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Final

**Remedial Investigation Report
Area of Concern (AOC) E**

**Former Naval Ammunition Support Detachment
Vieques, Puerto Rico**

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Acronyms and Abbreviations

amsl	Above Mean Sea Level
AOC	Area of Concern
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
BERA	Baseline Ecological Risk Assessment
bls	below land surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action – Navy
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
DAF	Dilution Attenuation Factor
DCA	dichloroethane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DoD	Department of Defense
DOI	United States Department of the Interior
DQE	Data Quality Evaluation
EBS	Environmental Baseline Survey
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
ERM	Environmental Resource Management, Inc.
ERP	Environmental Restoration Program
FID	flame ionization detector
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	Feasibility Study
ft	foot/feet
GIS	Geographic Information System
HAH	heterocyclic aromatic hydrocarbon
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient

IDW	investigation-derived waste
IR	Installation Restoration
LCS	laboratory confirmation sample
LNAPL	light non-aqueous phase liquid
MCL	Maximum Contaminant Level
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
ml/min	Milliliters per Minute
MOV	Municipality of Vieques
MPE	Multi-phase Extraction
MSL	Mean Sea Level
MTBE	methyl tert butyl ether
mV	millivolts
NASD	Naval Ammunition Support Detachment
NAVFAC	Naval Facilities Engineering Command
NM	not measured
NPL	National Priorities List
NRHP	National Register of Historic Places
NS	not sampled
NSRR	Naval Station Roosevelt Roads
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
OVA	Organic Vapor Analyzer
OVM	Organic Vapor Monitor
PA/SI	Preliminary Assessment/Site Investigation
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
ppm	parts per million
PREQB	Puerto Rico Environmental Quality Board
PRG	Preliminary Remediation Goal
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SERA	Screening Ecological Risk Assessment
SOP	Standard Operating Procedure

SSL	Site-Specific Screening Level
SVOC	semivolatile organic compound
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
Temp	temperature
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-DRO	total petroleum hydrocarbons, diesel-range organics
TPH-GRO	total petroleum hydrocarbons, gasoline-range organics
TPH-ORO	total petroleum hydrocarbons, oil and grease
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
VOC	volatile organic compound

Executive Summary

This report is the Remedial Investigation (RI) Report for Area of Concern (AOC) E, located at the Former Naval Ammunition Support Detachment (NASD) in Vieques, Puerto Rico. AOC E is the site of a former 500-gallon underground storage tank (UST) associated with a former vehicle maintenance operation within the main operational area (i.e., Public Works) of the Former NASD. Figure ES-1 shows the location of AOC E within the Former NASD. The UST was in service between about 1970 and 1996, during which time it was used to store used oil generated from vehicle maintenance activities that took place at the vehicle maintenance and transportation shop (Building 2016). Specifically, oil removed from vehicles on the vehicle maintenance platform was drained to the UST via an underground pipe between the platform and the UST. In 1996, the UST was removed and replaced with a 500-gallon aboveground storage tank (AST) that, in turn, was removed in 2001. Figure ES-2 shows the features associated with AOC E.

AOC E occupies less than about a tenth of an acre in the northwest portion of the active Public Works facility. The topography at AOC E is flat; stormwater at the site has been observed to pond rather than run off. To the north of the site, a stormwater ditch channels stormwater runoff toward the north from the Public Works access roads. There are no surface water bodies at or immediately adjacent to AOC E; the Vieques Passage is located approximately 850 feet (ft) north of the site.

Currently, there is no continuous human presence at or use of the site, but humans may periodically be present for routine grounds maintenance (e.g., mowing). Because of the developed and periodically maintained characteristic of AOC E, ecological habitat in the area is minimal. Vegetative cover is primarily grass, weeds, and scrub brush. No endangered or threatened species were observed at AOC E, nor are any expected to use the site as habitat. No cultural resources are located at AOC E.

The soil at the site comprises sandy clay of the Qa geologic unit with interspersed silty/clayey sand from ground surface to a depth of approximately 35 ft in the vicinity of the former UST. Beneath these deposits lies a clay-rich saprolite developed in place from the underlying granodiorite bedrock.

Groundwater levels at the site have been observed to fluctuate by about 15 ft, occurring part of the time in the saprolite and less often in the lowest portion of the unconsolidated deposits directly above the saprolite. The direction of groundwater flow is north-northwest toward the Vieques Passage. Slug-test data for several site monitoring wells suggest a relatively low groundwater velocity (about 1 ft/year). While slug test data in saprolite are prone to a high degree of uncertainty, the general absence of contamination in wells as little as about 50 ft downgradient of the former UST tend to support this velocity estimation.

Based on the distribution of contamination detected at AOC E, releases at the site occurred wholly or primarily as leaks from the former UST and associated piping. The data were collected through a series of investigations during which surface soil, subsurface soil, free product, and groundwater samples were collected in and around the area of the former UST

and associated piping. Figure ES-3 shows all the soil and groundwater (monitoring well) sampling locations. Evaluation of the data collected during the investigations indicates the following constituents likely associated with releases from the former UST and associated piping are present in the soil and/or groundwater at the site:

- **Volatile Organic Compounds (VOCs)**
 - Degreasing solvents such as 1,2-dichloroethane (1,2-DCA), 1,2-dichlorobenzene (1,2-DCB), and chlorobenzene (trace amounts of chlorinated solvents can be found in used engine oil and 1,2-DCB and chlorobenzene can also be associated with petroleum products)
 - Fuel-related constituents such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and methyl tert-butyl ether (MTBE)
- **Semivolatile Organic Compounds (SVOCs)**
 - Fuel-related polycyclic aromatic hydrocarbons (PAHs) such as 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorene, naphthalene, phenanthrene, and pyrene
 - Heterocyclic aromatic hydrocarbons (HAHs) caprolactam and acetophenone
 - Hydraulic-oil related phthalates bis(2-ethylhexyl)phthalate and butylbenzylphthalate
- **Total Petroleum Hydrocarbons (TPH)**
- **Inorganics**
 - Lead (while most inorganics analyzed for were detected in AOC E media, all but lead are likely to be wholly or primarily attributable to background)

Tables ES-1 through ES-3 provide statistical summaries of the constituents detected in surface soil, subsurface soil, and groundwater, respectively. The data were evaluated not only to determine the nature and extent of contamination present as a result of past releases, but were also compared to human health-based, ecological-based, and Puerto Rico UST-based screening values to gain an understanding of the magnitude of the releases. This comparison shows that there were relatively few detections of constituents in soil or groundwater above screening values, especially organics, with the exception of petroleum hydrocarbons in soil. Further, elevated concentrations in both soil and groundwater (with respect to screening values) are confined primarily to the area immediately under and around the former UST and associated piping.

