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FINAL REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN FOR AREA OF CONCERN E (AOC E) AT FORMER U S NAVAL AMMUNITION SUPPORT DETACHMENT VIEQUES ISLAND PUERTO RICO

05/01/2002

CH2M HILL

Final
Remedial Investigation/Feasibility Study Work Plan

for

Area of Concern E at

Former U.S. Naval Ammunition Support Detachment
Vieques Island, Puerto Rico

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the
LANTDIV CLEAN II Program
Contract No. N62470-95-D-6007
CTO-237

Prepared by

CH2MHILL

Tampa, Florida

May 2002

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4350 W. Cypress Street

Suite 600

Tampa, FL 33607-4155

JMS E052002004TPA

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List of Acronyms

AOC	Area of concern
ARARs	Applicable or relevant and appropriate requirements
AST	Aboveground storage tank
ASTM	American Society for Testing and Materials
bls	Below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	Cubic feet per minute
CLP	Contract laboratory program
COC	Chain-of-custody
COPC	Contaminant of potential concern
CSM	Conceptual site model
DAF	Dilution attenuation factor
DQE	Data quality evaluation
DQO	Data quality objectives
DRO	Diesel range organics
DV	Data validation
fbg	Feet below grade
ft	Foot/Feet
FSP	Field sampling plan
GIS	Geographical information system
gpm	Gallons per minute
GRO	Gasoline range organics
HHRA	Human health risk assessment
hp	Horsepower
IC	Institutional controls
IR	Installation restoration
IRA	Interim Remedial Action
LANTDIV	Atlantic Division
LCS	Laboratory confirmation sample
LPAS	Low-profile air stripper
MCL	Maximum contaminant level
MDL	Method detection limit
MPE	Multi-phase extraction
mg/kg	Milligrams per kilogram
MOV	Municipality of Vieques
MS/MSD	Matrix spike/matrix spike duplicate
msl	Mean sea level

NAPL	Non-aqueous phase liquid
NASD	Naval Ammunition Support Detachment
NSRR	Naval Station Roosevelt Roads
NTR	Navy Technical Representative
OVA	Organic vapor analyzer
OVM	Organic vapor meter
PAH	Polynuclear aromatic hydrocarbons
PA/SI	Preliminary Assessment/Site Investigation
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PCB	Polychlorinated biphenyls
ppm	Parts per million
PREQB	Puerto Rico Environmental Quality Board
PRG	Preliminary remedial goals
PVC	Polyvinyl chloride
QAPP	Quality assurance project plan
QA/QC	Quality assurance/quality control
RAGS	Risk assessment guidance for Superfund
RAO	Remedial action objectives
RBC	Risk-based concentration
RI/FS	Remedial investigation/feasibility study
RL	Reporting limit
SC	Site characterization
SOP	Standard operating procedures
SOW	Scope of work
SVE	Soil vapor extraction
SVOC	Semi-volatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TM	Technical memorandum
TRC	Technical review committee
TPH	Total petroleum hydrocarbons
TRPH	Total recoverable petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
USCS	Unified soils classification system
USGS	U.S. Geological Survey
UST	Underground storage tank
VOA	Volatile organic aromatic
VOC	Volatile organic compound
µg/L	Micrograms per liter
WWTP	Wastewater treatment plant

SECTION 1

Introduction

This Work Plan presents the investigation rationale, and technical approach for a Remedial Investigation/Feasibility Study (RI/FS) to be conducted at Area of Concern (AOC) E within the former public works compound of the former Naval Ammunition Support Detachment (NASD) in Vieques, Puerto Rico. The scope of the RI/FS is based on previous investigations conducted at AOC E, which were coordinated with the U.S. Environmental Protection Agency (USEPA) Region II and the Puerto Rico Environmental Quality Board (PREQB).

AOC E, also known as underground storage tank (UST) Site 2016, is the former location of a 550-gallon waste oil UST that was removed in 1996 and replaced with a 500-gallon aboveground storage tank (AST). The Phase I Expanded Preliminary Assessment/Site Investigation (PA/SI) (CH2M HILL, October 2000) completed at AOC E characterized the nature and extent of groundwater contamination, but recommended the site for a full RI/FS to evaluate risks posed by petroleum residuals left in place in soils within the source area following the removal of the waste oil UST in 1996. The PA/SI also recommended the evaluation of remedial alternatives to mitigate free product (floating fuel or waste oil) present in monitoring well MW-1. Based on this recommendation, this work plan also includes the technical requirements of a pilot test to assess the effectiveness of the multi-phase extraction (MPE) technology for removing the free product from the subsurface. Removal of free product at a UST site is a regulatory requirement of the PREQB.

This Work Plan provides a general description of the tasks to be performed as part of the RI/FS and a detailed description of the pilot test for AOC E. Detailed descriptions of sampling and analysis procedures and equipment, quality assurance protocols, health and safety requirements, or community relations planning procedures are addressed fully in the facility-wide Master Work Plan for the Former NASD (CH2M HILL, January 2001), which consists of the following six plans:

- Project Management Plan
- Master Quality Assurance Plan
- Data Management Plan
- Health & Safety Plan
- Investigation Derived Waste Management Plan
- Community Relations Plan

1.1 Objectives of the RI/FS

The primary objectives of the RI/FS at AOC E are to:

- Complete a field data collection program to evaluate the type, extent, and magnitude of contamination present in the soils and groundwater.

- Determine the current and potential future risks to human health and the environment from existing site soil and groundwater contamination based on the anticipated land use for the site.
- Develop and evaluate remedial action alternatives where unacceptable risks to human health or the environment are identified

If the RI determines that an unacceptable risk to human health or the environment exists, the objective of the FS is to evaluate remedial action alternatives that minimize the potential exposure to existing site contaminants.

The RI/FS will be completed in accordance with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and will follow the interim final *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, October 1988).

1.2 Organization of the Work Plan

This RI/FS Work Plan is organized as follows:

Section 1, Introduction, provides general background information regarding the RI/FS, summarizes the purpose of the investigation, and presents the expected results or goals of the RI/FS at AOC E.

Section 2, Site Background and Physical Setting, describes the location and environmental history of the facility, discusses previous investigations, and provides information concerning the physical setting of the site.

Section 3, Initial Evaluation and Data Quality Objectives, presents the conceptual site model developed during the project-scoping phase, which describes the potential migration and exposure pathways of site contaminants. This section also summarizes the preliminary assessment of human health and environmental impacts from site related activities. This section also documents the data requirements for both the risk assessment component of the program and the evaluation of remedial alternatives identified during formulation of the data quality objectives (DQOs) for the RI.

Section 4, Remedial Investigation Technical Approach and Investigation Procedures, provides a description of site-specific tasks to be completed as part of the RI at AOC E. These descriptions include AOC E site-specific RI site characterization tasks adapted from the detailed tasks identified in the quality assurance project plan (QAPP) and the field sampling plan (FSP) of the Master Work Plan.

Section 5, Human Health Risk Assessment (HHRA), describes the objectives of the HHRA process that will be incorporated into the RI report for AOC E and summarizes the HHRA components including contaminant identification, exposure assessment, toxicity assessment, and risk characterization.

Section 6, Preliminary Identification of Remedial Action Alternatives, describes the remediation action objectives (RAOs) and goals for the project. This section also includes a description of the proposed pilot study for mitigating the free phase product detected at MW-1.

Section 7, Remedial Investigation/Feasibility Study Report, describes the general contents of the RI/FS report including investigation, risk assessment, and pilot study results.

Section 8, Schedule, presents the anticipated RI/FS schedule for AOC E based on the scope of the project, and also identifies key activities and delivery dates.

Section 9, Project Management, summarizes the project management component of the program that defines the relationships and responsibilities for selected task and project management items. This section also provides a listing of personnel who will be part of the AOC E RI/FS team.

Section 10, References, presents a listing of references cited during compilation of the RI/FS Work Plan for AOC E.

SECTION 2

Site Background and Physical Setting

This section summarizes the available information on AOC E. This information was obtained from previous investigations conducted at the site and includes subsections describing the site setting, the regional and site-specific geology and hydrogeology, and summaries of previously completed investigations.

2.1 Site Setting

AOC E is located near the northwest corner of Building 2016 (the former vehicle maintenance and transportation shop) within the former public works compound of the Former NASD, located on Vieques Island, Puerto Rico. Figure 2-1 presents a regional location map. Figure 2-2 presents a facility location map for the Former NASD.

Building 2016 is located approximately 850 feet (ft) south of the Atlantic Ocean at the coordinates of 18º08′00″N latitude and 65º31′00″W longitude. AOC E and Building 2016 are approximately 45 ft above mean sea level (msl) and are accessed by paved roads that extend south from Route 200. Figure 2-3 presents a site map of AOC E.

The site is the former location of a 550-gallon fiberglass waste oil UST and associated single-wall steel piping system that was installed in 1970 to store waste oil generated from vehicle maintenance activities at Building 2016.

The former public works compound is now abandoned. A chain-link fence and signage have been erected around the site to restrict access during the RI/FS. The fence and signage will remain in place until activities associated with the CERCLA process have been completed. Representatives from the Municipality of Vieques (MOV) currently maintain the compound and are responsible for site access.

2.2 Previous Investigations

Previous investigations at the site included the UST removal by Reliable Mechanical Inc., in 1996, a Site Characterization (SC) completed by CH2M HILL in 1999, and an Expanded PA/SI conducted by CH2M HILL in 2000. The following subsections summarize these efforts.

2.2.1 UST Removal

AOC E was initially identified as an AOC following the removal of a 550-gallon waste oil UST in November 1996. The UST was replaced by a 500-gallon AST following the UST removal. The UST removal and closure activities were completed as part of the Naval Station Roosevelt Roads (NSRR) UST program being conducted under the auspices of the PREQB UST program.

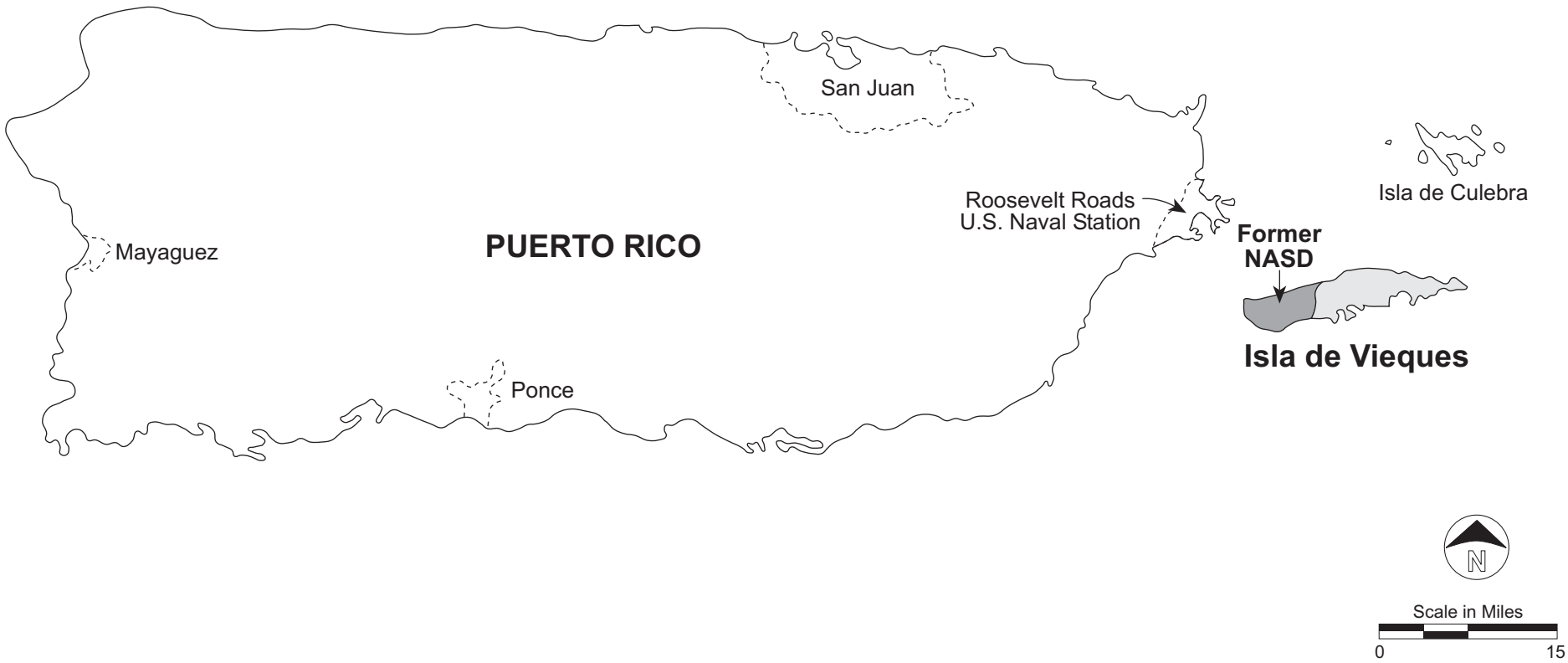

FIGURE 2-1
Site Location Map
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

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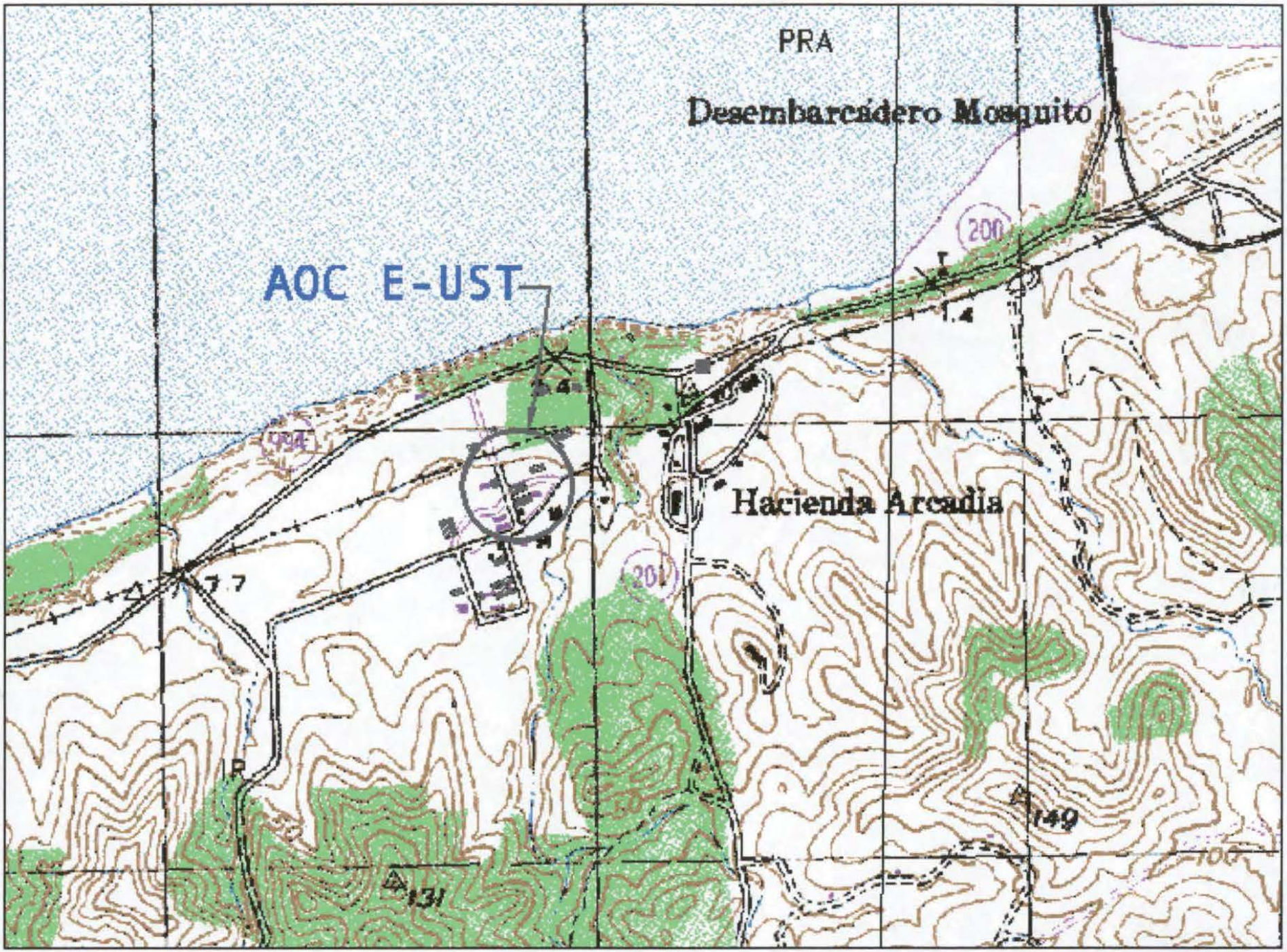
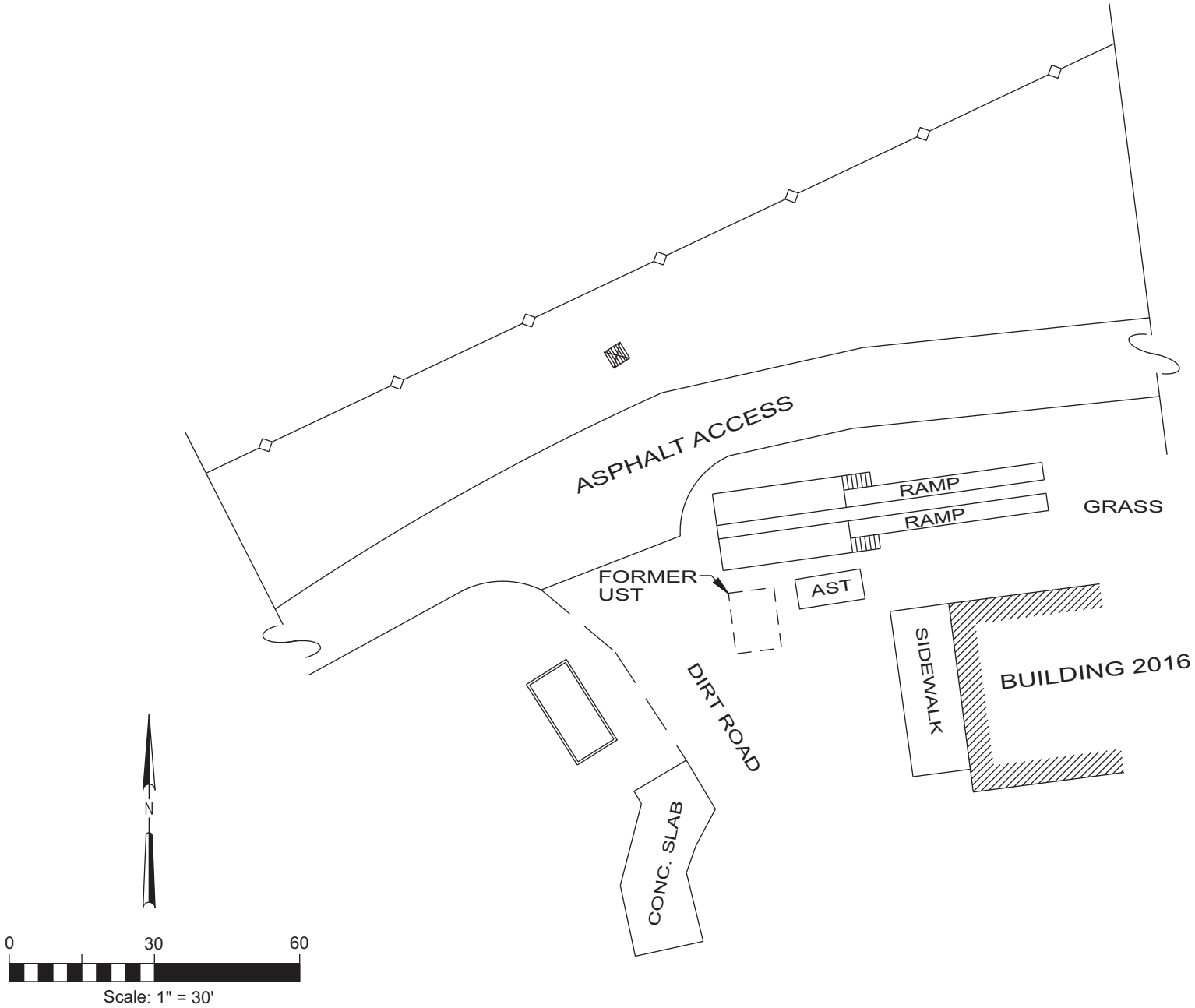


0' 500' 1000' 1500' 2000' 2500'

Figure 2-2
AOC E SITE LOCATION MAP
Former NASD, Vieques Island, Puerto Rico



Source: Site Characterization Report (CH2M HILL, April 1999)

FIGURE 2-3
AOC E Site Location Map
Former NASD, Vieques, Puerto Rico

CH2MHILL

Soils samples were collected during UST removal activities from the ends of the tank, below the tank, below the pipe trench, and from the stockpiled soil. These samples were analyzed for total recoverable petroleum hydrocarbons (TRPH) using EPA method 418.1, and for volatile organic aromatics (VOAs) (benzene, ethylbenzene, toluene, and total xylenes [BTEX]) using EPA Method 8020. The analytical results indicated detections of TRPH at concentrations ranging from 289 milligrams per kilogram (mg/kg) to 1,790 mg/kg.

