommendations

7.1 Conclusions

The presence of petroleum hydrocarbons in the soil and groundwater was assessed during this site characterization. The elevated concentrations of petroleum hydrocarbons are attributed to the former UST system located at Site 2016.

The measured groundwater flow direction is to the north, away from the existing UST. Two falling head tests were conducted to assess the aquifer properties at Site 2016; these tests indicated that the soils beneath Site 2016 have low hydraulic conductivity. The low hydraulic conductivity is attributed to the lithologic composition (silt, clay and saprolite) beneath Site 2016. The hydraulic gradient and groundwater flow velocity, calculated from water table elevation data and falling head tests, indicate a low groundwater flow velocity.

Laboratory analytical data indicated that concentrations of TPH in the soils were above PREQB target levels. The elevated soil TPH concentrations was detected in soil sample 2016-SB-2 (45-47 feet bls). None of the other soil samples collected from the interval above the water table exceeded PREQB target levels for TPH. No free product was encountered in any of the monitoring wells. No dissolved petroleum hydrocarbons other than benzene at 2016- MW-1, were found above method detection limits in groundwater samples collected from monitoring wells during this investigation.

A qualitative risk assessment was conducted to assess various exposure pathways. Based on the lack of complete exposure pathways, low K values, and lack of environmental receptors, it was determined that the groundwater quality and the amount and area of soil exceeding the PREQB TPH target levels of 100 mg/kg present at the site are not threats to human health or the environment.

7.2 Recommendations

Based on the information obtained from the field investigation and laboratory analytical data, CH2M HILL recommends that no corrective measures (no further action) be implemented at the site. Natural biodegradation processes are expected to reduce the levels of hydrocarbon concentrations in the soils at Site 2016 over time.

SECTION 8

References

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