Figure ES-4 shows a conceptual model of AOC E, including the historical features and estimated contamination migration route and extent. Based on the historical activities and extent of contamination identified during the RI and related investigations, the release mechanism at the site is believed to have been subsurface leaks from the former UST and associated piping. Therefore, the primary route of contaminant migration is likely vertical leaching through soil to groundwater and subsequent transport with groundwater flow through interstitial spaces in the saprolite (and to a lesser extent, the unconsolidated material overlying the saprolite). Because the saprolite consists of relatively “tight” clay, the

rate of groundwater transport is likely very low. This supposition is supported by the general absence of contamination downgradient of the former UST area and relatively low estimated groundwater flow velocity. Because of the nature of the released materials (i.e., used engine oils), residual contamination is likely present in the soil between the base of the former UST/associated piping excavation and the saturated zone. Additionally, because of the past (and potentially current) presence of floating product on the water table, the fluctuation of the groundwater surface has likely created a “smear zone” of contamination along the vertical extent of fluctuation.

The fate and transport of contaminants present in environmental media is dependent on many factors, such as the contaminant type, soil type, organic matter content, presence and abundance of microorganisms, climatic conditions, chemistry of infiltrating water, and rate of groundwater migration. Degradation of organic contaminants detected in the environmental media at AOC E can occur through biotic (biological-based [biodegradation]) or abiotic (non-biological-based) processes. The majority of organic contaminants detected at AOC E biodegrade primarily under aerobic conditions (e.g., 1,2-DCA, BTEX, MTBE, TPH). Several of the contaminants have been shown to biodegrade under both aerobic and anaerobic conditions (e.g., naphthalene, 2-methylnaphthalene). The rate at which biodegradation of these contaminants will occur is based on site-specific conditions, including the oxidation-reduction setting, presence and abundance of the proper microorganisms, and the concentrations of contaminants present.

Based on the nature, extent, and concentrations of constituents detected in environmental media at AOC E, potential ecological and human health risks were assessed. As noted previously, the developed and maintained area at and around the site provides minimal habitat. In fact, no preferred habitats were observed at AOC E, nor were any threatened or endangered species identified. Further, concentrations of constituents detected in surface soil were comparable to background concentrations. Therefore, no unacceptable risks were identified for potential ecological receptors at AOC E.

For potential human receptors, it is noted that the site is currently fenced and no human receptors are present except periodically (approximately once per year) when maintenance workers cut vegetation at the site with a bush hog. However, exposures to various environmental media at the site were evaluated for hypothetical recreational users, maintenance workers, construction workers, industrial workers, and residents. Based on these evaluations, no unacceptable risk (over that attributable to background) was identified for exposure to soil by hypothetical human receptors. The only unacceptable risks were identified for potable use of groundwater by hypothetical future residents. The risk assessment identified 1,2-DCA, MTBE, xylenes, 2-methylnaphthalene, and naphthalene as the groundwater chemicals of concern (COCs). Inorganics were eliminated as COCs because their presence is wholly or primarily attributable to background.

Based on the above information, it is concluded that releases of used oil occurred during vehicle maintenance activities, likely in the form of leaks from the former UST and associated piping. These releases resulted in contamination of soil and groundwater. However, the extent of contamination is generally limited to the immediate vicinity of the former UST and associated piping, with vertical leaching to groundwater representing the primary transport pathway. The extent of contamination is limited to a relatively small area by the nature of the releases (subsurface), the size of the release area (the size and extent of

the UST and associated piping), and the relatively “tight” material through which contamination must travel. Further, the contaminant levels present in soil are relatively low (with respect to human health-based and ecological-based screening values). In fact, potable groundwater use by residents is the only unacceptable risk identified for the site. In addition, only benzene was detected in groundwater above its Federal Maximum Contaminant Level (MCL). However, residual petroleum contamination in soil may be acting as a continuing source of groundwater contamination, and free product has been detected in the wells in the immediate vicinity of the former UST and associated piping.

As summarized above, although contaminants are present in both soil and groundwater at the site, only the groundwater contamination poses an unacceptable risk (under the potable use scenario) to hypothetical future residents. However, soil contamination between the bottom of the former UST/associated piping may act as a continuing source of groundwater contamination, including free product. For the above reasons, it is recommended that a Feasibility Study (FS) be performed to evaluate whether there are technically and economically viable remedial alternatives to address the contamination.

It is noted that the most recent groundwater constituent concentration data are from 2005. Because it has been approximately 2 years since groundwater data were collected, it is recommended that as part of the FS, another round of groundwater samples be collected from all site wells and analyzed for the following parameters:

- VOCs
- SVOCs
- Total and dissolved inorganics
- TPH-GRO, TPH-DRO, and TPH-ORO
- Nitrate, nitrite, sulfide, sulfate, total organic carbon (TOC), alkalinity, chloride, methane, ethane, ethene, ferrous iron, and functional gene testing for VOC and SVOC degrading microbes, as appropriate

At the same time as the groundwater samples are collected, free product thicknesses will also be determined. The free product thickness and additional round of VOC and SVOC data will provide current condition (as well as temporal) information that will assist in assessing viable groundwater remedial alternatives. Although the inorganic concentrations in groundwater are likely attributable to background based on the existing data, an additional round of inorganic data will help confirm this supposition. The additional geochemical and microbial parameters will be used to determine the potential for natural attenuation of the organic compounds and the potential for mobilization of inorganics. If free product is observed in any of the wells and there is sufficient quantity to permit collection, a sample of the free product will be collected from one well and analyzed for the following parameters:

- Viscosity
- Interfacial tension
- Density
- Hydrocarbon “fingerprint”