Contaminated soil was removed to a distance of approximately 5 ft on all sides of the tank and to a depth of approximately 4 ft below the tank. Figure 2-4 illustrates the approximate limits of the soil removal. The UST closure report indicated that additional contaminated soil remaining in the excavation was not removed at that time. No rationale was given for that decision although it appears that the volume and limits of soil removed was likely determined based on visual observation of grossly contaminated soil encountered on the side-walls of the UST pit following its removal. It would not have been possible at that time to adequately determine the volume of impacted soil from any release that may have occurred from the UST. Laboratory results from samples collected as part of UST closure activities confirmed that additional characterization was warranted at the site to investigate vertically and horizontally impacts to both soil and groundwater from the former UST.

2.2.2 Site Characterization

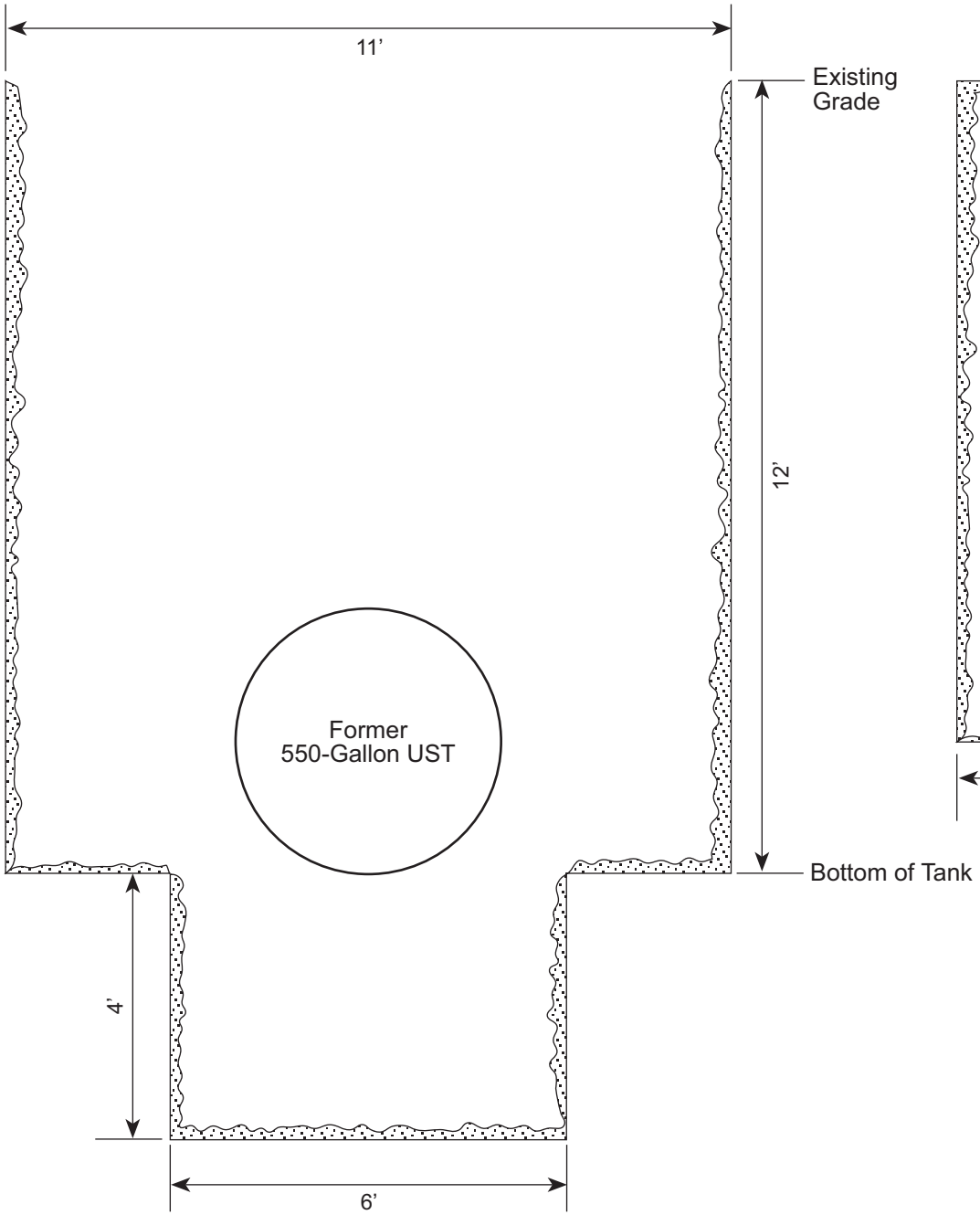
A SC was conducted in 1999 (CH2M HILL, April 1999) to assess the horizontal and vertical extent of potential soil contamination left in place after the UST removal, as well as to access potential impacts to groundwater. The SC included the installation and sampling of three monitoring wells, and the collection and analysis of soil samples collected during monitoring well installation and from two additional borings. In-situ hydraulic conductivity tests were also completed at two installed wells to evaluate aquifer characteristics and performance.

2.2.2.1 Monitoring Well Installation and Sampling Results

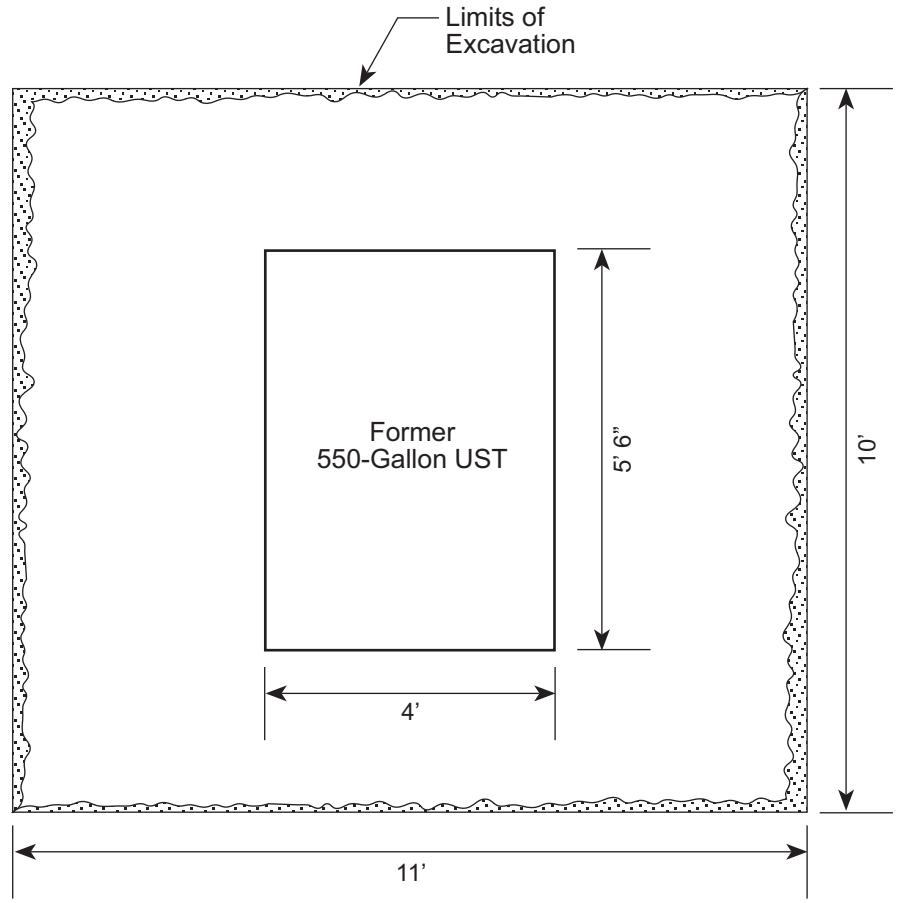
Three monitoring wells were installed as part of the SC to determine the presence and extent of potential groundwater contamination at the site. The wells (AOC E, MW-1, MW-2, and MW-3) were installed to a depth of 50 to 53 ft below land surface (bls). The wells were constructed so that the well screen straddled the groundwater table encountered at approximately 42 ft bls, to allow for evaluation of the presence of floating free product. Figure 2-5 shows the locations of the monitoring wells installed as part of the SC at AOC E.

The wells were checked for the presence of free product, and groundwater samples were collected for analysis of TRPH; total petroleum hydrocarbons (TPH) gasoline range organics (GRO); TPH diesel range organics (DRO); TPH-Oil; volatile organic compounds (VOCs) including BTEX; and polynuclear aromatic hydrocarbons (PAHs).

Free product was not detected in any of the three monitoring wells in August, 1998. The analytical results indicated concentration of benzene in monitoring well MW-1 at 17 micrograms per liter (µg/L), which exceeds the PREQB target level of 5 µg/L for that compound. BTEX was noted at a concentration of 42 µg/L in MW-1. TRPH, TPH-GRO, TPH-DRO, TPH-Oil, and PAHs were not detected at concentrations above the laboratory method detection limits (MDL) in MW-1. No exceedances of the MDLs for the analyzed parameters were detected in MW-2 and MW-3. Figure 2-5 presents analytical results.



PROFILE VIEW



PLAN VIEW

FIGURE 2-4
Limits of Excavation During Removal of Former 550-Gallon UST
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

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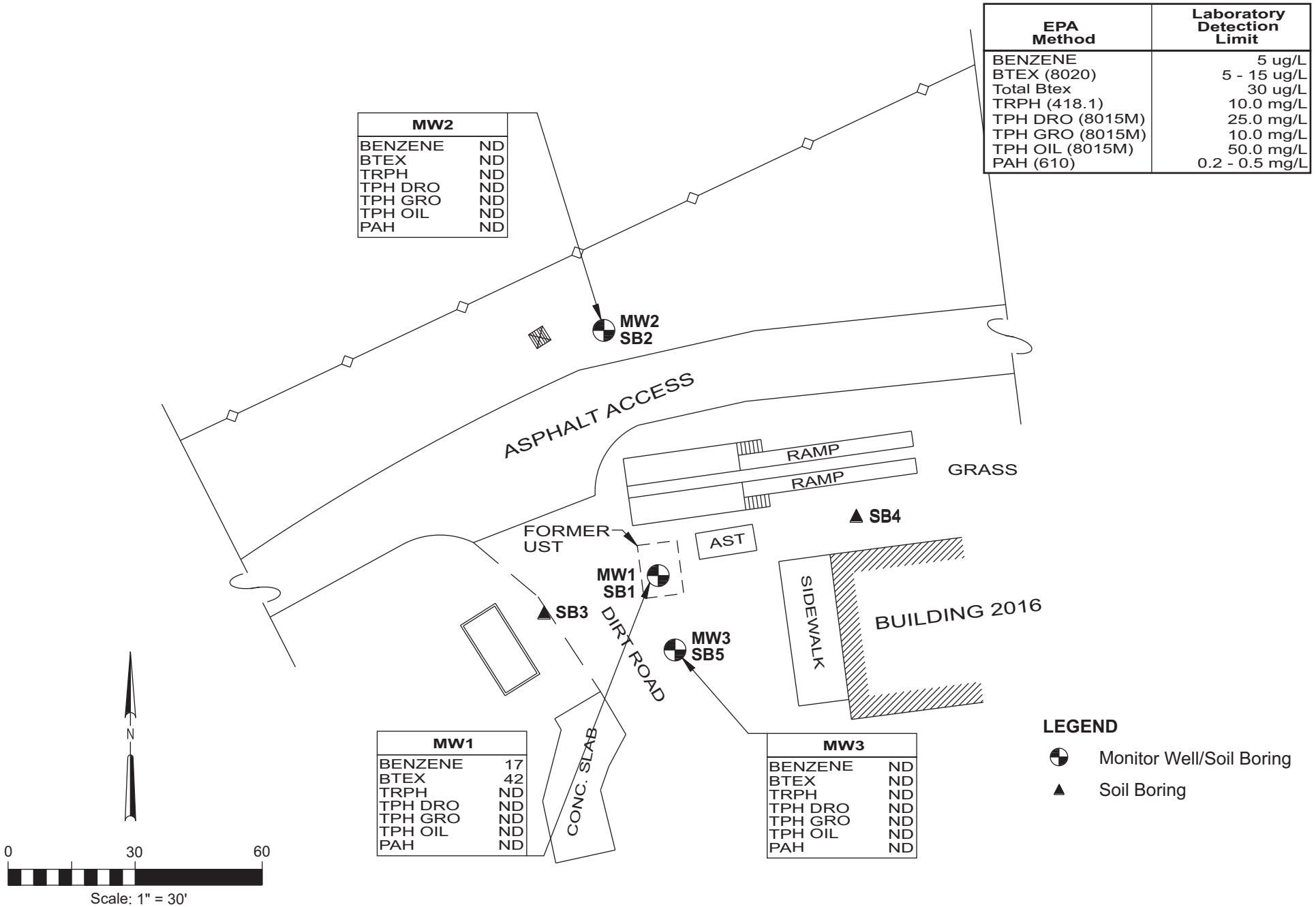
EPA Method	Laboratory Detection Limit
BENZENE	5 ug/L
BTEX (8020)	5 - 15 ug/L
Total Btex	30 ug/L
TRPH (418.1)	10.0 mg/L
TPH DRO (8015M)	25.0 mg/L
TPH GRO (8015M)	10.0 mg/L
TPH OIL (8015M)	50.0 mg/L
PAH (610)	0.2 - 0.5 mg/L



Source: Site Characterization Report (CH2M HILL, April 1999)

FIGURE 2-5

Site Characterization Groundwater - BTEX, TRPH and PAH Analytical Results

AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

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2.2.2.2 Soil Sampling and Analysis

Soil samples were collected at 2-ft intervals below the depth of the tank excavation during the installation of the three monitoring wells. In addition, soil samples were collected at 2-ft intervals at two additional boring locations. The soil samples were collected using stainless steel split-barrel samplers. These sample locations are designated as SB-1 through SB-5 on Figure 2-6.

The soil samples were screened in the field using an organic vapor analyzer (OVA) to obtain qualitative data regarding potential VOCs present in the soil. The OVA results indicated that only samples collected at SB-1 in the area of the former UST exhibited elevated OVA readings. Elevated readings refer to those readings that exceed 100 mg/kg parts per million (ppm). Elevated OVA readings were noted at depths from 12 to 47 ft bls from this boring. The 12-ft depth represents the approximate depth of soil excavation during the UST removal. Soil samples collected from soil borings SB-2 through SB-5 did not exhibit significant detections of VOCs. Headspace values from the SC effort at AOC E can be reviewed in Table 2-2, page 2-3 of the SC Report for Site No. 2016 (CH2M HILL, April 199).

In addition to field screening, soil samples were collected for laboratory analysis at the 4 to 6 ft bls interval and 45 to 47 ft bls interval from each boring, except at soil borings SB-3 and SB-4, where samples were collected only from the 4 to 6 ft interval. At the time of the site characterization efforts PREQB regulations associated with the UST program called for sample collection from the 4 to 6 ft interval and from the interval just above the water table. This rationale was used in selecting samples for laboratory analysis during the site characterization phase at the site. Deep soil samples were not collected at borings SB-3 and SB-4 because the water table was not encountered at that depth.