In addition to collecting additional groundwater data, there are several soil parameters that would be beneficial to assessing viable soil remedial alternatives. For example, assessing the viability of potential soil remedial alternatives, such as soil vapor extraction, can be enhanced with information such as soil permeability. Additionally, assessing the potential for residual soil contamination to act as a continuing source of contamination (and potentially free product) to groundwater can be enhanced with information such as leaching potential. Therefore, it is recommended that as part of the FS, the following additional soil data be collected:

- Continuous soil cores (one from beneath the former UST and one from beneath the former piping) to the top of the saturated zone, with soil samples collected approximately every 5 ft (to assess vertical stratification) and analyzed for:
 - VOCs
 - SVOCs
 - Inorganics
 - TPH-GRO, TPH-DRO, and TPH-ORO
 - TOC
 - Grain size
 - Bulk density (if undisturbed soil sample can be collected)
 - Porosity (if undisturbed soil sample can be collected)
 - Soil permeability
 - Synthetic Precipitation Leaching Procedure (SPLP)

A multi-phase extraction (MPE) pilot study was conducted during the RI in which free product, groundwater, and soil vapor were extracted. While the results of this pilot study indicate this technology is potentially viable, free product returned to the test wells following completion of the test. This may have been due to the relatively short period of time in which the pilot study was performed (i.e., approximately 2 months). In addition, it is possible that the target zone of treatment was not sufficient to address the vertical extent of residual soil contamination. Therefore, if the Navy determines that an additional pilot study would provide information beneficial to the evaluation of alternative(s) in the FS, the FS will be temporarily deferred and a pilot study work plan submitted for agency review.

Resumen Ejecutivo

Este reporte es el Reporte de Investigación de Remediación (RI, por sus siglas en inglés) para el Área de Preocupación (AOC, por sus siglas en inglés) E, localizado en el Antiguo Destacamento Naval de Apoyo de Municiones (NASD, por sus siglas en inglés) en Vieques, Puerto Rico. AOC E es el sitio de un antiguo tanque de almacenamiento subterráneo (UST, por sus siglas en inglés) de 500 galones asociado con las antiguas operaciones de mantenimiento de vehículos dentro del área principal de operación, (ej, Trabajos Públicos) del Antiguo NASD. La Figura ES-1 muestra la localización del AOC E dentro del Antiguo NASD. El UST estuvo en servicio entre los años 1970 y 1996, durante ese tiempo se utilizó para almacenar aceites generados durante las actividades de mantenimiento de vehículos llevadas a cabo en el taller de mantenimiento y transportación (Edificio 2016). En específico, el aceite removido de los vehículos en la plataforma de mantenimiento de vehículos era drenado hacia el UST a través de una tubería subterránea entre la plataforma y el UST. En el 1996, el UST fue removido y reemplazado por un tanque de almacenamiento sobre tierra de 500-galones (AST, por sus siglas en inglés) el cual, a su vez, fue removido en el año 2001. La Figura ES-2 muestra las características asociadas con AOC E.

AOC E ocupa menos de un décimo de acre en la porción noroeste de las facilidades activas de Trabajos Públicos. La topografía del AOC E es plana; se ha observado que las aguas de lluvia en el sitio se estancan en vez de fluir. Al norte del sitio, un arroyo de aguas de lluvia canaliza el flujo de las aguas hacia el norte de las carreteras de acceso a Trabajos Públicos. No hay aguas de superficie en ó adyacentes al AOC E; el Pasaje de Vieques se encuentra aproximadamente a 850 pies (ft) al norte del sitio.

Actualmente, no hay presencia humana o uso continuo del sitio, pero la presencia humana podría presentarse ocasionalmente durante el mantenimiento rutinario de los alrededores (ej., cortar el césped). Debido a las características desarrolladas y periódicamente sostenidas del AOC E, el hábitat ecológico del área es mínimo. La cubierta vegetativa consiste principalmente de hierba, y matorrales. No se observaron especies amenazadas o en peligro en el AOC E, tampoco se espera el uso del sitio como un hábitat. No se encuentra ningún recurso cultural en el AOC E.

El suelo en el sitio abarca la arcilla arenosa de la unidad geológica del Qa con la arena cenagosa/arcillosa entremezclada de la superficie de la tierra a una profundidad de aproximadamente 35 pies en la vecindad del antiguo UST. Debajo de estos depósitos se encuentra un saprolito rico en arcilla desarrollado debajo de un lecho rocoso subyacente de la granodiorita.

Se ha observado que los niveles de agua subterránea en el sitio fluctúan por alrededor de 15 pies, ocurriendo una parte del tiempo en el saprolito y menos a menudo en la porción más

Note: This summary is presented in English and Spanish for the convenience of the reader. Every effort has been made for the translations to be as accurate as reasonably possible. However, readers should be aware that the English version of the text is the official version.

Nota: Este resumen se presenta en inglés y en español para la conveniencia del lector. Se han hecho todos los esfuerzos para que la traducción sea precisa en lo más razonablemente posible. Sin embargo, los lectores deben estar al tanto que el texto en inglés es la versión oficial.

baja de los depósitos sin consolidar directamente sobre el saprolito. La dirección del flujo de agua subterránea es de norte al noroeste hacia el Pasaje de Vieques. Los datos de estudios (pruebas de bombeo) de varios pozos de monitoreo del sitio sugieren una velocidad relativamente baja de aguas subterráneas (alrededor de 1 pie/año). Mientras que los datos de prueba de bombeo en el saprolito son propensos a un alto grado de incertidumbre, la ausencia general de contaminación en los pozos tan cercanos como a 50 pies vertiente abajo del antiguo UST tiende a apoyar este estimado de velocidad.

De acuerdo con la distribución de la contaminación detectada en el AOC E, los escapes del sitio ocurrieron total o principalmente como escapes del antiguo UST y tuberías asociadas. Los datos fueron recopilados a través de una serie de investigaciones durante las cuales, la superficie del suelo, subsuelos, productos libres, y muestras de aguas subterráneas fueron recopilados en y alrededor del área del antiguo UST y tuberías asociadas. La Figura ES-3 muestra todos los suelos y aguas subterráneas (pozos de monitoreo) y localizaciones de muestreo. La evaluación de los datos recopilados durante la investigación indica la presencia de los siguientes componentes en el suelo y/o aguas subterráneas en el sitio, posiblemente asociados con escapes del antiguo UST y tuberías asociadas:

- **Compuestos Orgánicos Volátiles (VOC, por sus siglas en inglés)**
 - Solventes de desengrasar tales como 1,2-dicloroetano (1,2-DCA), 1,2-diclorobenceno (1,2-DCB), y clorobenceno (las cantidades de solventes clorinados que pueden ser rastreados pueden encontrarse en aceites de motor usados y 1,2-DCB y clorobenceno también pueden ser asociados a productos derivados de petróleo)
 - Compuestos relacionados con combustible tales como benceno, tolueno, etilbenceno y xilenos (BTEX) y éter butílico metílico (MTBE)
- **Compuestos Orgánicos Semi-volátiles (SVOCs)**
 - Hidrocarburos aromáticos policíclicos (PAHs) relacionados a combustible tales como 2-metilnaftaleno, acenafteno, antraceno, benceno(a)antraceno, benzo(g,h,i)perileno, criseno, fluoreno, naftalina, fenantreno, y pireno
 - Hidrocarburos aromáticos heterocíclicos (HAHs) caprolactama y acetofenona
 - Ftalatos relacionados con aceite hidráulico bis(2-etilexil)ftalato y butilbencil-ftalato
- **Hidrocarburos de Petróleo Total (TPH)**
- **Inorgánicos**
 - Plomo (aún cuando casi todos los inorgánicos analizados se detectaron en los medios del AOC E, todos, menos el plomo, probablemente sean total o principalmente atribuibles al trasfondo)

Las Tablas ES-1 a la ES-3 presentan resúmenes estadísticos de los componentes detectados en los suelos de superficie, subsuelos, y aguas subterráneas respectivamente. Los datos

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fueron evaluados no solamente para determinar la naturaleza y extensión de la contaminación presente como resultado de escapes anteriores, pero también se compararon con los criterios de evaluación de UST de Puerto Rico para la salud humana y ecológica hacia un mejor entendimiento de la magnitud de los escapes. Esta comparación demuestra que hubo relativamente pocas detecciones de compuestos en el suelo o aguas subterráneas sobre los valores de clasificación, especialmente orgánicos, a excepción de los hidrocarburos de petróleo en los suelos. Además, las concentraciones elevadas en suelos y aguas subterráneas, (con respecto a los valores de clasificación) se limitan principalmente al área inmediata, bajo y alrededor del antiguo UST y tuberías asociadas.

La Figura ES-4 muestra un modelo conceptual de AOC E, incluyendo las características históricas y la ruta y grado de migración estimado de la contaminación. En base a las actividades históricas y la extensión de la contaminación identificada durante el RI e investigaciones relacionadas, se cree que el mecanismo de escape en el sitio hayan sido escapes en el antiguo UST y tuberías asociadas. Por lo tanto, la ruta primaria de migración de la contaminación probablemente sea causada por una fuga vertical a través del suelo al agua subterránea y transportación subsiguiente con el flujo de agua subterránea a través de espacios intersticiales en el saprolito (y a un grado inferior, vía el material sin consolidar que cubre el saprolito). Debido a que el saprolito consiste de arcilla relativamente "compacta", el índice de transportación de agua subterránea es probablemente muy bajo. Esta suposición es apoyada por la ausencia general de contaminación vertiente abajo del antiguo área UST y de la velocidad de flujo estimada relativamente baja del agua subterránea. Debido a la naturaleza de los materiales escapados, (Ej., aceite de motor usado), es probable que la presencia de contaminación residual en el suelo entre la base de la excavación del antiguo UST y tuberías asociadas y la zona saturada. Además, debido a la presencia anterior (y potencialmente actual) de productos flotantes en la tabla de aguas, la fluctuación de la superficie de agua subterránea probablemente haya creado una "zona manchada" de contaminación a lo largo de la extensión de fluctuación vertical.

El destino y transporte de los contaminantes presentes en un medio ambiental depende de muchos factores, tales como el tipo de contaminación, tipo de suelo, contenido de material orgánico, presencia y abundancia de microorganismos, condiciones climáticas, químicos del agua infiltrada e índice de migración de aguas subterráneas. La degradación de los contaminantes orgánicos detectados en el medio ambiental en el AOC E pueden ocurrir a través de bióticos (base biológica [biodegradación]) o proceso abiótico (base no-biológica). La mayoría de los contaminantes orgánicos detectados se biodegradan mayormente bajo condiciones aeróbicas (Ej., 1,2-DCA, BTEX, MTBE, TPH). Varios de los contaminantes han demostrado biodegradación bajo ambas condiciones, aeróbicas y anaeróbicas (Ej., naftaleno, 2-metilnaftaleno). El índice al cual ocurriría la biodegradación de estos contaminantes se basa en las condiciones específicas del sitio, incluyendo el ajuste de reducción de oxidación, la presencia y abundancia de microorganismos adecuados y las concentraciones de contaminantes presentes.

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Basado en la naturaleza, extensión y concentración de componentes detectados en el medio ambiental en el AOC E, se evaluaron riesgos potenciales ecológicos y para la salud humana. Según observado previamente, el área desarrollada y mantenida en y alrededor del sitio, provee un hábitat mínimo. De hecho, no se observó ningún hábitat preferido en el AOC E, tampoco se identificó ninguna especie amenazada o en peligro. Además, las concentraciones de componentes detectados en los suelos de superficie fueron comparables a las concentraciones de trasfondo. Por lo tanto, no se identificaron riesgos inaceptables para receptores potenciales ecológicos en el AOC E. Para los receptores potenciales humanos, se observa que el sitio actualmente está cercado y no se encuentran receptores humanos presentes excepto ocasionalmente (aproximadamente una vez al año) cuando los trabajadores de mantenimiento recortan la vegetación del sitio con una azada. Sin embargo, se evaluó la exposición a varios medios ambientales del sitio para usuarios recreativos hipotéticos, trabajadores de mantenimiento, trabajadores de construcción, trabajadores industriales, y residentes. De acuerdo a estas evaluaciones, no se identificó ningún riesgo inaceptable (sobre aquellos atribuibles al trasfondo) por exposición al suelo de receptores humanos hipotéticos. Los únicos riesgos inaceptables fueron identificados para el uso potable de aguas subterráneas por residentes futuros hipotéticos. La evaluación de riesgo identificó 1,2-DCA, MTBE, xilenos, 2-metilnaftaleno, y la naftalina como Químicos de Preocupación (COC, por sus siglas en inglés) en aguas subterráneas (COCs). Los inorgánicos fueron eliminados como COCs debido a que su presencia es total o principalmente atribuible al trasfondo.