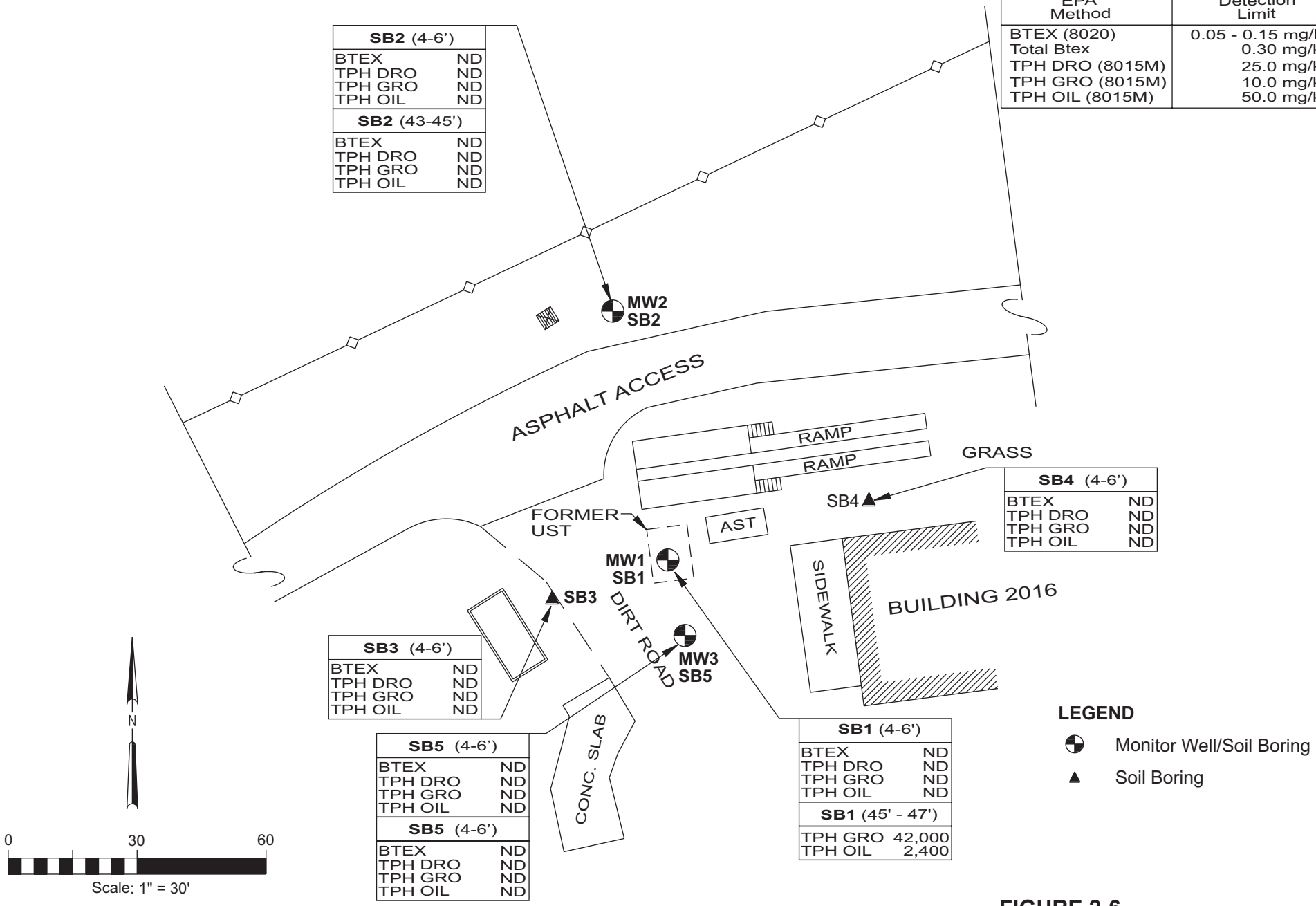
Laboratory analytical data indicated that TPH-GRO was detected at a concentration of 42,000 mg/kg in the soil sample from the 45 to 47 ft interval in soil boring SB-1. This soil boring and sample are located in the source area, adjacent to the former UST. The value of 42,000 mg/kg exceeds the PREQB target level of 100 mg/kg for this constituent. Figure 2-6 provides the analytical results.

2.2.2.3 Groundwater Flow Conditions

Monitoring well top-of-casing elevation and depth-to-water measurements also were collected to determine the groundwater flow direction across AOC E. The groundwater flow direction is to the north based on that data. Two in-situ permeability tests were also performed to determine the hydraulic conductivity of the surficial aquifer at the site. The permeability tests completed as part of the SC in 1999 were conducted at monitoring wells MW-2 and MW-3. Results of the permeability tests revealed that the soils beneath AOC E have a low hydraulic conductivity that ranges from 0.6 ft per day [ft/day] to 2.2 ft/day. The corresponding horizontal velocity was calculated as 0.0364 ft/day or 13.28 ft/year. Two additional permeability tests are proposed under the RI/FS program and will supplement the existing data previously collected at MW-2 and MW-3.

Groundwater flow direction and hydraulic permeability values will be further evaluated during implementation of the RI/FS at the site and will be used to develop groundwater flow maps that will be presented in the RI report.

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



Source: Site Characterization Report (CH2M HILL, April 1999)

FIGURE 2-6

Site Characterization Soil - BTEX and TPH Analytical Results - August 1998

AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

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2.2.3 Expanded PA/SI

In April and May 2000, CH2M HILL completed the PA/SI at AOC E to further define the extent of petroleum impacts to groundwater at the site. The investigations included installation and sampling of three new monitoring wells (AOC E-MW-4, MW-5, and MW-6) to supplement the existing monitoring well network at the site. Figure 2-7 presents the locations of the additional monitoring wells.

The PA/SI monitoring wells and the three existing monitoring wells were checked for the presence of free product, and samples were collected for VOCs, semi-volatile organic compounds (SVOCs), dissolved and total metals, pesticides, and polychlorinated biphenyls (PCBs). TPH and PAHs were eliminated from the groundwater target analyte list during the PA/SI effort in 2000 because these compounds were not identified above laboratory method detection limits from groundwater samples collected during the SC effort in 1999. Figure 2-5 (presently previously) of this Work Plan illustrates this graphically.

Approximately 2 inches of free product was present in monitoring well MW-1. Free product was not detected in the remaining monitoring wells, indicating that the extent of the free product is located within a 10-ft radius of MW-1. Analytical results indicated detection of benzene, 2-methylnaphthalene, bis(2-ethylhexyl) phthalate, naphthalene, and 1,2-dichloroethene at concentrations exceeding their respective maximum contaminant level (MCLs) and/or risk based concentrations (RBCs) in monitoring well AOC E-MW-5, located immediately down-gradient of the MW-1. Phthalate is a common laboratory artifact and not a petroleum plume compound. 1,2-dichloroethene is also not a compound of a petroleum plume, but is a degradation product of degreasers.

The extent of the dissolved petroleum plume appears to be localized, and is delineated by down-gradient monitoring wells AOC E-MW 2, AOC E-MW 4, AOC E-MW 5, and AOC E-MW6 either with no detections of petroleum constituents, or with detection's of petroleum constituents (benzene and 2-methylnaphthalene) at concentrations below applicable drinking water standards. Data from the proposed RI/FS will be used to develop a petroleum plume map for the site. In addition to the petroleum-related contaminants detected in groundwater, several metals also were detected above regulatory screening criteria. These detected metals will be evaluated against the background values derived for the site. Figure 2-7 presents the constituent detections in groundwater that exceeded regulatory criteria. Constituent concentrations presented in Figure 2-7 are in mg/L (ppm).

Results of the PA/SI confirmed that a release of petroleum hydrocarbons to groundwater occurred at the site, probably a result of releases to the subsurface associated with the former 550-gallon waste oil UST. The PA/SI recommended additional site investigations through a full RI/FS process to fully evaluate the extent of the petroleum hydrocarbons present in soil and groundwater at the site, as well as to evaluate remedial alternatives.

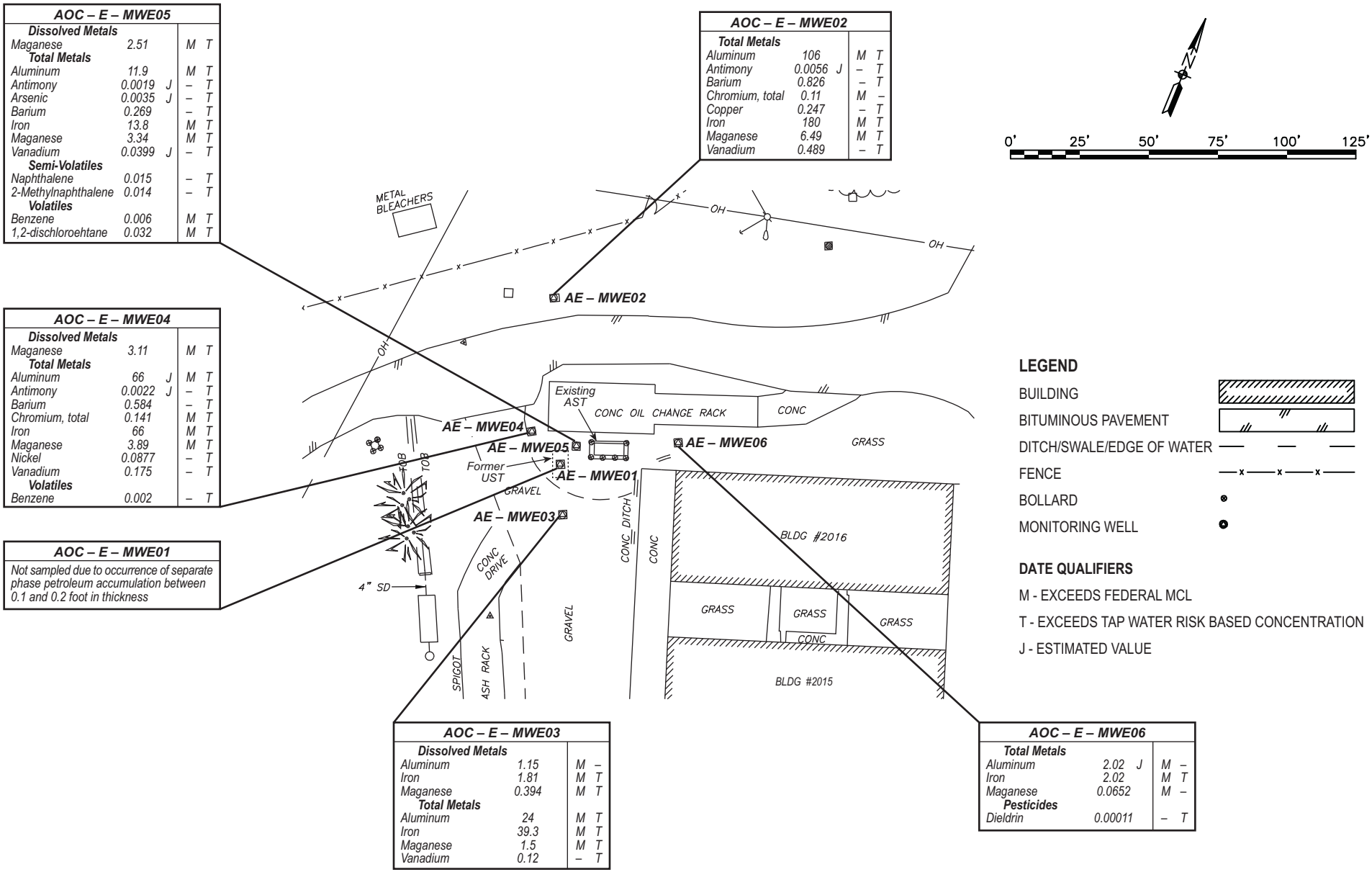

FIGURE 2-7

AOC-E Preliminary Assessment/Site Investigation
Groundwater Detections Above Screening Criteria – April-May 2000
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

Source: Preliminary Assessement/Site Investigation Report (CH2M HILL, October 2000)

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2.3 Regional and Site-Specific Geology

2.3.1 Regional Geology

The geology of Vieques is characterized by volcanic rocks generally overlain by alluvial deposits and limestone in certain areas of the island. Volcanic andesites of Late Cretaceous age were deposited in a marine environment. A quartz-diorite plutonic complex intruded the andesites, and is exposed over a large percentage of the island. A gradual change in texture from coarse to fine-grained quartz-diorite has been observed from west to east. Limestone of Tertiary age occurs in sectors of the north, south, and eastern parts of the island. The most extensive areas of limestone are found on the south coast peninsulas. The limestone is generally soft and yellowish and well indurated where exposed to the atmosphere. The sedimentary deposits are generally of Quaternary age, consisting of a mixture of sand, silt, and clay. The sediments consist of alluvial deposits, beach and dune deposits, and swamp and marsh deposits. The floodplains consist of beach and dune deposits formed by calcite, quartz, volcanic rock fragments and minor magnetite (U.S. Geological Survey [USGS], 1989). Refer to the Master Work Plan for the Former NASD (CH2M HILL, January 2001) for a detailed description of the geology of the area.

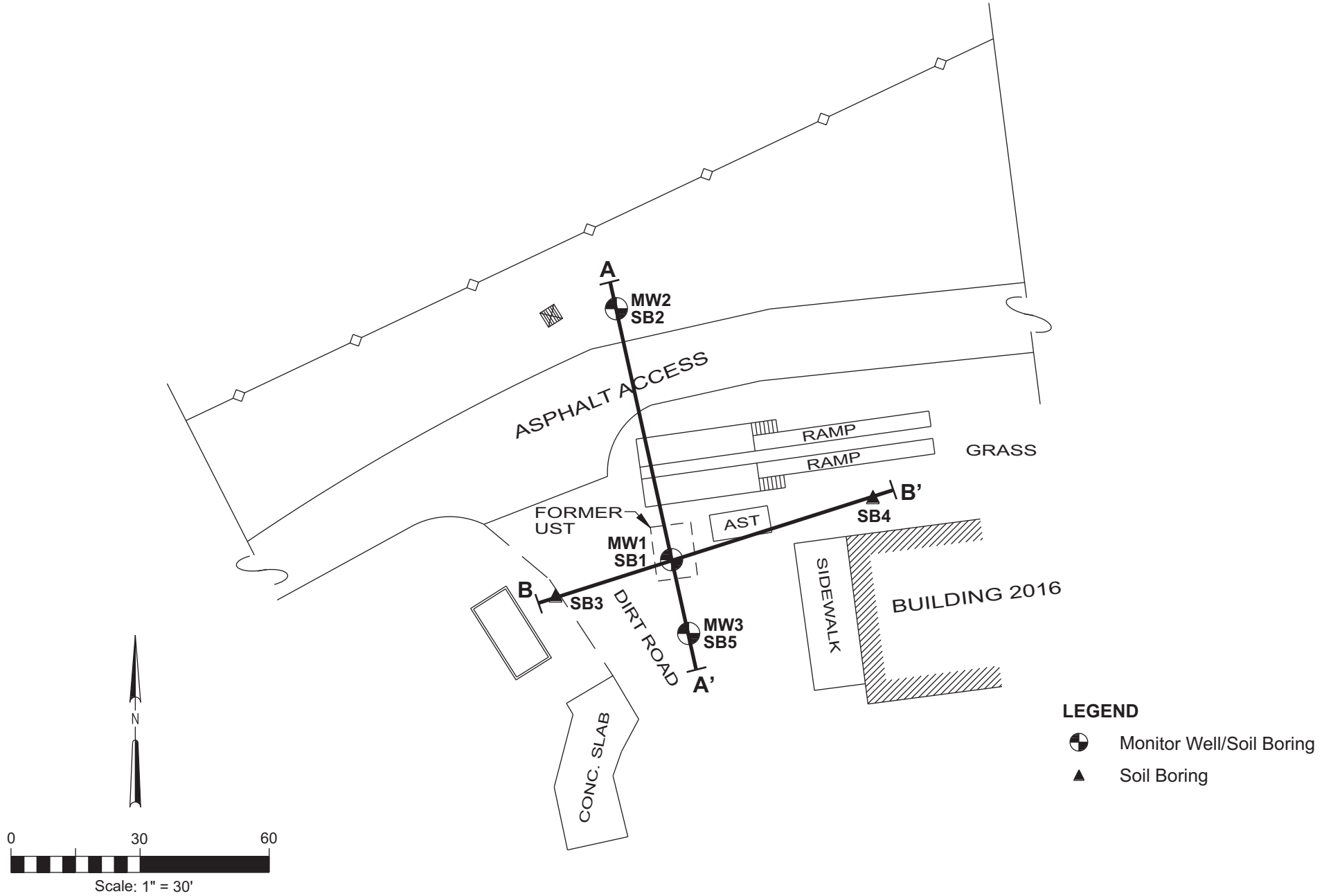
2.3.2 Site-Specific Geology

The soil samples collected during the installations of soil borings and monitoring wells associated with the SC Report (CH2M HILL, April 1999) and PA/SI (CH2M HILL, October 2000) were used to describe the site geology.

AOC E lies near rolling topography (approximately 45 ft above msl) underlain by the weathered volcanic rock. Beneath AOC E, 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. These sediments generally possess high plasticity when moist, are very hard when dry, and are not easily crumbled under hand pressure. Figures 2-8, 2-9, and 2-10 present cross sections of the site geology based on soil boring logs.

2.4 Hydrogeology

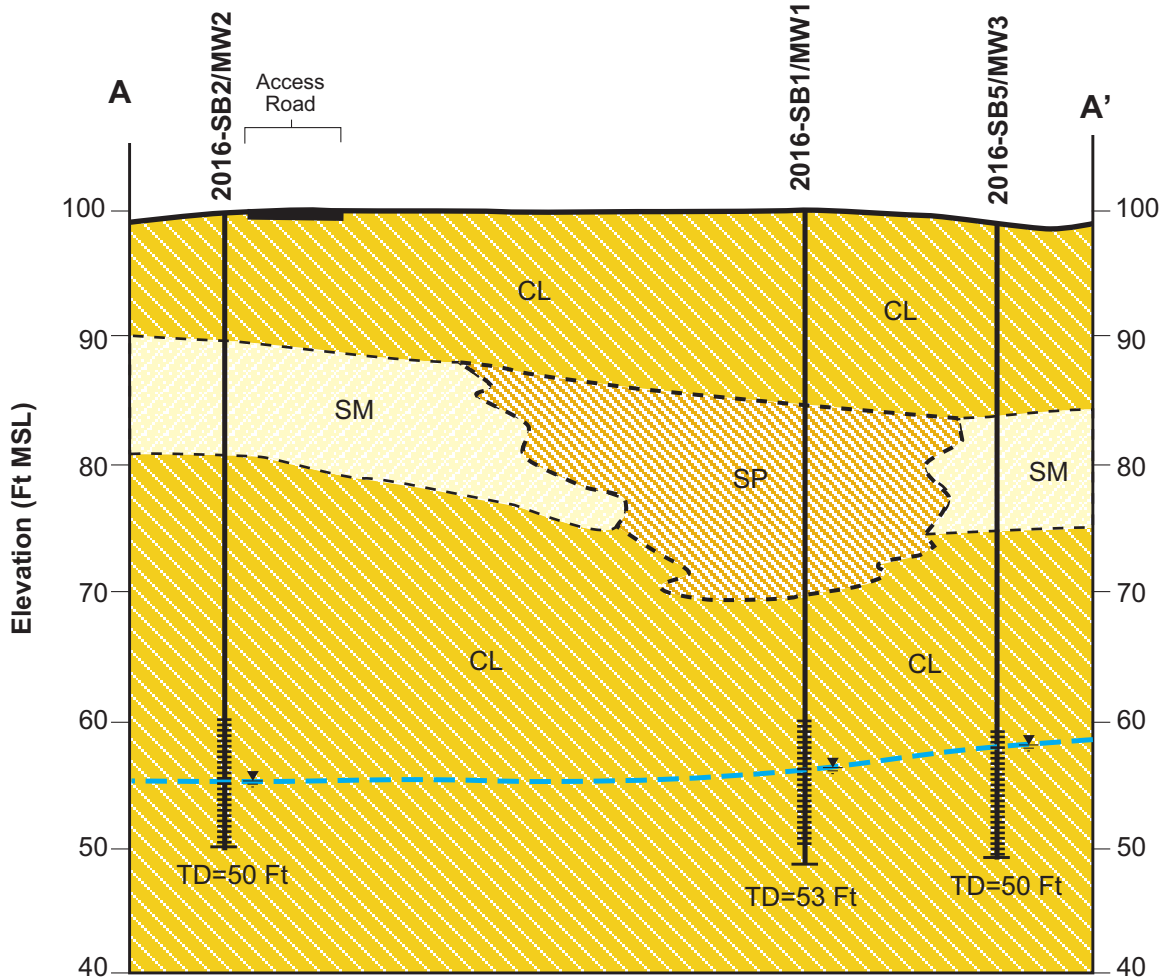
AOC E is underlain by a potentially semi-confined surficial aquifer system, which is composed of plastic clays. Groundwater was encountered at the site at depths of 50 ft bls during monitoring well installation procedures; however, the water levels eventually stabilized at depths of approximately 41 to 42 ft bls. The depth to groundwater of 50 feet below grade (fbg) initially observed during well advancement procedures refers to the depths to groundwater immediately following auger/casing advancements towards the terminal depth. Groundwater levels are typically gauged inside the augers/casing and allowed to sit for a period of time [times differ based on geology] to allow the groundwater to stabilize to natural levels in the formation. It is not unusual, especially in this sandy clay geology, for groundwater to "stabilize" at levels significantly different than what was first observed and noted during advancement efforts. The aquifer at the site is considered to be

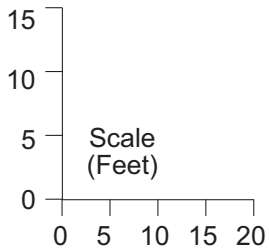


Source: Site Characterization Report (CH2M HILL, April 1999)

FIGURE 2-8
Location of Geologic Cross Sections
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL





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 2-9
Geologic Cross-Section A-A'
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL

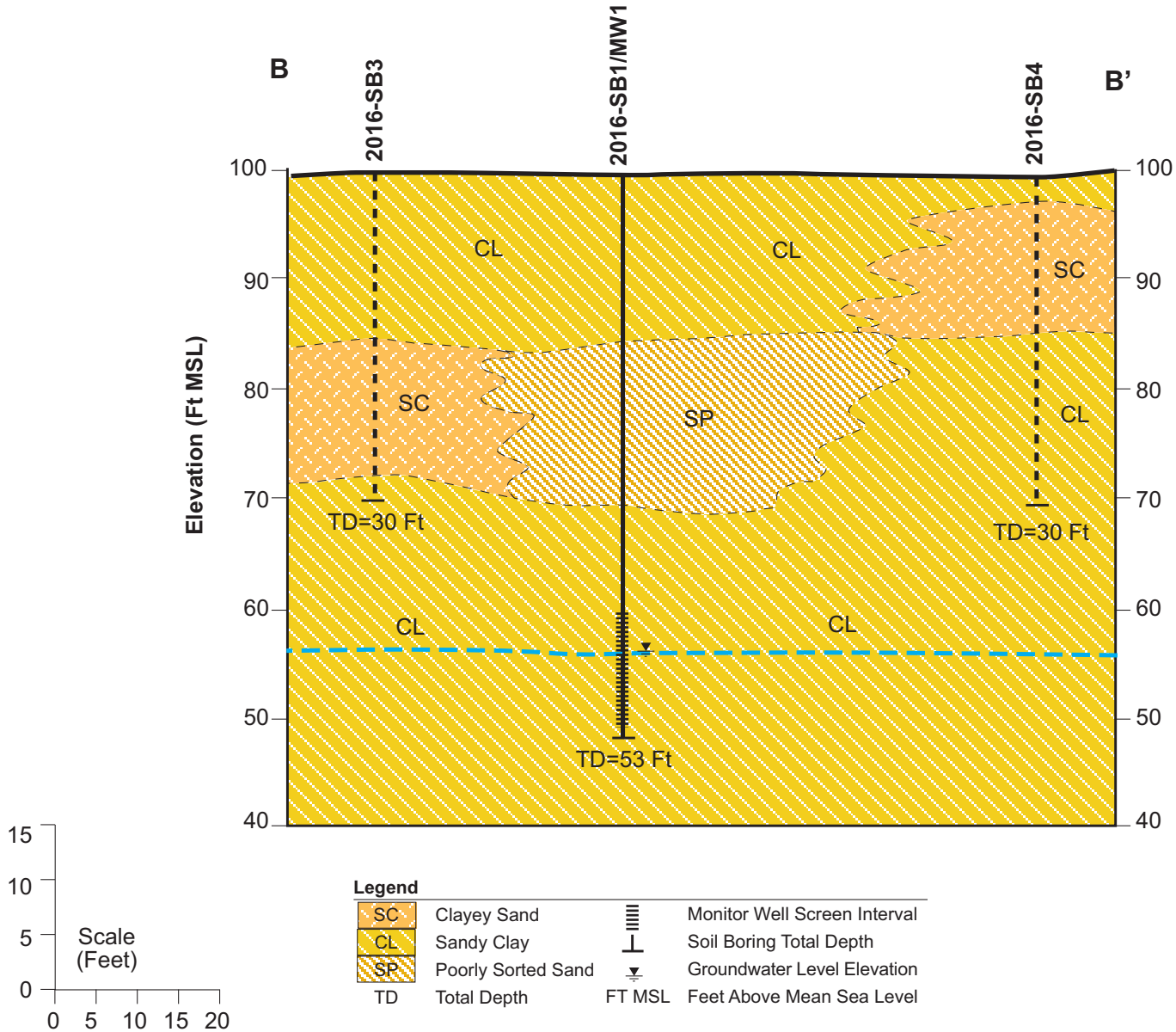


FIGURE 2-10
Geologic Cross-Section B-B'
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL

semi-confined and groundwater levels in a semi-confined aquifer are typically higher in a cased well than what is first encountered in the formation. The monitoring wells are screened from 40-50 fbg and straddle the initially observed water level and the final stabilized level

Groundwater flow at AOC E is controlled by elevation differences between adjacent hills and the gently sloping topography. Groundwater flow at the site is in a northern direction away from the former UST toward the Atlantic Ocean (Figure 11-2, CH2M HILL, October, 2000). 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. Based on the in-situ hydraulic conductivity results of the SC, the subsurface material exhibits a relatively low hydraulic conductivity of 1.4 ft/day and a low groundwater velocity of 13.18 ft/year. Features in the clays, such as cracks or thin sand lenses, can contribute to higher hydraulic conductivity in the areas where in-situ permeability tests were performed.

SECTION 3

Initial Evaluation and Data Quality Objectives

An understanding of the dynamics between the site conditions, contaminants present at the site, and potential receptors is essential to scoping the RI/FS work tasks. Based on the extensive investigation work previously conducted at the site, a conceptual site model (CSM) has been prepared. Based on the CSM, preliminary RAOs were developed. The RAOs were developed as part of this RI/FS Work Plan to assist in identifying preliminary remedial action alternatives and RI data requirements.

This section discusses the CSM and preliminary RAOs for the site. This section is not meant to replace the baseline HHRA to be conducted as part of the RI (as discussed in detail in Section 4 of this Work Plan), but will be expanded upon during preparation of the HHRA. Based on the results of the baseline HHRA, the RAOs may be modified as necessary to be protective of human health and the environment.

3.1 Applicable or Relevant and Appropriate Requirements

The screening of validated analytical results against Federal and State standards, criteria, and guidance that are determined to be applicable or relevant and appropriate requirements (ARARs) provides the rationale for recommendations of further investigation or no further action. Screening against ARARs also aids in the evaluation of risks posed by contaminants present at the site and site cleanup goals. The screening process provides a systematic method to identify target analytes present at the site that may require more detailed evaluation. The screening of analytical data obtained from the sampling events involves screening to regulatory criteria and established background concentrations. The ARARs for this investigation, by media, are as follows:

<u>Groundwater</u>

- Maximum Contaminant Level, *Drinking Water Standards and Health Advisories*, USEPA 2000
- USEPA Region IX Preliminary Remedial Goals (PRGs) - Tap Water Values, November 22, 2000
- PREQB Water Quality Criteria
- PREQB Underground Storage Tank Regulations
- NASD Groundwater Background Criteria, CH2M HILL 2001

<u>Soil</u>

- Region IX Preliminary Remedial Goals – Residential Soil Values, November 22, 2000
- Region IX Preliminary Remedial Goals – Industrial Soil Values, November 22, 2000

- Region IX Soil Screening Level, Migration to Ground Water – Dilution Attenuation Factor (DAF) 20, November 22, 2000
- Ecological Soil Water Criteria: *EPA Amended Guidance on Ecological Risk Assessments at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders*, Region IV Office of Technical Services, December 10, 1998
- NASD Background Soil Criteria, CH2M HILL 2001

3.2 Conceptual Site Model

Exposure pathways must be identified to adequately define the RAOs. Exposure pathways describe how a chemical can move from its source to a receptor. Components of an exposure pathway include a contaminant source; release mechanism; and the transport, migration, and fate of the contaminant. Figure 3-1, the CSM, presents the evaluation of the exposure pathway for AOC E.

Key assumptions in development of the CSM include:

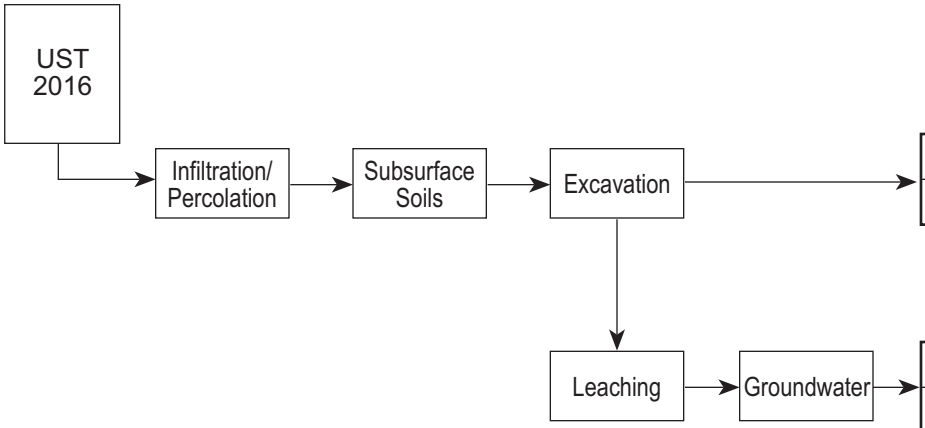
1) The former waste oil UST was the source of contamination, but the source has been removed
2) Sampling and analysis conducted as part of the SC and PA/SI that indicate that soil and groundwater are the only media affected by site contamination.

Based on the CSM developed for AOC E, no current receptors are present at the site, assuming the current non-residential land use. Potential future receptors include construction workers exposed to subsurface soil contamination during excavation activities, and potential residents and workers exposed to groundwater contaminants. The elements of the exposure assessment are presented in the following subsections.

3.2.1 Analytes Previously Detected at the Site

The results of previous investigations indicated the presence of the following analytes in groundwater at the site:

- Benzene
- 1,2-dichloroethene
- Naphthalene
- 2-methylnaphthalene
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Nickel
- Phthalate
- Potassium
- Selenium
- Sodium
- Vanadium
- Zinc



EXPOSURE ROUTE	POTENTIAL HUMAN RECEPTORS (1)				
	Current Industrial Worker	Current Adolescent Trespasser	Future Industrial Worker	Future Construction Worker	Future Adult/Child Resident
Injestion			●	●	
Dermal Contact			●	●	
Injestion	—	—	●	●	●
Inhalation	—	—	—	—	●
Dermal Contact	—	—	—	—	○

LEGEND

→ Pathway - Past, Current, and Hypothetical Future

● Principal Pathways for Quantittive Evaluation

○ Pathways for Qualitative Evaluation Only

— Incomplete Pathways

Note:
1. Potential human receptors under reasonable current and future land use scenarios.

FIGURE 3-1
Conceptual Site Model for Human Health Risk
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL

These analytes have been identified as contaminants of potential concern (COPCs) at AOC E because the concentrations exceeded regulatory screening criteria. In addition to these COPCs, free product was also present in groundwater in the vicinity of MW-1. Section 2 of this Work Plan discussed the detected concentrations and extent of these contaminants.

3.2.2 Contaminant Source

The contaminant source at the site was the former 550-gallon waste oil UST. This source was removed in 1996 as part of the UST program at NSRR. No other known sources of contaminants are present at the site.

3.2.3 Release Mechanism

The mechanism for contaminant release at the site included waste oil leaking from the UST to subsurface soils and subsequent leaching to groundwater system at the site. Although the UST was removed in 1996, it was not clearly established that all contaminated soils were removed during this effort and a potential future release mechanism of contaminants leaching from soil to groundwater exists at the site.

3.2.4 Contaminant Transport

Analytical data from the Expanded PA/SI activities indicated that groundwater was affected by site contaminants. The primary transport mechanism for contamination at the site is movement with groundwater. Additional aquifer performance testing will be conducted as part of the RI to evaluate the rate of contaminant movement in groundwater.

3.2.5 Contaminant Migration

After contaminants have entered the groundwater, several migration pathways are possible. Contamination in shallow aquifers can migrate downward to deeper aquifers, contaminating potential drinking water sources. Contamination can also migrate horizontally and may eventually reach offsite receptors.

Any additional information related to groundwater flow direction and aquifer layout/characteristics will be further evaluated during the RI/FS field program and will be reported in the RI report.

3.2.6 Exposure Pathways

The CSM (included as Figure 3-1) shows the potential exposure pathways associated with the site. The major potential exposure pathway associated with the site includes releases of contaminants to the groundwater, contaminant migration through the groundwater, and exposure through the use of the groundwater as a potential drinking water source.

3.3 Preliminary Remedial Action Objectives and Goals

The preliminary RAOs and goals were developed to assist in identifying preliminary remedial action alternatives and RI data requirements. The preliminary RAOs are based on the existing data for the site and the CSM.

As part of the development of the RAOs, the Federal MCLs were evaluated against contaminants present in the groundwater. Because the concentrations of some contaminants detected in groundwater at the site exceeded the MCLs, the RAOs for the site include prevention of ingestion of contaminated groundwater exceeding MCLs, and prevention of migration to surface waters.

Subsurface soil contamination remained within the former UST area following UST removal efforts, and may present a potential future groundwater source since contamination may leach from the soil to groundwater. In addition, workers may be exposed to contamination during excavation activities. The extent of soil contamination will be further evaluated during the RI, and may require remediation.

SECTION 4

RI Technical Approach and Investigation Procedures

This section details the technical approach and investigation methodologies developed to perform additional investigatory activities for the RI for AOC E. This work plan provides the rationale and proposed locations of additional field investigations. Details regarding field sampling procedures and health and safety requirements are addressed in the facility-wide Master Work Plan for the Former NASD (CH2M HILL, January 2001).

4.1 Data Quality Objectives

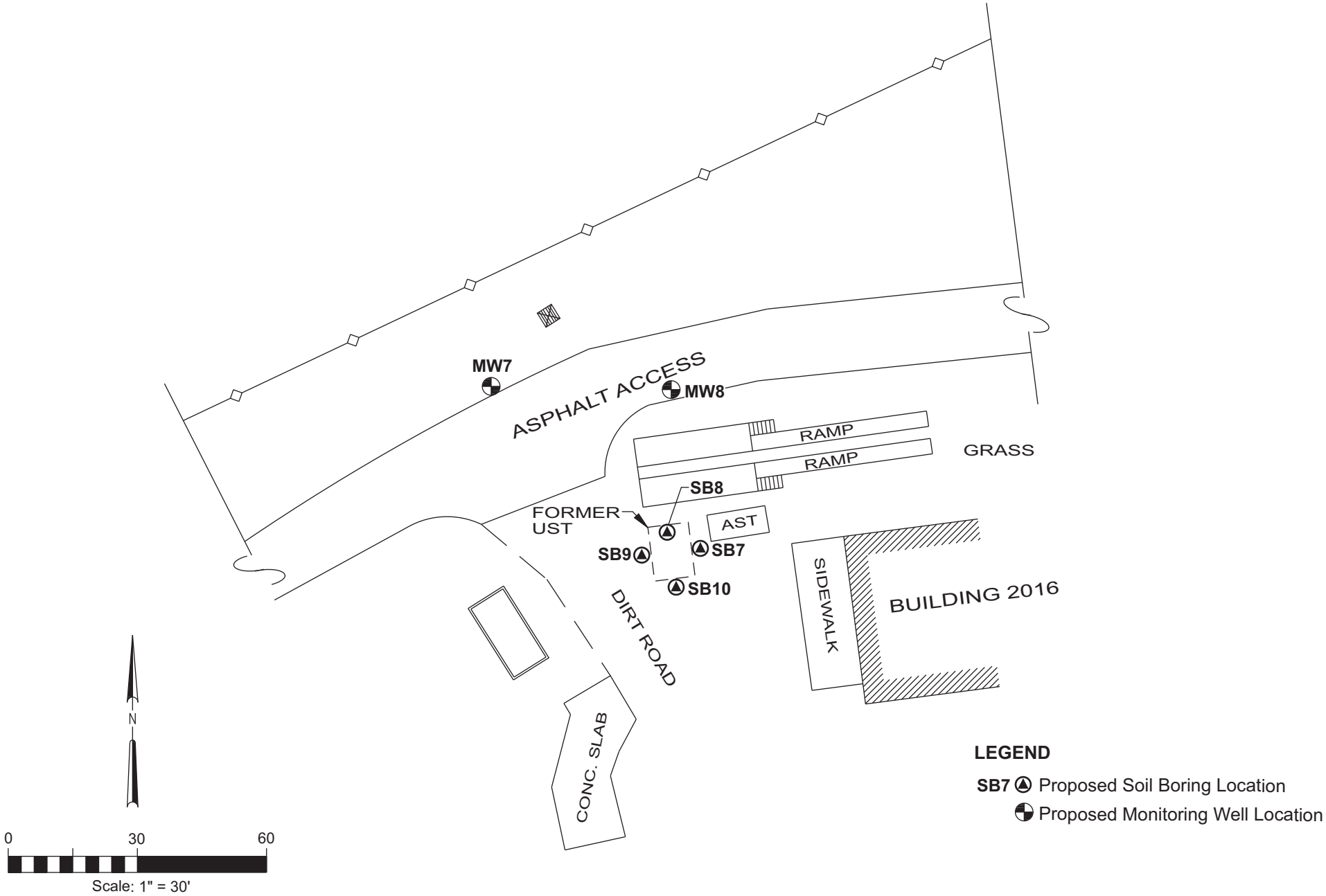
Previously collected data and any new data collected as part of the RI will be used for site characterization, risk assessment, and remedial action alternative evaluations. These DQOs require a high level of quality assurance/quality control (QA/QC). Appropriate QA/QC samples were collected during previous investigations at AOC E, and the samples were analyzed at a fixed base laboratory that fulfilled the requirements of the U.S. Navy's QA/QC Program Manual and the USEPA's Contract Laboratory Program (CLP) and SW846 methods. Therefore, previously collected data will be used as part of the decision making process. Samples proposed as part of this RI will be collected and analyzed in a similar fashion so that the data meets the high level DQOs.