De acuerdo con la información antes dicha, se concluye que los escapes de aceite usado ocurrieron durante las actividades de mantenimiento de vehículos, probablemente en forma de escapes del antiguo UST y tuberías asociadas. Estos escapes dieron lugar a la contaminación de suelos y aguas subterráneas. Sin embargo, la extensión de la contaminación generalmente es limitada a la vecindad inmediata del antiguo UST y tuberías asociadas, con la fuga vertical al agua subterránea representando la ruta de transportación primaria. La extensión de la contaminación se limita a un área relativamente pequeña debido a la naturaleza de los escapes (subsuelos), el tamaño del área de escape (el tamaño y extensión del UST y tuberías asociadas), y el material relativamente "compacto" a través del cual la contaminación debe viajar. Además, los niveles del contaminante en el suelo son relativamente bajos (con respecto a los niveles de clasificación basados en la salud humana y ecológica). De hecho, el uso potable del agua subterránea por los residentes es el único riesgo inaceptable identificado para el sitio. Además, solo benceno fue detectado en aguas subterráneas sobre los Niveles Máximos Federales de Contaminación (MCL, por sus siglas en inglés). Sin embargo, la contaminación residual de petróleo en suelos puede actuar como fuente de contaminación continua de aguas subterráneas, y se han detectado productos libres en los pozos en el área inmediata del antiguo UST y tuberías asociadas.

Según lo resumido anteriormente, aun cuando existen contaminantes presentes en suelos y aguas subterráneas en el sitio, solo la contaminación de aguas subterráneas presentan un riesgo inaceptable (bajo un escenario de uso potable) para futuros residentes hipotéticos. Sin embargo, la contaminación del suelo entre el fondo del antiguo UST/tuberías asociadas

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podría actuar como una fuente de contaminación continua de aguas subterráneas, incluyendo productos libres. Por las razones anteriores, se recomienda un Estudio de Viabilidad (FS, por sus siglas en inglés) para evaluar si hay alternativas de remediación técnicas y económicamente factibles para tratar la contaminación.

Se observa que los datos mas recientes de concentraciones de componentes en aguas subterráneas se remontan al año 2005. Debido a que hace aproximadamente dos años desde que se recogieron los datos de aguas subterráneas, se recomienda como parte del FS, se recoja otro conjunto de muestras de aguas subterráneas de todos los pozos del sitio y se analicen para los siguientes parámetros:

- VOCs
- SVOCs
- Inorgánicos totales y disueltos
- TPH-GRO, TPH-DRO, and TPH-ORO
- Nitrato, nitrito, sulfuro, sulfato, carbón orgánico total (TOC), alcalinidad, cloruro, metano, etano, eteno, hierro ferroso, y prueba funcional de genes para VOC y SVOC para los microbios de degradación, según apropiado

Al mismo tiempo de recoger las muestras de aguas subterráneas, se determinará el espesor de los productos libres. El espesor de los productos libres y un conjunto de datos adicionales de VOC y SVOC proveerá información sobre las condiciones actuales (así como también las temporales) que ayudarán a determinar alternativas factibles de remediación para el agua subterránea. A pesar de que las concentraciones de inorgánicos en aguas subterráneas probablemente sean atribuibles al trasfondo de acuerdo a los datos existentes, un conjunto de datos inorgánicos adicionales ayudaría a confirmar esta suposición. Los parámetros geoquímicos y microbianos adicionales se utilizarán para determinar el potencial de atenuación natural de los compuestos orgánicos y el potencial para la movilización de los inorgánicos. Si se observa producto libre en cualquiera de los pozos y la cantidad es suficiente para permitir una recolección, se recogerá una muestra del producto libre de un pozo y se analizará para los siguientes parámetros:

- Viscosidad
- Tensión Interfacial
- Densidad
- Hidrocarburo “huella”

Además de recoger datos adicionales del agua subterránea, existen varios parámetros de suelos que serían beneficiosos para determinar alternativas de remediación de suelo viables. Por ejemplo, la determinación de la viabilidad de las alternativas potenciales de remediación del suelo, tales como extracción de vapor del suelo, se puede realizar con

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información tal como la permeabilidad del suelo. Además, la determinación del potencial para que la contaminación residual del suelo actúe como una fuente de contaminación continua (y de producto potencialmente libre) al agua subterránea puede ser realizada con información tal como el potencial de fuga. Por lo tanto, se recomienda la recolección de los siguientes datos de suelo adicionales como parte del FS:

- Interior del suelo continuo (uno de debajo del antiguo UST y uno de debajo de la antigua tubería) a la cubierta de la zona saturada, con muestras de suelo recogidas a aproximadamente 5 pies (para tratar estratificación vertical) y analizados por:
 - VOCs
 - SVOCs
 - Inorgánicos
 - TPH-GRO, TPH-DRO, y TPH-ORO
 - TOC
 - Tamaño del grano
 - Densidad del volumen (si la muestra del suelo imperturbado puede ser recogida)
 - Porosidad (si la muestra del suelo imperturbado puede ser recogida)
 - Permeabilidad del suelo
 - Procedimiento de Fuga de Precipitación Sintética (SPLP)

Un estudio piloto de extracción multifacético (MPE, por sus siglas en inglés) se llevó a cabo durante el RI en el cual se extrajo producto libre, agua subterránea y vapor del suelo. Mientras que los resultados de este estudio piloto indican que la tecnología es potencialmente factible, luego de completarse las pruebas, el producto libre fue devuelto a los pozos de pruebas. Esto pudo haber sido debido relativamente al corto periodo de tiempo en el cual el estudio experimental fue realizado (Ej., aproximadamente 2 meses). Además es posible que la zona de alcance de tratamiento no fuese suficiente para tratar la extensión vertical de la contaminación residual de suelo. Por lo tanto, si la Marina determina que un estudio piloto adicional proveería más información beneficiosa para la evaluación de alternativa(s) en el FS, el FS será diferido y un plan de trabajo para estudio piloto será sometido temporalmente para revisión de la agencia.

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TABLE ES-1
 Surface Soil Summary Statistics
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Chemical Name	Vieques Human Health Screening Value	Vieques Ecological Screening Value	PREQB UST Corrective Action Criteria	Number of Analyses	Number of Detects ²	Range of Concentrations ²	Number of Detects Above Human Health Screening Value ²	Number of Detects Above Ecological Screening Value ²	Number of Detects Above PREQB UST Corrective Action Criteria ²
Chemical Name									
Volatile Organic Compounds (µg/kg)									
No Detections									
Semi-volatile Organic Compounds (µg/kg)									
Acetophenone	780,000	--	--	7	1	88	0	NA	NA
Di-n-octylphthalate	240,000	--	--	7	1	350	0	NA	NA
bis(2-Ethylhexyl)phthalate	35,000	10,000	--	7	1	330	0	0	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)									
4,4'-DDD	2,400	10	--	7	1	2.1	0	0	NA
4,4'-DDE	1,700	10	--	7	1	8.4	0	0	NA
4,4'-DDT	1,700	10	--	7	1	3.6	0	0	NA
Aroclor-1260	110	40,000	--	7	1	12	0	0	NA
Total Metals (mg/kg)									
Aluminum	7,600	--	--	7	0	NA	0	NA	NA
Antimony	3.1	78	--	7	0	NA	0	0	NA
Arsenic	0.39	18	--	7	0	NA	0	0	NA
Barium	1,600	330	--	7	0	NA	0	0	NA
Cadmium	3.7	32	--	7	2	0.58-0.82	0	0	NA
Calcium	--	--	--	7	0	NA	NA	NA	NA
Chromium	210	0.4	--	7	0	NA	0	0	NA
Cobalt	140	13	--	7	0	NA	0	0	NA
Copper	310	70	--	7	0	NA	0	0	NA
Iron	2,300	--	--	7	0	NA	0	NA	NA
Lead	400 ¹	120	50	7	5	11.6-52.1	0	0	1
Magnesium	--	--	--	7	0	NA	NA	NA	NA
Manganese	180	220	--	7	0	NA	0	0	NA
Mercury	2.3	0.1	--	7	0	NA	0	0	NA
Nickel	160	38	--	7	0	NA	0	0	NA
Potassium	--	--	--	7	0	NA	NA	NA	NA
Sodium	--	--	--	7	0	NA	NA	NA	NA
Vanadium	7.8	2	--	7	0	NA	0	0	NA
Zinc	2,300	120	--	7	1	82.7	0	0	NA
Total Petroleum Hydrocarbons (mg/kg)									
TPH-diesel range	--	--	100	7	0	NA	0	0	0
TPH-oil range	--	--	100	7	2	190-270	NA	NA	2

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ Lead Action Level

² For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE ES-2

Subsurface Soil Detection Summary
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Chemical Name	Vieques Human Health Screening Value	PREQB UST Corrective Action Criteria	Number of Analyses	Number of Detects ²	Range of Concentrations ²	Number of Detects Above Human Health Screening Value ^c	Number of Detects Above PREQB UST Corrective Action Criteria ^c
Volatile Organic Compounds (µg/kg)							
1,2-Dichlorobenzene	110,000		8	4	2-54	0	NA
Acetone	1,400,000		8	1	5	0	NA
Benzene	640	5,000	31	7	0.31-4,150	1	0
Ethylbenzene	190,000	10,000	31	13	0.25-14,200	0	1
Isopropylbenzene	57,000		8	4	8-370	0	NA
Methyl-tert-butyl ether (MTBE)	17,000		8	1	4	0	NA
Methylcyclohexane	260,000		8	3	2-220	0	NA
Toluene	630,000	10,000	31	8	1.1-2,750	0	0
Xylene, total	27,000	10,000	31	10	18.7-90,600	1	4
Semi-volatile Organic Compounds (µg/kg)							
1,1-Biphenyl	300,000		8	2	310-330	0	NA
2-Methylnaphthalene	31,000		8	4	77-6,000	0	NA
Acenaphthene	370,000		8	1	140	0	NA
Anthracene	2,200,000		8	1	78	0	NA
Benzo(a)anthracene	620		8	2	100-130	0	NA
Benzo(g,h,i)perylene	230,000		8	1	130-160	0	NA
Butylbenzylphthalate	1,200,000		8	1	210	0	NA
Chrysene	62,000		8	2	130	0	NA
Fluoranthene	230,000		8	2	130-160	0	NA
Fluorene	270,000		8	1	190	0	NA
Naphthalene	5,600		8	2	3,100-3,500	0	NA
Phenanthrene	2,200,000		8	3	370-590	0	NA
Pyrene	230,000		8	2	230-320	0	NA
bis(2-Ethylhexyl)phthalate	35,000		8	5	99-700	0	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)							
4,4'-DDE	1,700		8	2	1.5-7.8	0	NA
4,4'-DDT	1,700		8	1	9.2	0	NA
Aldrin	29		8	1	1.1	0	NA
Aroclor-1254	110		8	1	15	0	NA
Endrin aldehyde	1,800		8	1	2.1	0	NA
alpha-BHC	90		8	2	4.1-5.3	0	NA
gamma-Chlordane	1,600		8	2	5-8.3	0	NA
Total Metals (mg/kg)							
Aluminum	7,600		8	0	NA	NA	NA
Antimony	3.1		8	0	NA	NA	NA
Arsenic	0.39		8	0	NA	NA	NA
Barium	1,600		8	0	NA	NA	NA
Calcium	--		8	0	NA	NA	NA
Chromium	210		8	0	NA	NA	NA
Cobalt	140		8	0	NA	NA	NA
Copper	310		8	1	75.8	0	NA
Iron	2,300		8	2	39,800-43,000	1	NA
Lead ¹	400	50	8	1	11.9	0	0
Magnesium	--		8	2	18,600-19,300	NA	NA
Manganese	180		8	0	NA	NA	NA
Nickel	160		8	0	NA	NA	NA
Potassium	--		8	0	NA	NA	NA
Silver	39		8	1	0.29	0	NA
Sodium	--		8	0	NA	NA	NA
Vanadium	7.8		8	0	NA	NA	NA
Zinc	2,300		8	0	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)							
Oil and Grease	--	100	19	11	63.1-19,300	NA	8
TPH-diesel range	--	100	16	5	9.4-490	NA	3
TPH-gas range	--	100	16	6	0.12-42,000	NA	1
TPH-oil range	--	100	16	6	180-2,600	NA	6
Total Petroleum Hydrocarbons, C10-C28	--	100	19	9	4.7-3,780	NA	6
Total Petroleum Hydrocarbons, C6-C10	--	100	19	8	0.012-2,150	NA	5
Total recoverable TPH	--	100	8	8	80-36,000	NA	6