4.2 Field Investigation

This section describes the field activities to be conducted for the RI at AOC E. The RI component of the program consists of the installation and sampling of an additional monitoring well to determine the downgradient extent of groundwater contamination, collection of groundwater samples from the existing monitoring wells to obtain current data for decision making, and collection and analysis of soil samples to further define the extent of soil contamination. Figure 4-1 presents the proposed sampling locations. These tasks are described in the following subsections.

4.2.1 Monitoring Well Installation

One monitoring well will be added to the network of six monitoring wells that currently exist at the site. This well is scheduled to be installed approximately 60 feet to the north-northwest of MW-1 (source area) to evaluate groundwater quality in that area. This monitoring well, designated as MW-07, will be installed to a depth of approximately 50 ft bls and will be constructed using 10 ft of 0.01-inch slot polyvinyl chloride (PVC) well screen coupled with 40 ft of 2-inch-diameter Schedule 40 PVC casing using flush joint threads. The proposed location for this monitoring well is illustrated in Figure 4-1.



Source: Site Characterization Report (CH2M HILL, April 1999)

FIGURE 4-1

Proposed RI/FS Soil Boring Locations and Monitoring Well Location Map

AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL

The well borehole will be advanced with post-hole diggers to a depth of at least 4 ft bls to provide clearance of underground utilities, then drilled with hollow-stem augers or air hammer techniques to the appropriate depth. Continuous soil samples will be collected during installation from 12 to 50 ft bls to supplement the lithologic descriptions obtained during installation of MW-1. These samples will be described in the field in accordance with the Unified Soils Classification System (USCS). Specifically, sample descriptions included soil type, USCS symbols, predominant and secondary grain sizes with relative proportions (Modified Wentworth Scale), color (Munsell Color System), and lithologic boundaries. In addition, the samples will be screened with an organic vapor meter (OVM) and the associated readings will be recorded in the boring logs.

4.2.2 Groundwater Sampling and Analysis

The newly installed monitoring well and five of the six existing monitoring wells will be sampled for VOCs, SVOCs, and metals to further evaluated these constituents detected during previous sampling events, as well as to provide a baseline for the pilot study. Monitoring well MW-1 will not be sampled during this event due to the presence of free phase product accumulation. Groundwater sampling will be conducted in accordance with the techniques described in the Master Work Plans. In general, the wells will be purged and sampled using low-flow sampling techniques to minimize turbidity of the samples. Table 4-1 presents the numbers of groundwater samples to be collected as part of this evaluation, including QA/QC samples. Section 2 of the Master Field Sampling Plan for the former NASD (CH2M HILL, January 2001) presents details regarding the required containers, preservatives, and holding times for groundwater and soil samples.

TABLE 4-1
Groundwater Sample Parameters, Methods, and Quantities for AOC E
Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples	Equipment Rinseate Blanks	Field Blanks	Field Duplicates	Matrix Spike/ Duplicate	Total Number of Samples
TCL VOCs	SW-846 Method 8260B	6	1	1	1	1	10
TCL SVOCs	SW-846 Method 8270C	6	1	1	1	1	10
TAL Metals and Cyanide	SW-846 Methods 6010B and 7000 series	6	1	1	1	1	10

Notes:
Trip blanks – one per cooler containing VOC samples
Equipment Rinseate blanks – one per matrix per day; blank for filtered samples is a filtration blank
Field Blanks – one per matrix per day
Field Duplicates – one per every ten samples per matrix/medium
Matrix Spike/Matrix Spike Duplicates – One per 20 samples per matrix

As previously discussed, TPH and PAHs have been eliminated from the analyte list based on historical data from the sampling and analysis program during the SC effort in 1999 for those compounds. Similarly, pesticides and PCBs have now been eliminated from the analyte list for groundwater since those compound were not identified above screening criteria during the PA/SI sampling and analysis program and are not considered compounds of concern at the site.

4.2.3 Soil Sampling and Analysis

Additional subsurface soil samples are proposed to define the horizontal and vertical extent of soil contamination in the source area. Initially, four soil borings are proposed to determine whether contaminated soil remains at the edge of the area excavated during the UST removal. A fifth soil boring with soil samples for laboratory analysis will be completed at the location of the proposed monitoring well MW-07. A sixth and final boring with soil sampling for laboratory analysis will be completed to the north-northeast of monitoring well MW-5 which has exhibited a petroleum sheen in past sampling events. This boring, which may be potentially converted to a permanent monitoring well is being included in the field program to further evaluate any free or dissolved phases of constituents in that area hydraulically down-gradient from the source area.

The total number of soil samples to be collected for analyses will depend on the field screening results, however, a minimum of two samples from each boring will be collected for analysis and up to four samples from each boring may be analyzed by the laboratory depending on conditions encountered in the field. Additional borings may be required, if sampling results indicate that contamination above PREQB criteria (100 ppm TPH) is present in one or more of these boring locations. Additional borings will be conducted by placing borings at increasing distances from the contaminated boring until the extent of soil contamination has been defined. Figure 4-1 (presented previously) shows the proposed soil boring locations.

All soil samples collected for OVM screening will be subsequently placed in containers with teflon lined lids and placed on ice until samples for laboratory submittal are selected based on OVM data. Soil samples for VOC analysis will be collected with encore samplers and placed on ice until sample intervals for laboratory analysis are determined. Once all intervals for laboratory analysis are selected, the samples will be transferred to the appropriate containers, logged in, placed on ice, and prepared for subsequent shipment to the laboratory.

It is anticipated that samples will be collected continuously from a depth of 12 ft bls to approximately 50 ft bls for OVM screening and selection for laboratory analysis of at least two of those samples. The soil borings will be advanced utilizing a truck-mounted drill rig, and subsurface soil samples will be collected with 2-inch stainless steel split-barrel spoons or from air-hammer cuttings after the desired depth has been reached. The applicable Standard Operating Procedures (SOP) for the collection of soil samples is presented Attachment 2, Section 4.4.1 of the Master Work Plan for The Former NASD (CH2M HILL, January 2001).

4.2.3.1 OVM Soil Screening

The soil samples will be screened for petroleum contamination using an OVM with a photo-ionization detector using the headspace method to help determine the extent of contamination in the field. The analysis will include half filling a 16-ounce mason jar with the soil sample and covering the opening of the mason jar with foil. The headspace in the jar will then be sampled with the OVM after the sample has been allowed to sit for a minimum of 5 minutes. The OVM measures the concentration of organic vapors in the jar, providing a relative indication of the degree of petroleum contamination in the soil sample. In addition to OVM screening, each sample will be inspected for hydrocarbon staining and petroleum odor.

4.2.3.2 Laboratory Analysis

For each boring, the soil sample with the highest OVM reading and the deepest sample will be submitted to a fixed base laboratory for VOCs, TPH-GRO, TPH-DRO, and Oil & Grease. Table 4-2 provides a listing of soil sample parameters and methods and also includes the number of soil samples to be collected as part of this evaluation, including QA/QC samples. Details regarding the required containers, preservatives, and holding times for groundwater and soil samples are presented in Section 2 of the Master Field Sampling Plan for the Former NASD (CH2M HILL, January 2001).

TABLE 4-2
Soil Sample Parameters, Methods, and Quantities for AOC E
Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples	Equipment Rinseate Blanks	Field Blanks	Field Duplicates	Matrix Spike/ Duplicate	Total Number of Samples
BTEX	8021	10-20	1	1	1-2	1	14-25
TPH (DRO)	8015M	10-20	1	1	1-2	1	14-25
TPH (GRO)	8015M	10-20	1	1	1-2	1	14-25
Oil & Grease	9071	10-20	1	1	1-2	1	14-25

Notes:
Trip blanks – one per cooler containing VOC samples
Equipment Rinseate blanks – one per matrix per day; blank for filtered samples is a filtration blank
Field Blanks – one per matrix per day
Field Duplicates – one per every ten samples per matrix/medium
Matrix Spike/Matrix Spike Duplicates – One per 20 samples per matrix

4.2.4 Water Level Elevations

Water level measurements will be collected from the monitoring wells installed as part of the AOC E investigation (as well as from nearby monitoring wells installed as part of investigations not associated with AOC E) to provide a broader perspective of groundwater flow than could be achieved by using only the onsite wells. The water levels will be obtained by measuring the depth to water from a marked location on the top of casing which has been surveyed to the nearest 0.01 ft msl.

4.2.5 Aquifer Hydraulic Conductivity Testing

In-situ hydraulic conductivity tests will be performed on selected monitoring wells (AOC E-MW 5 and AOC E-MW 7) using the slug test method to obtain estimates of the aquifer hydraulic conductivity in the shallow and deep intervals at the site. The test will involve installing a pressure transducer in the well. The transducer is connected to a data logger programmed to measure water level during the tests. After the initial water level is measured, a 1-inch diameter by 5-ft long PVC slug will be lowered into the well. The rise and decline of the water level in the well will be observed until the approximate original water level elevation is achieved. The slug will then be quickly removed from the well, causing the water to drop rapidly. The data logger will measure and record the recovery of the water level in the well until the water level has reached the approximate pre-test groundwater elevation. The data will be analyzed using the methods described by Bouwer and Rice (1976) to determine the hydraulic conductivity of the aquifer.

4.3 Sampling Equipment Decontamination

All non-disposable sampling equipment will be decontaminated immediately after each use. The applicable SOPs for the decontamination of personnel and equipment are presented in Attachment 2, Section 10.1.1 of the Master Work Plan, and are included with the FSP checklist.

4.4 Sample Designation

Sampling locations and sampled media collected during the background investigation will be assigned unique designations to allow the sampling information and analytical data to be entered into a Geographic Information System (GIS) data management system to be developed for The Former NASD. The following sections describe the sample designation specifications.

4.4.1 Specification for Field Location Data

Field station data consist of information assigned to a physical location in the field where a sample is collected. For example, a soil boring that has been installed will require a name that will uniquely identify it with respect to other soil boring locations, or other types of sampling locations. The station name provides for a key in the database to which any samples collected from that location can be linked to form a relational database.

A listing of the location identification numbers will be maintained by the field team leader, who will be responsible for enforcing the use of the standardized numbering system during all field activities. Each station will be designated by an alphanumeric code that will identify the station location by facility, site type, site number, location type, and sequential location number. The scheme that will be used to identify field station data is documented in Section 3 of the Master Field Sampling Plan for The Former NASD, and summarized in Table 4-3.

TABLE 4-3
Field Station Identification Scheme

First Segment	Second Segment	
Facility, Station Type, Site Number	**Station Type**	**Station Number, Qualifier**
AAANNN	**AA**	**NNNA**
Facility: ND = Former NASD Station Type: S = Site O = Operable Unit U = UST A = AOC BG = Background Site Number: AOC E	Station Type: SB = Subsurface Soil Sample Location SD = Sediment Sample Location SS = Surface Soil Sample Location SW = Surface Water Sample Location GW = Groundwater Sample Location Station Number: Sequential Station Number Qualifier: S = Shallow D = Deep	

Notes:
"A" = alphabetic
"N" = numeric

4.4.2 Specifications for Analytical Data

Analytical data will be generated through sampling of soil and groundwater at AOC E. Each analytical sample collected will be assigned a unique sample identifier. The scheme used as a guide for labeling analytical samples in the field is documented below. The format that will be used for electronic deliverables from the analytical laboratory and the data validator is documented below.

4.4.2.1 Sample Identification Scheme

A standardized numbering system will be used to identify all samples collected during groundwater and soil sampling activities at AOC E. The numbering system will provide a tracking procedure to ensure accurate data retrieval of all samples taken. A listing of the sample identification numbers will be maintained by the field team leader, who will be responsible for enforcing the use of the standardized numbering system during all sampling activities. Sample identification for all samples collected during the investigations will use the following format.

Each sample will be designated by an alphanumeric code that will identify the facility, site, matrix sampled, and a sequential sample number. QA/QC samples will have a unique sample designation. Table 4-4 documents the general guide for sample identification. If one qualifier is pertinent to the sample ID but another is not, only the Table 4-3 applicable qualifiers will be used. A non-utilized character space does not have to be maintained.

TABLE 4-4
Sample Designation Scheme
Former NASD, Vieques, Puerto Rico

First Segment	Second Segment		Third Segment
Facility, Station, and Site Number	**Sample Type**	**Sample Location + Sample Qualifier**	**Additional Qualifiers (sample depth, sampling round, etc.)**
AAANN	**AA**	**NNNA or NNAA**	**ANN or NNNN**
Facility:	Sample Type:		Additional Qualifiers:
ND = NASD	DS = Direct Push – Soil		1. Monitoring Well Groundwater Sample (refers to sampling round for that well):
Station Type:	DW = Direct Push – Water		
S = Site	SD = Sediment		
W = SWMU	SS = Surface Soil		
O = Operable Unit	TB = Trip Blank		R01 - Round 1
U = UST	EB = Equipment Blank		R02 - Round 2
A = AOC	FB = Field Blank		R03 - Round 3
BK = Background	FD = Field Duplicate		2. Direct Push Subsurface Sample (refers to depth of sample):
Site Number:	Sample Location:		
AOC E	1. Station Samples (NNA)		
	NNA - refers to sequential station number		Enter depth of top of sample interval
	NN**A** - letter qualifier for Deep, Shallow, or Composite, sample (if applicable).		3. QC Samples
	2. QC Samples (NNN)		NNNN - refers to day and year of sampling event
	NNN - numbered sequentially for each type of blank (i.e., 1, 2, etc.) collected for that day's sampling		
	N**NN** - refers to month of sampling event		
	Sample Qualifiers:		
	F = filtered sample		
	P = duplicate sample		

Notes:
"A" = alphabetic
"N" = numeric

4.4.2.2 Electronic Deliverable File Format

An offsite laboratory will analyze the samples collected for the RI and will tabulate the results in an electronic format specified by CH2M HILL. The data validator will add data validation qualifiers to the table of analytical results. In addition to hard copy data package deliverable, CH2M HILL will receive an electronic file from the data validator in a tabular format that will facilitate downloading into a database. Table 4-5 shows the format that will be used for electronic deliverables.

TABLE 4-5
Analytical Data Electronic Deliverable
Former NASD, Vieques, Puerto Rico

Analytical data must be delivered in a format compatible with Microsoft Access 2.0 or 7.0		
Field Name	**Field Type**	**Description**
Sample_ID	A20	The CH2M HILL sample ID (taken from the Chain of Custody).
Sample_Analysis	A5	The analysis performed on the sample. We classify our samples into six main groups: VOA, SVOA, INORG, PEST, WCHEM, and FMETAL (for filtered samples).
Date_Analyzed	D	The date the sample was analyzed.
Date_Received	D	The date the sample was received in the lab.
Date_Collected	D	The date the sample was collected.
Lab_Sample_ID	A15	The lab sample ID.
Dilution_Factor	N	The dilution factor used, if applicable.
SDG_Number	A6	The SDG number.
CAS_Number	A6-A2-A1	CAS Number of the compound being analyzed (Note that the CAS number must consist of three number segments of defined length, separated by dashes).
Chem_Name	A50	The compound being analyzed.
Ana_Value	N	The analytical result.
Std_Qual	A5	The lab qualifiers, if any (e.g., U, UJ, B).
DV_Qual	A5	The data validation qualifier (e.g., J, R).
Units	A10	The unit of the result (e.g., MG/L).
Detect_Limit	N	The detection limit for the compound.
Method	A15	Analytical method used to analyze the sample fraction.

4.5 Sample Analysis and Validation

This task involves efforts related to the sample management and data validation. CH2M HILL will be responsible for tracking sample analysis and obtaining results from the laboratory. The analytical data generated during the AOC E RI field program will be validated by an independent data validation subcontractor according to the USEPA's *Laboratory Data Validation Functional Guidelines for Evaluation Organic Analyses* (USEPA, 1994).

4.5.1 Sample analysis

All analyses of soil, sediment, and groundwater will be conducted at a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and USEPA's CLP and SW 846 (for methods not covered by CLP). The laboratory must follow the scope of work prepared by the project team. A signed certificate of analysis will be provided with each laboratory data package, along with a certificate of compliance certifying that all work was performed in accordance with the CLP scope of work (SOW). All analyses will be performed following the highest level of Navy guidance. Analyses will include the proper ratio of field QC samples recommended by Navy guidance for the DQOs.

This task includes checking the data from the laboratory and converting it into an electronic format that can be readily incorporated into the GIS data management system for The Former NASD.

4.5.2 Field Quality Control Procedures

QC duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process. The QAPP provides details with regard to the number and frequency of field QC samples to be collected during the investigation.

4.5.3 Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample.

American Society for Testing and Materials (ASTM) Type II water will be used for blanks. Four types of blanks can be generated during sampling activities: trip blanks, field blanks, equipment rinseate blanks, and temperature blanks.

VOCs are expected to be detected as part of the pilot program scheduled as part of the RI for AOC E. One trip blank will be included in each cooler used for the daily shipment of VOC samples. If more than one cooler is being sent on a given day, all of the VOC samples should be placed in one cooler, if possible, to minimize the number of trip blanks needed. The trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and returned unopened for analysis. Trip blanks will indicate if there is contamination during shipment to the field, from storage in the field, or from shipment from the field to the analytical laboratory.

One field blank will be collected per sampling event. If sampling events extend beyond 1 week (5 working days) or for windy and dusty field conditions, the number of field blanks should be increased. Field blanks are used to determine the chemical quality of water used for such procedures as decontamination and blank collection.

One equipment blank per sample medium will be obtained for each day of sampling. Equipment blanks will give an indication of the efficiency of decontamination procedures.

USEPA has recently requested that a temperature blank be included in each cooler containing samples for CLP analyses so that the laboratory can record the temperature

without disturbing the samples. The temperature blank will be labeled, but will not be given a sample number nor will it be listed as a sample on the chain-of-custody (COC) form.