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ Lead Action Level

² For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE ES-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	1998					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ²
Volatile Organic Compounds (µg/L)									
1,2-Dichlorobenzene	37	600		0	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.12	5		0	NA	NA	NA	NA	NA
Acetone	550	--		0	NA	NA	NA	NA	NA
Benzene	0.35	5	5	2	1	17	1	1	1
Chlorobenzene	11	100		0	NA	NA	NA	NA	NA
Chloroform	0.17	80		0	NA	NA	NA	NA	NA
Cyclohexane	1,000	--		0	NA	NA	NA	NA	NA
Ethylbenzene	130	700	700	2	0	NA	NA	NA	NA
Isopropylbenzene	66	--		0	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	11	--		0	NA	NA	NA	NA	NA
Methylcyclohexane	520	--		0	NA	NA	NA	NA	NA
Toluene	230	1,000	1,000	2	0	NA	NA	NA	NA
Xylene, total	--	10,000	10,000	2	0	NA	NA	NA	NA
m- and p-Xylene	21	--		0	NA	NA	NA	NA	NA
o-Xylene	21	--		0	NA	NA	NA	NA	NA
Semi-volatile Organic Compounds(µg/L)									
2-Methylnaphthalene	2.4	--		0	NA	NA	NA	NA	NA
Acenaphthene	37	--		0	NA	NA	NA	NA	NA
Acetophenone	61	--		0	NA	NA	NA	NA	NA
Butylbenzylphthalate	730	--		0	NA	NA	NA	NA	NA
Caprolactam	1,800	--		0	NA	NA	NA	NA	NA
Di-n-butylphthalate	360	--		0	NA	NA	NA	NA	NA
Diethylphthalate	2,900	--		0	NA	NA	NA	NA	NA
Fluorene	24	--		0	NA	NA	NA	NA	NA
Naphthalene	0.62	--		0	NA	NA	NA	NA	NA
Phenanthrene	18	--		0	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	4.8	6		0	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/L)									
Dieldrin	0.0042	--		0	NA	NA	NA	NA	NA
Total Metals (µg/L)									
Aluminum	3,600	--		0	NA	NA	NA	NA	NA
Amenable cyanide	--	--		0	NA	NA	NA	NA	NA
Antimony	1.5	6		0	NA	NA	NA	NA	NA
Arsenic	0.045	10		0	NA	NA	NA	NA	NA
Barium	730	2,000		0	NA	NA	NA	NA	NA
Beryllium	7.3	4		0	NA	NA	NA	NA	NA
Cadmium	1.8	5		0	NA	NA	NA	NA	NA
Calcium	--	--		0	NA	NA	NA	NA	NA
Chromium	11	100		0	NA	NA	NA	NA	NA
Cobalt	73	--		0	NA	NA	NA	NA	NA
Copper	150	1,300		0	NA	NA	NA	NA	NA
Cyanide	73	200		0	NA	NA	NA	NA	NA
Iron	1,100	--		0	NA	NA	NA	NA	NA
Lead	15	15	50	0	NA	NA	NA	NA	NA
Magnesium	--	--		0	NA	NA	NA	NA	NA
Manganese	88	--		0	NA	NA	NA	NA	NA
Mercury	1.1	2		0	NA	NA	NA	NA	NA
Nickel	73	--		0	NA	NA	NA	NA	NA
Potassium	--	--		0	NA	NA	NA	NA	NA
Selenium	18	50		0	NA	NA	NA	NA	NA
Silver	18	--		0	NA	NA	NA	NA	NA
Sodium	--	--		0	NA	NA	NA	NA	NA
Thallium	0.24	2		0	NA	NA	NA	NA	NA
Vanadium	3.6	--		0	NA	NA	NA	NA	NA
Zinc	1,100	--		0	NA	NA	NA	NA	NA
Dissolved Metals (µg/L)									
Aluminum	3,600	--		0	NA	NA	NA	NA	NA
Antimony	1.5	6		0	NA	NA	NA	NA	NA
Arsenic	0.045	10		0	NA	NA	NA	NA	NA
Barium	730	2,000		0	NA	NA	NA	NA	NA
Beryllium	7.3	4		0	NA	NA	NA	NA	NA
Cadmium	1.8	5		0	NA	NA	NA	NA	NA
Calcium	--	--		0	NA	NA	NA	NA	NA
Chromium	11	100		0	NA	NA	NA	NA	NA
Cobalt	73	--		0	NA	NA	NA	NA	NA
Copper	150	1,300		0	NA	NA	NA	NA	NA
Iron	1,100	--		0	NA	NA	NA	NA	NA
Lead	15	15	50	0	NA	NA	NA	NA	NA
Magnesium	--	--		0	NA	NA	NA	NA	NA
Manganese	88	--		0	NA	NA	NA	NA	NA
Nickel	73	--		0	NA	NA	NA	NA	NA
Potassium	--	--		0	NA	NA	NA	NA	NA
Selenium	18	50		0	NA	NA	NA	NA	NA
Silver	18	--		0	NA	NA	NA	NA	NA
Sodium	--	--		0	NA	NA	NA	NA	NA
Thallium	0.24	2		0	NA	NA	NA	NA	NA
Vanadium	3.6	--		0	NA	NA	NA	NA	NA
Zinc	1,100	--		0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (µg/L)									
TPH-gas range	--	--	50,000	2	0	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	0	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	50,000	2	0	NA	NA	NA	NA