4.5.4 Duplicates

Field duplicate samples will be collected at a frequency of one field duplicate per 10 field samples per matrix. The locations from which the duplicates are taken will be selected randomly. Each duplicate sample will be split evenly into two sample containers and submitted for analysis as two independent samples.

4.5.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

MS/MSD samples will be collected at a frequency of one MS/MSD for every 20 field samples collected. Analytical results of these samples indicate the impact of the matrix (water, soil, sediment) on extracting the analyte for analysis. MS/MSD samples give an indication of the laboratory's analytical accuracy and precision within the sample matrix. Data validators will use these results to evaluate the accuracy of the analytical data.

4.6 Data Validation

Analytical results will be validated by CH2M HILL subcontractors approved by the Navy. Data validators will use USEPA's Region II guidance (*Functional Guidelines*).

The hard copy data packages will be reviewed by the subcontractor chemists using the process outlined in USEPA's *Data Validation Functional Guidelines for Evaluating Organic Analyses* (USEPA, 1994). Areas of review included (when applicable to the method) holding time compliance, calibration verification, blank results, matrix spike precision and accuracy, method accuracy as demonstrated by laboratory confirmation samples (LCSs), field duplicate results, surrogate recoveries, internal standard performance, and interference checks. A data review worksheet will be completed for each data package and any non-conformance will be documented. This data review and validation process is independent of the laboratory's checks and focuses on the usability of the data to support the project data interpretation and decision-making processes.

Data that are not within the acceptance limits will be appended with a qualifying flag, which consists of a single or double-letter abbreviation that reflects a problem with the data. The following flags will be used in the evaluation:

- **U -** Undetected. Analyte was analyzed for but not detected above the MDL.
- **UJ -** Detection limit estimated. Analyte was analyzed for, and qualified as not detected. The result is estimated.
- **J -** Estimated. The analyte was present, but the reported value may not be accurate or precise.
- **R -** Rejected. The data are unusable. (NOTE: Analyte/compound may or may not be present.)

Numerical sample results that are greater than the MDL but less than the laboratory reporting limit (RL) are qualified with a "J" for estimated as required by USEPA's *Functional Guidelines* (USEPA, 1994).

4.7 Data Quality Evaluation

Analytical data will be collected during this investigation in the form of laboratory analytical results and the database will be populated with data validation qualifier results.

The data quality evaluation (DQE) is the quantitative and qualitative evaluation of overall trends in the project-specific database. The objective of the DQE process is to understand the effects of the overall analytical process on data usability to support project-specific DQOs. The DQE includes an analysis of the effect of the specific sample matrix on the overall analytical process.

The DQE deliverable is a DQE Technical Memorandum (TM) that can be used by the project team to readily understand project-specific data usability. Topics to be addressed in the DQE TM include the following:

- *Potential blank contamination*—the effect on the usability of data for compounds detected in both the field or laboratory blank samples and the corresponding field samples
- *Laboratory performance*—evaluation of the recovery for blank spike samples such as the LCS, calibration criteria, etc.
- *Potential matrix interferences*—evaluation of the accuracy and precision for surrogates, spiked field samples, and duplicate field sample results
- *Assessment of Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCCs)*—comparison of data validation (DV) findings with PARCCs (precision, accuracy, representativeness, comparability, and completeness)

This task also includes the evaluation of validated laboratory data and field-generated data. The data evaluation will include incorporation of historical data from the previous investigations, tabulation of the data, and generation of figures and/or tables associated with data (e.g., sampling location maps).

SECTION 5

Human Health Risk Assessment

An HHRA will be conducted for AOC E in accordance with the USEPA Risk Assessment Guidance for Superfund (RAGS). The results of the HHRA will be incorporated into the RI Report. An ecological risk assessment is not planned at AOC E since results of a qualitative ecological survey completed for the PA/SI conducted at the site indicated that the site is very small (less than ½ acre) and offers a very limited habitat for wildlife species, occasional birds may frequent this area but to a very limited extent. In addition, the site is located within a paved and gravel maintenance compound that is not conducive to attracting wildlife. Based on this, the need to complete a more detailed quantitative ecological survey does not appear to be warranted.

5.1 Objective of the HHRA

The objective of the HHRA at AOC E is to evaluate potential human health risks (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases (i.e., under an assumption of no action). The HHRA contributes to the site characterization and subsequent development, evaluation, and selection of appropriate response alternatives. The results of the HHRA will be used to:

Assess if additional remedial response action is necessary at the site

Determine if preliminary remediation goals need to be modified

Evaluate the magnitude of risk at the site, and identify the primary causes of that risk

In general, the objective of the HHRA at AOC E will be attained by identifying and characterizing the following:

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, groundwater, and soil)
- Environmental fate and transport mechanisms within specific environmental media such as physical, chemical, and biological degradation processes and hydrogeologic conditions
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat, and the likelihood of such impact or threat occurring
- Level(s) of uncertainty associated with the above items

5.2 Components of the HHRA

The following components of the risk assessment process, as discussed in RAGS, will be conducted as part of the HHRA for AOC E:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization

Sufficient information to adequately and accurately support these components of the risk assessment will be collected as part of the RI process. Use of the CSM, discussed in Subsection 3.11, will help focus the HHRA process.

SECTION 6

Identification of Remedial Action Alternatives

The RAO and goals have been developed for AOC E to assist in identifying remedial action alternatives. The RAO for AOC E is as follows:

- Provide adequate protection to human health and the environment from direct contact, ingestion, or inhalation of the hazardous constituents in soil and groundwater beneath the site.

Institutional controls (ICs) were put in place on the site which restrict construction activities that require excavation, and restrict the groundwater at the site from use as a future drinking water source. These deed restrictions (Site Management Plan, CH2M HILL, July 2001) ICs adequately protect human health and the environment from direct contact, ingestion, and inhalation of the contaminants present at the site, but the ICs limit future uses of the site until the site is remediated. Therefore, the goals of the remedial action alternative that will be developed during the detailed analysis stage include:

- Implementation of a site remediation approach that will reduce the free product or non-aqueous phase liquid (NAPL) contaminant mass and residual soil contamination present at the site
- Restoration of groundwater to beneficial uses within a reasonable timeframe, given the particular circumstances of the site
- Consideration of innovative technologies when such technologies offer potential for superior treatment performance or lower costs for performance similar to that of presumptive remedies.

6.1 Development and Evaluation of Alternatives

Remedial alternatives will be developed for soil and groundwater cleanup at the site within the FS, based on the RAO and goals. Each alternative will be evaluated against the nine criteria outlined in CERCLA which include:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State/support agency acceptance
- Community acceptance

Several presumptive remedial technologies and/or alternatives are unlikely to pass the screening process in the FS for technical and implementation reasons due to the existing site conditions (the presence of free product, depth to water being greater than 45 ft bls, the tight clayey formation at the site, and low water yield). For example, the aquifer at the site may not produce sufficient groundwater quantities or a sufficient radius of influence for conventional "pump and treat" technologies to work effectively.

Innovative technologies such as MPE, however, have proven successful in cleanup of sites with similar contaminants and site characteristics. Pilot testing of this innovative technology is proposed, as discussed in the following subsections. The MPE pilot test will be implemented as an Interim Remedial Action (IRA) to remove the free product layer as required by PREQB.

6.2 Pilot Study

Pilot-scale testing is intended to provide quantitative performance, cost, and design information for remediating a site. Pilot studies should be evaluated as early as possible in the RI/FS process because pilot tests may take several months or longer to complete. If a lengthy study is required and is not initiated early, completion of the FS may be delayed.

The MPE has been selected for pilot testing because the technology has effectively recovered free product, petroleum-contaminated groundwater, and soil vapors at rates that exceed the capability of other available technologies. In addition (and unlike conventional pump and treat technologies), MPE is expected to provide beneficial removal of contaminants present in the smear zone resulting from water table fluctuations.

The MPE system is equipped with a vacuum pump that aggressively draws the contaminated groundwater and free product to the recovery well by creating a low pressure point. The resultant rate of free product and dissolved contamination recovery is increased substantially above the rates possible using a gravity feed submersible or pneumatic pump system. In addition, an MPE system can be configured to create a groundwater mound at the extraction point or to create a controlled cone of depression by using a drop tube placed within the recovery well.

The pilot study will consist of one MPE recovery well (MW-1) to conduct groundwater and soil vapor extraction, off-gas treatment, and groundwater treatment using a low-profile air stripping (LPAS) unit and activated carbon.

6.2.1 MPE Design

The pilot MPE system will consists of trailer-mounted MPE system equipped the following:

- 15 horsepower (hp) liquid ring vacuum pump capable of 160 cubic feet per minute (cfm) at 20 inches of mercury (Hg)
- 150-gallon liquid/gas separator knockout tank
- 50-gallon product recovery tank
- Two 30-gallon per minute (gpm) transfer pumps
- 1-inch totalizing flow meter
- 300-gallon groundwater holding tank

- 300-gallon product holding tank
- 150-gallon seal water tank
- 50 gpm shallow tray air stripping unit equipped with a 1500-cfm blower
- Thermal catalytic oxidizer

Figure 6-1 presents a schematic of the MPE system.

6.2.2 MPE Operation

6.2.2.1 Groundwater Recovery and Treatment

Free product recovery will be accomplished primarily by direct extraction and volatilization. The rate of liquid phase free product recovery will be highest during the initial weeks of operation when free product or NAPL will be physically extracted from the vicinity of the recovery well. Subsequently, the rate of liquid phase free product recovery will drop off once a steady-state condition is reached. The residual NAPL recovery following steady-state condition will be accomplished primarily by volatilization.

The free product mass present at the site will be estimated during the RI process. Based on the estimated mass of free product present and on observed free product removal rates, an estimated time for cleanup of the NAPL will be calculated.

Total fluid recovery will be comprised of free product, groundwater, and vapor. As a result, free product and groundwater will be emulsified with entrained air. An oil/water separator will be used to separate the free product prior to groundwater treatment. Recovered free product will be transferred to a product holding tank for storage prior to offsite disposal. The groundwater will be treated using an LPAS, as discussed below, and transferred to a treated groundwater storage tank for storage prior to testing and proper disposal.

If laboratory results indicate that VOCs are less than PREQB Water Quality Standards for groundwater (Appendix A), the water will be discharged on the ground at Site AOC E. If the PREQB Water Quality Standards are exceeded, the groundwater will be treated using the LPAS again. If the PREQB Water Quality Standards are met, the water will be discharged on the ground.

If the PREQB Water Quality Standards are exceeded the second time, the groundwater will be disposed of at an industrial WWTP, according to TCLP criteria for VOCs.

6.2.2.2 Low Profile Air Stripper Operation

The contaminated groundwater separated from the oil/water separator will be treated using an LPAS. The LPAS operates by forcing air through perforated baffled trays filled with recovered groundwater, which cascades downward in a counter-current manner. The residence time of the contaminated groundwater in each tray provides extensive air-to-water contact, thus driving the dissolved volatile and semi-volatile contaminants from the water into the air stream. This unit process consists of the following features:

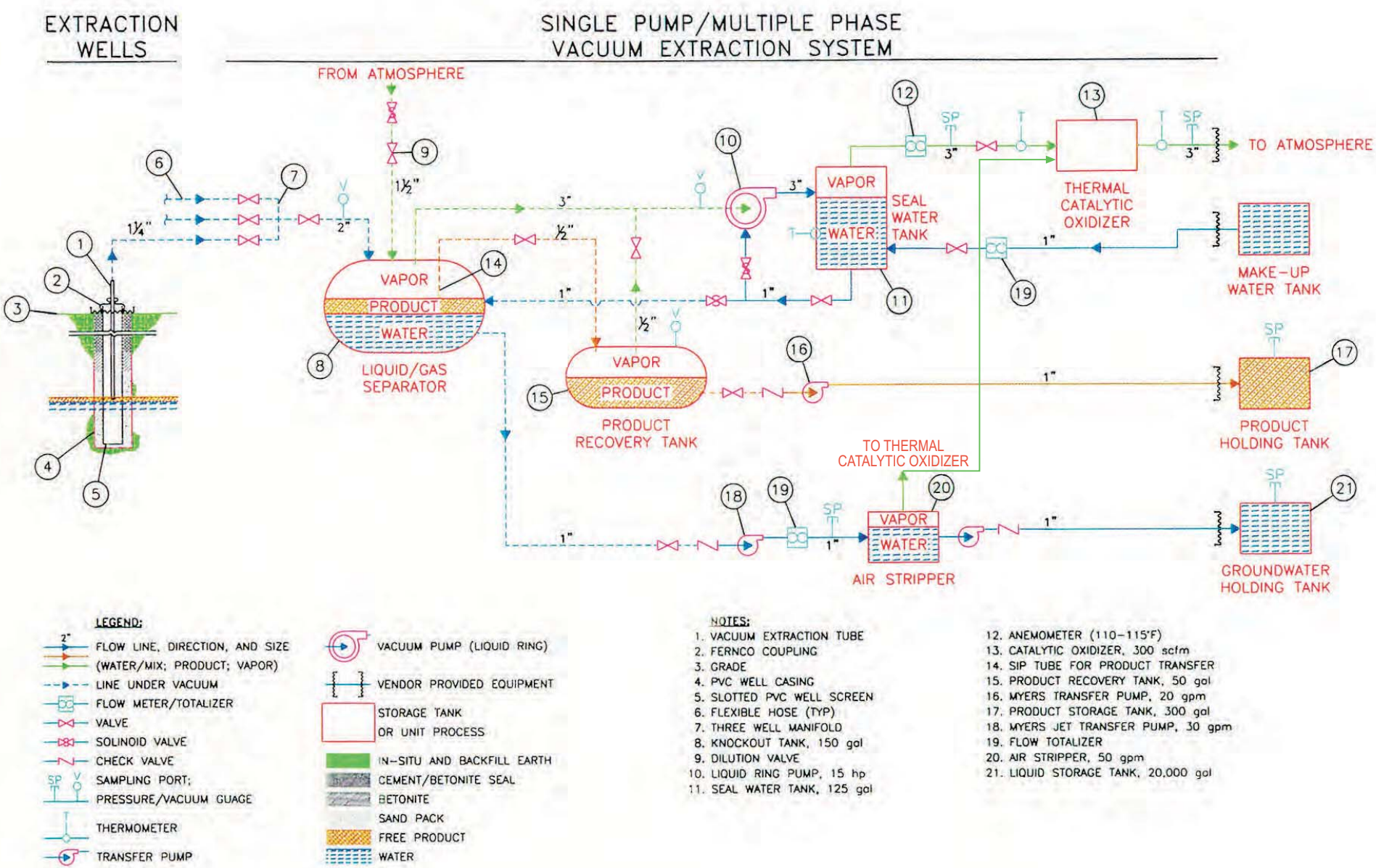


FIGURE 6-1
Multi Phase Extraction System
AOC E (UST Site 2016), Former NASD, Vieques, Puerto Rico

CH2MHILL

- An air stripping unit consisting of a sump and perforated baffled aeration trays providing an enhanced area of mass transfer between liquid and gas phase streams
- A blower, attached at the base of the tray aeration unit, to provide a counter-current air stream with the liquid phase influent
- An automatic shutoff air flow switch fitted into the air stripper that will serve to disable the MPE recovery system in case of blower failure or reduced air flow to the tray aerator
- A centrifugal pump used to discharge the groundwater from the LPAS. The LPAS sump will be equipped with a high and low water level sensor to control the discharge pump
- An air pressure gauge for monitoring of fouling effects and air flow rate observations
- A high water level sensor in the air stripper sump that will deactivate the recovery system should a high-level alarm condition be reached

6.2.2.3 Vadose Zone Vapor Recovery

The soil matrix contaminant partitioning typically consists of immicible contaminant liquids partitioning to aqueous and vapor phases, aqueous to the vapor phase, and sorption to the soils. Airflow through the soil matrix induces volatilization. Gas/liquid equilibrium forces the contaminant liquid phase into a gas phase for subsequent removal by the air flow stream. In addition, the soluble sorption phase contaminants partition to the liquid phase for subsequent removal by the induced airflow, thus removing contaminant mass from the vadose zone or smear zone and reducing the residual NAPL. Therefore, vadose zone vapor recovery will occur during the MPE operation.

The vapor flow rate estimates and radius of influence will be determined based on the results of the pilot study. The vacuum blower size may be modified during the design of the full-scale system to allow several recovery wells to be placed online to achieve the required radius of influence of soil vapor extraction (SVE).

6.2.2.4 Air Emission

Air emissions from the MPE system will be treated using a thermal catalytic oxidizer. The thermal catalytic oxidizer burns VOCs to form carbon dioxide and water vapor.

6.2.3 MPE System Controls

The MPE remediation system will be equipped with an air/liquid separator, liquid ring vacuum pump, LPAS, product recovery tank, water seal tank, and a product-holding tank. A vacuum relief valve to protect the pump will be installed on the inlet to the blower per manufacturer recommendations.

The system control panel will provide interlocking controls for the liquid ring vacuum pump, air stripper sump high water level alarm sensor, air stripper low pressure blower switch, air/liquid separator high level alarm, liquid ring water seal tank low level, product recovery tank high level alarm, and product tank high level alarm. If any of the high-level alarm sensors are activated, operation of the liquid ring vacuum pump will be shut down. The system can only be started manually after the problem has been identified and corrected. Pump system sensors and controls are summarized below.

The vapor flow rate, free product recovery rate and groundwater flow rate from each MPE recovery well will be controlled by a gate valve position at each MPE recovery well. Air entrainment from the MPE recovery wells will be monitored by a clear PVC sight tube. In addition, pressure gauges will be positioned at each wellhead.

The recovered product includes free product, groundwater, and soil vapors. Conventional flow meters are unable to measure two-phase flows for individual recovery wells. The total system groundwater flow will be measured with a flow meter on the LPAS discharge line.

The air/liquid separator tank will be equipped with various sensors. The air/liquid separator tank transfer pump will be controlled by a float-type high-pump on and low-pump off sensor. In addition, the air/liquid separator tanks will be equipped with a float sensor capable of detecting the presence of free product and activating a solenoid valve to remove accumulated free product.

The product recovery tank will be equipped with a high level alarm (system shut down), and a high level pump-on and low level pump-off switch. The high level pump will activate the product transfer pump to transfer free product from the product recovery tank to the product holding tank. The product holding tank will be equipped with a high level full indication and a high-level alarm switch.

A water seal tank will be equipped with high and low liquid level sensor to automatically fill the tank from an onsite potable water source.

Vacuum and temperature gauges will be installed at the inlet of the air/water separator tank and liquid ring vacuum pump. A pressure and temperature gauge will be installed at the liquid ring vacuum pump outlet. The gauges will be used to monitor the liquid ring pump performance.

The groundwater recovery rates from MPE wells can vary from one location to another onsite. Each MPE well will be equipped with a throttling valve to regulate the amount of airflow and total fluid recovery as necessary. The control valve will be installed on each MPE well to provide operational flexibility. This feature will allow areas of high levels of free product and groundwater contaminants to be isolated for more intensive remediation, and to alternate airflow paths across the saturation and smear zone. Vacuum gauges will be installed upstream of the air/water flow valves to monitor the vacuum induced at each MPE recovery well.

6.2.4 Set-up and Trial Run

Set-up will include equipment and personnel mobilization to the site, installation and set-up of the mobile treatment system, and installation of vacuum monitoring points. Upon completion of the system set-up, a trial run will be performed to verify the effluent water quality. This must be performed prior to full-scale operation because of the presence of free product, to verify effluent quality so that treated groundwater can be properly disposed. The samples will be analyzed for BTEX, TPH-DRO, TPH-GRO, and TPH-Oil after start-up, at the middle of the test, and prior to shutdown.

Source well AOC E-MW-1 will be used at the extraction well. Existing monitoring wells AOC E-MW-2 through AOC E-MW-6 will be used as vacuum monitoring points. The

existing monitoring wells are located at intervals of approximately 10, 15, 20, 40, and 60 ft from the extraction well. The monitoring points will be connected to water-filled manometers and magnehelic gauges to monitor the induced vacuum.

Liquid levels and free product thickness will be recorded at all monitoring wells prior to start-up. A drop tube will then be inserted into the extraction well (AOC E-MW-1). The multi-phase mobile system will be activated and the effluent will be discharged into the groundwater holding tank. The trial will be run until the groundwater holding tank reaches its maximum capacity. The free product tank liquid levels will be monitored continuously during the trial run.

6.2.5 Full-Scale Pilot Testing

Liquid levels and free product thickness will be recorded at all monitoring wells prior to start-up. The pilot test will be performed at incremental extraction wellhead vacuum settings (minimum of three) to determine the optimum extraction vacuum required to cost effectively design the full-scale system. Each vacuum setting will be run until the induced vacuum and groundwater level stabilize. Once stabilization is reached, the vacuum will be increased to the next vacuum setting.

During the pilot test, groundwater influent and effluent samples will be collected and submitted for laboratory analysis for BTEX, TPH-DRO, TPH-GRO, and TPH-Oil. An influent sample will be collected prior to the air stripper during the second and last pilot test vacuum setting (total of two influent samples). An effluent sample will be collected after the air stripper during the second and last pilot test vacuum setting (total of two effluent samples).

Treated groundwater will be collected in the groundwater storage tank prior to disposal. Samples of the water will be analyzed for BTEX, TPH-DRO, TPH-GRO, and TPH-Oil to determine the proper disposal method.

Data from the test will include the radius of influence of the induced vacuum, radius of influence of the groundwater table, extraction wellhead vacuum, groundwater flow direction and rate, and an estimation of the volume of free product recovered during the pilot test.

6.2.6 Post-Pilot Study Sampling

Following the pilot study, the new and existing monitoring wells will be monitored for free product and sampled for VOCs and SVOCs to evaluate the effectiveness of the pilot study.

SECTION 7

Remedial Investigation/Feasibility Study Report

A draft RI/FS Report will be prepared for submittal to LANTDIV, NSRR, USEPA, and PREQB. Based on the review comments on the Draft RI and FS Reports, Final Reports will be prepared. An outline of the RI and FS Reports is presented below.

Remedial Investigation Report

Executive Summary

1. Introduction
   - 1.1 Purpose of Report
   - 1.2 Site Background
     - 1.2.1 Site Description
     - 1.2.2 Site History
     - 1.2.3 Previous Investigations
     - 1.2.4 Physical Characteristics of Study Area
   - 1.3 Report Organization

2. Field Activities
   - 2.1 Decontamination of Sampling Equipment
   - 2.2 Monitoring Well Installation
   - 2.3 Monitoring Well Development
   - 2.4 Monitoring Well Purging and Sampling
   - 2.5 Groundwater Elevation Measurements
   - 2.6 Subsurface Soil Sampling
   - 2.7 Aquifer Performance Testing
   - 2.8 Surveying
   - 2.9 Laboratory Field Sampling Protocol

3. Nature and Extent of Contamination
   - 3.1 Risk-Based Criteria Screening Procedure
   - 3.2 Soils
   - 3.3 Groundwater

4. Contaminant Fate and Transport
   - 4.1 Potential Routes of Migration
   - 4.2 Contaminant Persistence
   - 4.3 Contaminant Migration

5. Baseline Risk Assessment
   - 5.1 Human Health Evaluation
     - 5.1.1 Exposure Assessment
     - 5.1.2 Toxicity Assessment

5.1.3 Risk Characterization
5.2 Environmental Evaluation

6. Pilot Study
6.1 Pilot Study Description
6.2 Pilot Study Results
6.3 Design Considerations
7. Conclusions and Recommendations

Feasibility Study Report

8. Identification of Screening Technologies
8.1 Remedial Action Objectives
8.2 General Response Actions
8.3 Identification of Screening Technology Types and Process Options
8.3.1 Identification of Screening Technologies
8.3.2 Evaluation of Technologies and Selection of Representative Technologies

9. Development and Screening of Alternatives
9.1 Development of Alternatives
9.2 Screening of Alternatives
9.2.1 Alternative 1
9.2.1.1 Description
9.2.1.2 Evaluation
9.2.2 Alternative 2
9.2.2.1 Description
9.2.2.2 Evaluation
9.2.3 Alternative 3 (etc.)

10. Detailed Analysis of Alternatives
10.1 Introduction
10.2 Individual Analysis of Alternatives
10.2.1 Alternative 1
10.2.1.1 Description
10.2.1.2 Evaluation
10.2.2 Alternative 2
10.2.2.1 Description
10.2.2.2 Evaluation
10.2.3 Alternative 3 (etc.)

11. Conclusions and Recommendations

12. References

SECTION 8

Project Schedule

Table 8-1 presents the proposed project schedule for the RI/FS at AOC E.

TABLE 8-1
Project Schedule, AOC E RI/FS
Former NASD, Vieques, Puerto Rico

Task	Start Date	End Date
Draft Work Plan	12/11/01	1/28/02
Regulatory Review	1/29/02	3/05/02
Final Work Plan	3/06/02	3/15/02
Field Work (Additional Characterization)	3/18/02	3/29/02
Laboratory Analysis	4/01/02	5/01/02
Data Validation	5/02/02	6/03/02
Pilot Study	6/01/02	8/01/02
Post Pilot Study Sampling	8/02/02	8/02/02
Laboratory Analysis	8/03/02	9/03/02
Data Validation	9/04/02	10/04/02
Draft RI/FS Report	10/05/02	12/05/02
Regulatory Review	12/06/02	01/31/03
Respond to Comments	02/01/03	03/01/03
Final RI/FS Report	03/02/03	04/02/03
ROD	04/03/03	04/17/03
ROD Public Review	04/18/03	06/18/03
Remedial Design	06/19/03	09/19/03
Remedial Action Initiation	09/20/03	09/20/03

SECTION 9

Project Management

The CH2M HILL Project Manager designated for the oversight of this project is Mr. Marty Clasen. Mr. Clasen will be supported by Mr. John Tomik, who serves as Activity Manager for Vieques Island. Mr. Clasen will be assisted by Mr. Ferreira and Mr. Keith Coats in the everyday management of this project. Mr. Erik Isern will be the CH2M HILL field team leader for this project.

The RI/FS program (soil and groundwater sampling, and remedial pilot study) will be performed by qualified CH2M HILL staff members. CH2M HILL will notify LANTDIV and NSRR as to which CH2M HILL personnel will mobilize to the site prior to initiating field activities.

The Navy Technical Representative (NTR) is Mr. Chris Penny. Mr. Penny is the LANTDIV representative, and provides technical direction on the project. He also coordinates funding and overall interaction with other agencies and interested parties. Mr. Penny can be contacted at the address and phone number listed below.

Ms. Madeline Rivera Ruiz is the Installation Restoration (IR) Program Coordinator for NSRR. Ms. Ruiz is responsible for the coordination of all Naval environmental activities at NSRR and Vieques Island. Ms. Ruiz can be contacted at the address and phone number listed below.

Mr. Chris Penny
Remedial Project Manager
Installation Restoration Section
Environmental Programs Branch
Environmental Division
Atlantic Division (LANTDIV) Code 1822
Naval Facilities Engineering Command
1510 Gilbert Street
Norfolk, VA 23511-2699
(757) 322-4815

Ms. Madeline Rivera Ruiz
U.S. Naval Station Roosevelt Roads
Environmental Engineering Division
Public Works Department, Bldg. 31
Ceiba, Puerto Rico 00735
(787) 865-5337

SECTION 10

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APPENDIX A

PREQB Water Quality Standards

FINAL DRAFT

COMMONWEALTH OF PUERTO RICO
OFFICE OF THE GOVERNOR
ENVIRONMENTAL QUALITY BOARD

Pursuant to and in accordance with the Environmental Policy Act (Law No. 9 of June 18, 1970, as amended), this

PUERTO RICO WATER QUALITY STANDARDS REGULATION, AS AMENDED

Has been promulgated by Resolution Number R- to enhance, maintain and preserve the quality of the waters of Puerto Rico compatible with the social and economic needs of Puerto Rico.

Dated this

JUNTA DE CALIDAD AMBIENTAL
FEB 05.2002
BIBLIOTECA

Associate Member

Vice-Chairman

Chairman

NOTE: (THE ORIGINAL WATER QUALITY STANDARDS REGULATION WAS FILED IN THE DEPARTMENT OF STATE ON JANUARY 4, 1974. SUBSEQUENT AMENDMENTS WERE MADE ON MAY 1974. OCTOBER 1976 AND FEBRUARY 1983, ~~AND~~ NOVEMBER 1987, AND JULY 1990)

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ARTICLE 3 - WATER QUALITY STANDARDS AND USE CLASSIFICATIONS TO BE PROTECTED IN THE WATERS OF PUERTO RICO

Pursuant to the intent of this Regulation, the following water quality standards and use classifications are promulgated for the protection of the uses assigned to the classifications of the coastal, surface, estuarine wetlands and ground waters of the Commonwealth of Puerto Rico.

The following water quality standards shall apply at all times, except in:

(1) surface waters during periods when their flows are less than the average minimum seven day low flow which occurs once in any two consecutive years.

(2) waters within mixing zones authorized by this Board pursuant to Article 5 of this Regulation.

(3) surface, coastal, estuarine and ground waters where it is demonstrated to the satisfaction of the Board that the natural background concentration exceeds the established water quality standards.

(4) surface waters in the immediate vicinity of a discharge for which a wasteload allocation has been authorized by this Board pursuant to Article 10 of this Regulation.

(5) intermittent streams when the conditions of Section 4.3 of this Regulation are met.

3.1 General Water Quality Standards:

All waters shall meet generally accepted aesthetic qualifications. These waters shall, except as specifically noted, meet the following quality standards:

3.1.1 Solids and Other Matter:

The waters of Puerto Rico shall not contain floating debris, scum and other floating materials attributable to discharges in amounts sufficient to be unsightly or deleterious to the existing or designated uses of the waterbody.

3.1.2 Color, Odor, Taste and Turbidity:

The waters of Puerto Rico shall be free from color, odor, taste and turbidity attributable to discharges in such a degree as to create a nuisance to the enjoyment of the existing or designated uses of the waterbody.

3.1.3 Radioactive Materials

In the waters of Puerto Rico the concentration of Radium-226 and Strontium-90 shall not exceed 3 and 10 picocuries per liter respectively. In the absence of Strontium-90 and alpha emitters the gross beta concentrations shall not exceed 1,000 picocuries per liter.

3.1.4 Temperature:

(A) Except by natural causes, no heat may be added to the waters of Puerto Rico which would cause the temperature of any site to exceed 90°F or 32.2°C.

(B) No thermal discharge or combination of thermal discharges into or onto the surface, estuarine and coastal waters shall be injurious to fish or shellfish or the culture or propagation of a balanced indigenous population there of nor in anyway affect the designated uses.

(C) In stratified lakes, thermal discharges shall be confined to the epilimnetic layer.

(D) No thermal discharge or combination of thermal discharges shall be made to ground waters.

3.1.5 Suspended, Colloidal or Settleable Solids:
Solids from wastewater sources shall not cause deposition in or be deleterious to the existing or designated uses of the waters.

3.1.6 Biochemical Oxygen Demand:
The allowable level of biochemical oxygen demand of wastewater sources will be determined on a case by case basis depending on the assimilative capacity of the receiving water body. Such determination will be performed to assure compliance with the dissolved oxygen standard applicable to the receiving water body.

3.1.7 Asbestos
In order to assure for the protection of human health from the potential carcinogenic effects of exposure to asbestos the waters of Puerto Rico shall not exceed 7 MFL (million fibers per liter) of asbestos, except when established that such presence is due to the natural occurrence of geologic deposits of asbestiform minerals.

3.1.8 Oil and Grease
The waters of Puerto Rico shall be substantially free from floating non-petroleum oils and greases as well as petroleum derived oils and greases.

3.1.9 Substances in Toxic Concentrations and Synergistic Toxic Effects:
The waters of Puerto Rico shall not contain any substance at such concentration which, either alone or as result of synergistic effects with other substances is toxic or produces undesirable physiological responses in human, fish or other fauna or flora. In Sections 3.1.9(A), 3.1.9(B), and 3.1.9(C) are identified specific substances for which numeric water quality standards have been established.

3.1.9(A) Specific Standards for InorganicSome Substances:

The maximum allowable concentration of these specific substances in coastal, surface, estuarine and groundwaters shall not exceed the following at any time:

SUBSTANCE	COASTAL/ESTUARINE WATERS ug/l	SURFACE WATERS ug/l	GROUND WATERS ug/l
+* Antimony	4,300 (AL)	14.0 (HH)	5.0 (DW)
+* Arsenic (As)	1.4 (AL)150.0	0.18 (SH)50.0 (DW)	50.0 (DW)0.022 (HH)
# Barium (Ba)	1,000.0	1,000.0 (DW)	-
+* Beryllium (Be)		0.068 (HH)	
# Boron (B)	4,800.0	1,000.0 (AL)	
+% Cadmium (Cd)	9.30 (AL)5.0	Note 1 (AL)	5.00 (DW)
+ Chromium III (Cr) (Total)	300.0 (AL) -	Note 2 (AL)50.0	-
+ Chromium VI	-	11.0 (AL)	-
+ Copper (Cu)	3.1 (AL)50.0	Note 32 (AL)	1300 (DW)
+ Cyanide (CN)	1 (AL)20.0	5.2 (AL)20.0	200 (DW)
# Fluoride (F)	1,300.0 -	700.0 (DW)	-
+% Lead (Pb)	8.1 (AL)15.0	Note 63 (AL)	15.0 (DW) 50.0
Manganese (Mn)	100.0 (HH)	50.0 (DW)	-
+ Mercury (Hg)	0.051 (HH, AL)1.0 (AL, HH)	0.050 (HH, AL)1.0 (AL, HH)	2.0 (DW)
+ Nickel	8.23 (AL)	Note 4 (AL)	-
Nitrate plus Nitrite (as N)	-	10,000 (DW)	-
Nitrogen (NO_3, NO_2, NH_3)	5000 5,000.0	-	-
+ Selenium (Se)	71.0 (AL)10.0	5.0 (AL)10.0 (HH)	50.0 (DW)

+ Silver (Ag)	2.0 (AL)	Note 5 (AL) ~~2.0~~	-
Sulfide (S) (undissociated H_2S)	2.0 (AL)	2.0 (AL)	-
+ Zinc (Zn)	81.0 (AL)~~50.0~~	Note 7 (AL)~~50.0~~	-

LEGEND:

Note 1. Concentration in ug/l must not exceed the numerical value given by $e^{(0.7852\ [\text{Ln Hardness}]-2.7153.490)}$

Note 2. Concentration in ug/l must not exceed the numerical value given by $e^{(0.8190545\ [\text{Ln Hardness}]+0.6848-1.465)}$

Note 3. Concentration in ug/l must not exceed the numerical value given by $e^{(0.8545\cancel{1.273}\ [\text{Ln Hardness}]-1.7024\cancel{4.705})}$

Note 4. Concentration in ug/l must not exceed the numerical value given by $e^{(0.8460\ [\text{Ln Hardness}]+0.05844.1645)}$

Note 5. Concentration in ug/l must not exceed the numerical value given by $e^{(1.72\ [\text{Ln Hardness}] - 6.52)}$

Note 6. Concentration in ug/l must not exceed the numerical value given by $e^{(1.273\ [\text{Ln Hardness}] - 4.705)}$

Note 7. Concentration in ug/l must not exceed the numerical value given by $e^{(0.8473\ [\text{Ln Hardness}]\ +0.884)}$

Identification codes for the applicability of standards to uses, both designated and existing uses.

AL = Protection of the waterbody for the propagation and preservation of species dependent on the waterbody.

DW = Protection of the waterbody for use as source of drinking water supply.

HH = Protection of the waterbody or aquatic life for reasons of human health.

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* = Identifies a substance that may be a carcinogen.

+ = Identifies a priority pollutant.

= Identifies a substance which numeric standard for coastal waters will be evaluated to determine the feasibility of eliminating it.

% = In cases where the surface water body is used as a source of drinking water supply, the water quality standard for the indicated substance shall not exceed the drinking water standard upstream from the water intake.

Should express metals as dissolved and as function of WER. Provide EPA conversion factors.

3.1.9(B) Specific Standards for Pesticides:

1. Organochlorides and Other Persistent Pesticides:
Organochloride and other persistent pesticides residues in surface, ground, estuarine and coastal waters shall not exceed 1/100 of the 96 hr LC50 of species approved by the Board. In the specific case of the pesticides identified below, the concentration shall not exceed the value listed below (micrograms per liter or ppb):

	Substance	Coastal/Estuarine Waters (ug/l)	Surface Waters (ug/l)	Ground Waters (ug/l)
+*	Aldrin-~~Dieldrin~~	0.0014 (HH)~~0.00074~~	0.0013 (HH)~~0.00074~~	-
+*	Dieldrin	0.0014 (HH)	0.0014 (HH)	-
+*	Chlordane	0.004 (AL)~~0.0046 (HH)~~	0.0043 (AL)~~0.0046 (HH)~~	0.2 (AP) b*
+*	DDT and Metabolites	0.001 (AL)~~0.00024 (HH)~~	0.001 (AL)~~0.00024 (HH)~~	-
+	Endosulfan	0.0087 (AL)	0.056 (AL)	0.056 (AL) (a)
+	Endrin	0.0023 (AL)	0.036~~023~~ (AL)	0.0023 (AL) (a)
+*	Heptachlor	0.0021 (HH)	0.0021 (HH)	40.0 (DW) (b)
+*	Lindane (Gamma BHC)	0.16 (AL)~~0.074~~	0.19 (HH)~~0.0022~~	3.0 (DW) (b)
	Metoxichlor	0.0320 (AL)	0.0320 (AL)	3.0 (DW)~~0.020 (AL) (a)~~
	Mirex	0.001 (AL)	0.001 (AL)	~~0.001 (AL) (a)~~
+	Pentachlorophenol	7.9 (AL)	2.8~~0.07~~ (HH)	2.8 (AL)(a)/50 (DW)(b)~~0.07 (AL) (a)~~
	~~Perthane~~	~~0.07 (AL)~~	~~0.07 (AL)~~	~~0.07 (AL) (a)~~
+*	Toxaphene	0.0002 (AL)	0.0002 (AL)	3.0 (DW)~~0.0002 (AL) (a)~~

(a) = For groundwaters that flow into stream beds, estuarine waters or wetlands.
(AL), (HH), (DW) *, +: See legend in table of Section 3.1.9(A)(1).
(b) = For groundwaters that are used or can be used as a source of drinking water.

2. Organothiophosphorus and other Non-persistent Pesticides:
Organothiophosphorus and other non-persistent pesticides residues in surface, ground, estuarine and coastal waters shall not exceed 1/10 of the 96 hr LC50 of species approved by the Board. In no case shall the following pesticides exceed the concentration (micrograms per liter or ppb) listed:

Substance	Coastal/Estuarine Waters (ug/l)	Surface Waters (ug/l)	Ground Waters (ug/)
Azinphos – Methyl	0.01 (AL)	0.01 (AL)	0.01 (AL) (a)
Chlorpyrifos	0.0056 (AL)	0.041 (AL)	0.041 (AL) (a)
Coumaphos	0.010 (AL)	0.010 (AL)	0.010 (AL) (a)
2.4 – D	-	100.0 (DW)	100.0 (DW)
+ Demeton	0.10 (AL)	0.10 (AL)	0.10 (AL) (a)
Fenthion	0.40 (AL)	0.40 (AL)	0.40 (AL) (a)
Malathion	0.10 (AL)	0.10 (AL)	0.10 (AL) (a)
Naled	0.40 (AL)	0.40 (AL)	0.40 (AL) (a)
Parathion	-	0.013 (AL)	0.013 (AL) (a)
2.4.5 - TP (Silvex)	-	10.0 (DW)	50.0 ~~510.0~~ (AL) (a)

(a) = For groundwaters that flow into stream beds, estuarine waters or wetlands.
(AL), (DW), +: See Legend in table of Section 3.1.9(A)(1).

3.1.9(B) Specific Standards for Pesticides:

3. Pesticides in Ground Water Class SG1: Ground waters shall be free of all persistent pesticides that affect human health.

3.1.9(C) Specific Standards for Non-Pesticide Organic Substances and Carbon Tetrachloride.

These specific substances shall not exceed the maximum allowable concentration, at any time in coastal, surface, estuarine and ground waters.

SUBSTANCE	CLASSES SB & SC (ug/l)	CLASS SD (ug/l)	CLASS SG1 (ug/l)
+* Benzene	710.0 (HH)~~400.0~~	12 (HH)~~5.0 (DW)~~	5.0 (DW)
+*2-Chlorophenol	400 (HH)	120 (HH)	-
+*2,4- Dichlorophenol	790 (HH)	93 (HH)	-
+*2,4- Dimethylphenol	2,300 (HH)	540 (HH)	-
+*2-Methyl -4,6- Dinitrophenol	765 (HH)	13.4 (HH)	-
+*2,4- Dinitrophenol	14,000 (HH)	70 (HH)	-
+*Phenol	4,600,000 (HH)	21,000 (HH)	-
+*2,4,6- Trichlorophenol	65 (HH)	21 (HH)	
+* Carbon Tetrachloride	44.0 (HH)~~69.4~~	2.5 (HH)~~5.0 (DW)~~	5.0 (DW)
~~**Dichlorobenzenes~~	~~2,600.0 (HH)~~	~~75.0 (HH)~~ ~~75.0 (DW)~~	
+* 1,2 Dichlorobenzene	17,000 (HH)	2,700 (HH)	-
+* 1,3 Dichlorobenzene	2,600 (HH)	400 (HH)	-
+* 1,4 Dichlorobenzene	2,600 (HH)	400 (HH)	-
+* 1,2-Dichloroethane	990.0 (HH)~~2,430.0~~	3.8 (HH)~~5.0 (DW)~~	5.0 (DW)
+* 1,1-Dichloroethylene	32 (HH)~~18.5~~	0.57 (HH)~~7.0 (DW)~~	7.0 (DW)
85 ~~**Phenolic Substances~~	~~10.0~~	~~1.0~~ ~~1.0~~	
+* Tetrachloroethylene	88.5 (HH)	85.0 (HH)	5.0 (HH)
+ 1,1,1-Trichloroethane	1,030.0 (HH)	200.0 (HH)	200.0 (DW)
+* Trichloroethylene	81007.0 (HH)	275.0 (HH)	5.0 (DW)
+* Vinyl Chloride	5,25046.0 (HH)	2.0 (HH)	2.0 (DW)
PCBs ?			

~~**= This parameter will be evaluated to determine the feasibility of establishing standards for more specific groups of substances.~~

(DW), (HH), *, +: See Legend in table of Section 3.1.9(A)(1)

3.1.9(D) Specific Standards for Volatile Organic Substances

These specific substances shall not exceed the maximum allowable concentration, at any time in coastal, surface, estuarine and ground waters.

SUBSTANCE	CLASSES SB & SC (ug/l)	CLASS SD (ug/l)	CLASS SG1 (ug/l)
+*Acrolein	780 (HH)	320 (HH)	-
+*Acrilonitryl	6.6 (HH)	0.59 (HH)	-
+*Benzene	710 (HH)	12 (HH)	5.0 (DW)
+*Bromoform	3,600 (HH)	43 (HH)	-
+*Chlorobenzene	21,000 (HH)	680 (HH)	100 (DW)
+*Chlorodibromomethane	340 (HH)	4.1 (HH)	-
+*Chloroform	4,700 (HH)	57 (HH)	100 (DW)
+*Dichlorobromomethane	460 (HH)	5.6 (HH)	5.0 (DW)
+*1,2 Dichloropropane	390 (HH)	5.2 (HH)	-
+*1,3 Dichloropropane	1,700 (HH)	10 (HH)	-
+*Ethylbenzene	29,000 (HH)	3,100 (HH)	700 (DW)
+*Methyl Bromide	4,000 (HH)	48 (HH)	-
+*Methylene Chloride	16,000 (HH)	470 (HH)	-
+*1,1,2,2 Tetrachloroethane	110 (HH)	1.7 (HH)	-
+*1,2,4 Trichlorobenzene	940 (HH)	260 (HH)	9.0 (DW)
+ 1,1,2 Trichloroethane	420 (HH)	6.0 (HH)	5.0 (DW)

3.1.9(E) Specific Standards for Semi-Volatile Organic Substances

These specific substances shall not exceed the maximum allowable concentration, at any time in coastal, surface, estuarine and ground waters.

	SUBSTANCE	CLASSES SB & SC (ug/l)	CLASS SD (ug/l)	CLASS SG1 (ug/l)
+*	Acenaphthene	2,700 (HH)	1,200 (HH)	-
+*	Anthracene	110,000 (HH)	9,600 (HH)	-
+*	Benzidine	0.0054 (HH)	0.0012 (HH)	-
+*	BenzoaAnthracene	0.49 (HH)	0.044 (HH)	-
+*	BenzoaPyrene	0.49 (HH)	0.044 (HH)	-
+*	BenzobFluoranthene	0.49 (HH)	0.044 (HH)	-
+*	BenzokFluoranthene	0.49 (HH)	0.044 (HH)	-
+*	Bis2-ChloroethylEther	14.0 (HH)	0.31 (HH)	-
+*	Bis2-ChloroisopropylEther	170,000 (HH)	1,400 (HH)	-
+*	Bis2-EthylhexylPthalate	59 (HH)	18 (HH)	-
+*	Butylbenzyl Pthalate	5,200 (HH)	3,000 (HH)	-
+*	2-Chloronaphthalene	4,300 (HH)	1,700 (HH)	-
+*	Chrysene	0.49 (HH)	0.044 (HH)	-
+*	DibenzoahAnthracene	0.49 (HH)	0.044 (HH)	-
+*	3,3-Dichlorobenzidine	0.77 (HH)	0.4 (HH)	-
+*	Diethyl Pthalate[W]	120,000 (HH)	23,000 (HH)	-
+*	Dimethyl Pthalate[W]	2,900,000 (HH)	313,000 (HH)	-
+*	Di-n-Butyl Pthalate[W]	12,000 (HH)	2,700 (HH)	-
+*	2,4-Dinitrotoluene	9.1 (HH)	0.11 (HH)	-

+*	1,2-Diphenylhydrazine	5.4 (HH)	0.40 (HH)	-
+*	Fluoranthene	370 (HH)	300 (HH)	-
+*	Fluorene	14,000 (HH)	1,300 (HH)	-
+*	Hexachlorobenzene	0.0077 (HH)	0.0075 (HH)	+.0 (HH)
+*	Hexachlorobutadiene	500 (HH)	4.4 (HH)	-
+*	Hexachlorocyclopentadiene	17,000 (HH)	240 (HH)	50 (HH)
+*	Hexachloroethane	89.0 (HH)	19.0 (HH)	-
+*	Ideno 1,2,3-cdPyrene	0.49 (HH)	0.044 (HH)	-
+*	Isophorone	26,000 (HH)	360 (HH)	-
+*	Nitrobenzene	1,900 (HH)	17.0 (HH)	-
+*	N-Nitrosodimethylamine	81.0 (HH)	0.0069 (HH)	-
+*	N-Nitrosodiphenylamine	160 (HH)	50 (HH)	-
+*	N-Nitrosodi-n-Propylamine	14.0 (HH)	0.05 (HH)	-
+*	Pyrene	11,000 (HH)	960 (HH)	-
+*	Toluene	200,000 (HH)	6,800 (HH)	1,000 (HH)
+*	1,2-Trans-Dichloroethylene	140,000 (HH)	700 (HH)	-

3.1.10 Synergistic Toxic Effects:

The waters of Puerto Rico shall not contain two or more substances in concentrations whose combination will result in synergistic toxic effects or which will produce chronic or other undesirable physiological responses in humans, fish or other fauna or flora.

3.2 Use Classifications and Water Quality Standards for Specific Classifications:

3.2.1 Class SA:

(A) Usages and Description:

Coastal waters and estuarine waters of high quality and/or exceptional ecological or recreational value whose existing characteristics shall not be altered, except by natural causes, in order to preserve the existing natural phenomena.

(B) Standards:

No parameter, whether or not considered in this Article, shall be altered in concentration, except by natural causes. Substances reactive with methylene blue shall not be present.

3.2.2 Class SB:

(A) Usages and Description:

Coastal waters and estuarine waters intended for use in primary and secondary contact recreation, and for propagation and preservation of desirable species, including threatened or endangered species.

(B) Standards:

1. Dissolved Oxygen:

Shall not contain less than 5 mg/l, except when natural phenomena cause this value to be depressed.

2. Coliforms:

The fecal coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 200 colonies/100 ml, and not more than 20 percent of the samples shall exceed 400 colonies/100 ml. In waters intensely used for primary contact recreation, the enterococci density in terms of geometric mean of at least five representative samples taken sequentially shall not exceed 35/100 ml. No single sample should exceed the upper confidence limit of 75 % using 0.7 as the log standard deviation until sufficient site data exist to establish a site-specific log standard deviation.

3. pH:

In no case the pH will lie outside the range of 7.3 and 8.5, standard pH units, except when caused by natural phenomena.

4. Color:

Shall not be altered except by natural causes.

5. Turbidity:

Shall not exceed 10 nephelometric turbidity units (NTU), except by natural causes.

6. Taste and Odor Producing Substances:

Shall not be present in amounts that will interfere with primary contact recreation or will render any undesirable taste and/or odor to edible aquatic life.

7. Sulfates:

For SB estuarine waters, sulfates shall not exceed 2,800 mg/l.

8. Surfactants as MBAS:

Shall not exceed 500 ug/l.

3.2.3 Class SC:

(A) Usages and Description:

Coastal waters intended for uses where the human body may come in indirect contact with the water (such as fishing, boating, etc.), and for use in propagation and preservation of desirable species, including threatened or endangered species.

(B) Standards:

1- Dissolved Oxygen

Shall contain not less than 4 mg/l except when natural conditions cause this value to be depressed.

2- Coliforms

The coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 10,000 colonies/100 ml of total coliforms or 2,000 colonies/100ml of fecal coliforms. Not more than 20 percent of the samples shall exceed 4,000 colonies/100 ml of fecal coliforms.

3- pH

In no case the pH will lie outside of 7.3 and 8.5, except when caused by natural phenomena.

4- Color

Shall not be altered by other than natural phenomena except when it can be proven that such change in color is harmless to biota and aesthetically acceptable.

5- Turbidity

Shall not exceed 10 nephelometric turbidity units (NTU).

6- Taste and odor producing substances

Shall contain none in amounts that will render any undesirable taste or odor to edible aquatic life.

7- Sulfates

For estuarine waters classified SC, sulfates shall not exceed 2,800 mg/l.

8- Surfactants as MBAS:

Shall not exceed 500 ug/l.

3.2.4 Class SD:

A) Usages and Description:

Surface waters intended for use as a raw source of public water supply, propagation and preservation of desirable species, including threatened or endangered species, as

(B) Standards:

1- Dissolved Oxygen

Shall contain not less than 4 mg/l except when natural conditions cause this value to be depressed.

2- Coliforms

The coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 10,000 colonies/100 ml of total coliforms or 2,000 colonies/100ml of fecal coliforms. Not more than 20 percent of the samples shall exceed 4,000 colonies/100 ml of fecal coliforms.

3- pH

In no case the pH will lie outside of 7.3 and 8.5, except when caused by natural phenomena.

4- Color

Shall not be altered by other than natural phenomena except when it can be proven that such change in color is harmless to biota and aesthetically acceptable.

5- Turbidity

Shall not exceed 10 nephelometric turbidity units (NTU).

6- Taste and odor producing substances

Shall contain none in amounts that will render any undesirable taste or odor to edible aquatic life.

7- Sulfates

For estuarine waters classified SC, sulfates shall not exceed 2,800 mg/l.

8- Surfactants as MBAS:

Shall not exceed 500 ug/l.

3.2.4 Class SD:

A) Usages and Description:

Surface waters intended for use as a raw source of public water supply, propagation and preservation of desirable species, including threatened or endangered species, as

well as primary and secondary contact recreation. Primary contact recreation is precluded in any stream or segment that does not comply with Section 3.2.4(B)12 of this Article until such stream or segment meets the goal of the referred section.

(B) Standards:

1. Dissolved Oxygen:

   Shall contain not less than 5.0 mg/l except when natural conditions cause this value to be depressed.

2. Coliforms:

   The coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 10,000 colonies/100 ml of total coliform or 200 colonies/100 ml of fecal coliforms. Not more than 20 percent of the samples shall exceed 400 colonies/100 ml of fecal coliforms.

3. pH:

   Shall always lie between 6.0 and 9.0 except when natural phenomena cause the value of pH to fall outside this range.

4. Color:

   Shall not exceed 15 units according to the colorimetric platinum-cobalt standard, except when due to natural phenomena. In cases where the water body normally exceeds this value, the mechanism provided under Section 6.10 of this Regulation may be used to develop site-specific criteria.

5. Turbidity:

   Shall not exceed 50 nephelometric turbidity units (NTU), except when due to natural phenomena.

6. Total Dissolved Solids:

   Shall not exceed 500 mg/l, except when due to natural phenomena.

7. Taste and Odor Producing Substances:

   Shall not be present in amounts that will interfere with the use for potable water supply, or will render any undesirable taste and/or odor to edible aquatic life.

8. Total Phosphorus:

Total phosphorus shall not exceed 1 ppm (mg/), in surface water bodies upstream from reservoirs, in segments of surface water bodies with drinking water intakes or estuarine waters except when it is demonstrated to the satisfaction of the Board that a higher value of total phosphorus in combination with prevailing nitrogen derived nutrients will not contribute to eutrophic conditions in the water body.

9. Surfactants as MBAS:

Shall not exceed 100 ug/l.

10. Sulfates:

Shall not exceed 250 mg/l, except when due to natural phenomena.

11. Chlorides:

Shall not exceed 250 mg/l, except when due to natural phenomena.

12. Other Pathogenic Organisms:

These waters shall be free of other pathogenic organisms.

13. Total Ammonia:

Total ammonia shall not exceed 1 mg/l upstream from the points given by coordi--nates for the following segments:

Río Cibuco - 18°21'13" / 66°20'07"
Río Hondo - 18°26'13" / 66°09'36"
Río Guaynabo - 18°22'32" / 66°07'59"
Río Bayamón - 18°24'39" / 66°09'09"
Río Piedras - 18°24'34" / 66°04'10"
Quebrada Blasina - 18°23'27" / 65°58'28"
Río Caguitas - 18°15'11" / 66°01'26"
Río Bairoa - 18°15'28" / 66°02'13"
Río Chico - 17°59'16" / 66°00'18"
Río Coamo - 18°03'52" / 66°22'10"
Río Guayanilla - 18°00'50" / 66°47'04"
Río Guanajibo - 18°07'18" / 67°03'56"

3.2.5 Class SE:

(A) Usages and Description:

Surface waters and wetlands of exceptional ecological value, whose existing characteristics should not be altered in order to preserve the existing natural phenomena.

(B) Standards:

No parameter, whether or not considered in this Article, shall be altered in concentration, except by natural causes. Substances reactive with methylene blue shall not be present.

3.2.6 Class SG1:

(A) Usages and Description:

Ground waters intended for use as source of drinking water supply and agricultural uses including irrigation. Also included under this class are those groundwaters that flow into waters which support ecological communities of exceptional ecological value in accordance with Sections 2.1.1 and 2.2.2 of this Regulation.

(B) Standards:

1. Dissolved Gases:

The composition, combination and concentration of dissolved gases shall not be altered except by natural causes.

2. Coliforms:

Fecal coliforms shall not exceed 0/100 ml in any sample by the MF (Membrane Filter) method.

3. pH:

Shall not be altered except by natural causes.

4. Color:

Shall not be altered except by natural causes.

5. Turbidity:

Shall not be altered except by natural causes.

6. Total Dissolved Solids:

   Shall not be altered except by natural causes. Here the term natural causes does not include salt water intrusion. unless this results from severe draught conditions.

7. Taste and Odor Producing Substances:

   Shall not be altered except by natural causes.

8. Surfactants as MBAS:

   Shall not be present.