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE ES-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	2000						2002					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹	Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹
Volatile Organic Compounds (µg/L)															
1,2-Dichlorobenzene	37	600		4	2	3 - 4	0	0	NA	4	1	4.5	0	0	NA
1,2-Dichloroethane	0.12	5		4	1	32	1	1	NA	4	1	4.9	1	0	NA
Acetone	550	--		4	3	10 - 12	0	NA	NA	4	0	NA	NA	NA	NA
Benzene	0.35	5	5	4	2	2 - 6	2	1	1	4	1	0.72	1	0	0
Chlorobenzene	11	100		4	0	NA	NA	NA	NA	4	1	1.4	0	0	NA
Chloroform	0.17	80		4	0	NA	NA	NA	NA	4	1	0.39	1	0	NA
Cyclohexane	1,000	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Ethylbenzene	130	700	700	4	1	0.9	0	0	0	4	0	NA	NA	NA	NA
Isopropylbenzene	66	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	11	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Methylcyclohexane	520	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Toluene	230	1,000	1,000	4	1	0.3	0	0	0	4	0	NA	NA	NA	NA
Xylene, total	--	10,000	10,000	4	2	0.9 - 20	NA	0	0	4	0	NA	NA	NA	NA
m- and p-Xylene	21	--		4	2	0.9 - 17	0	NA	NA	0	NA	NA	NA	NA	NA
o-Xylene	21	--		4	1	3	0	NA	NA	0	NA	NA	NA	NA	NA
Semi-volatile Organic Compounds(µg/L)															
2-Methylnaphthalene	2.4	--		4	1	14	1	NA	NA	4	0	NA	NA	NA	NA
Acenaphthene	37	--		4	0	NA	NA	NA	NA	4	1	0.55	0	NA	NA
Acetophenone	61	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Butylbenzylphthalate	730	--		4	1	0.4	0	NA	NA	4	0	NA	NA	NA	NA
Caprolactam	1,800	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Di-n-butylphthalate	360	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Diethylphthalate	2,900	--		4	1	0.6	0	NA	NA	4	0	NA	NA	NA	NA
Fluorene	24	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Naphthalene	0.62	--		4	1	15	1	NA	NA	4	0	NA	NA	NA	NA
Phenanthrene	18	--		4	1	0.6	0	NA	NA	4	0	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	4.8	6		4	1	1	0	0	NA	4	0	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/L)															
Dieldrin	0.0042	--		4	1	0.11	0	NA	NA	0	NA	NA	NA	NA	NA
Total Metals (µg/L)															
Aluminum	3,600	--		4	4	2,020 - 106,000	2	NA	NA	4	4	851 - 38,600	1	NA	NA
Amenable cyanide	--	--		0	NA	NA	NA	NA	NA	4	2	5.52 - 7.18	NA	NA	NA
Antimony	1.5	6		4	3	1.9 - 5.6	3	0	NA	4	0	NA	NA	NA	NA
Arsenic	0.045	10		4	1	3.5	1	0	NA	4	2	2.1 - 3.2	2	0	NA
Barium	730	2,000		4	3	269 - 826	1	0	NA	4	3	127 - 624	0	0	NA
Beryllium	7.3	4		4	1	0.55	0	0	NA	4	3	0.39 - 0.42	0	0	NA
Cadmium	1.8	5		4	0	NA	NA	NA	NA	4	1	0.48	0	0	NA
Calcium	--	--		4	3	103,000 - 121,000	NA	NA	NA	4	2	70,100 - 127,000	NA	NA	NA
Chromium	11	100		4	2	110 - 141	2	2	NA	4	4	4.3 - 59.2	2	0	NA
Cobalt	73	--		4	2	36.1 - 118	1	NA	NA	4	3	2 - 13.2	0	NA	NA
Copper	150	1,300		4	2	144 - 247	1	0	NA	4	2	8.5 - 74.1	0	0	NA
Cyanide	73	200		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Iron	1,100	--		4	2	66,000 - 180,000	2	NA	NA	4	4	990 - 32,100	3	NA	NA
Lead	15	15	50	4	4	1.5 - 11.7	0	0	0	4	1	2.8	0	0	0
Magnesium	--	--		4	3	48,900 - 101,000	NA	NA	NA	4	2	45,900 - 66,300	NA	NA	NA
Manganese	88	--		4	3	3,340 - 6,490	3	NA	NA	4	4	79.4 - 6,410	3	NA	NA
Mercury	1.1	2		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Nickel	73	--		4	3	24.4 - 87.7	1	NA	NA	4	4	3.8 - 37.4	0	NA	NA
Potassium	--	--		4	2	10,400 - 12,000	NA	NA	NA	4	1	8,360	NA	NA	NA
Selenium	18	50		4	1	5.6	0	0	NA	4	2	4.4 - 5.5	0	0	NA
Silver	18	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Sodium	--	--		4	3	137,000 - 152,000	NA	NA	NA	4	1	146,000	NA	NA	NA
Thallium	0.24	2		4	0	NA	NA	NA	NA	4	2	5.2 - 6.6	2	2	NA
Vanadium	3.6	--		4	2	175 - 489	2	NA	NA	4	4	14.2 - 90.3	4	NA	NA
Zinc	1,100	--		4	2	248 - 377	0	NA	NA	4	2	60.5 - 134	0	NA	NA
Dissolved Metals (µg/L)															
Aluminum	3,600	--		4	0	NA	NA	NA	NA	4	2	84.6 - 84.9	0	NA	NA
Antimony	1.5	6		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Arsenic	0.045	10		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Barium	730	2,000		4	2	173 - 247	0	0	NA	4	3	118 - 413	0	0	NA
Beryllium	7.3	4		4	0	NA	NA	NA	NA	4	1	0.37	0	0	NA
Cadmium	1.8	5		4	1	0.46	0	0	NA	4	0	NA	NA	NA	NA
Calcium	--	--		4	2	89,400 - 99,500	NA	NA	NA	4	2	69,200 - 117,000	NA	NA	NA
Chromium	11	100		4	1	3.9	0	0	NA	4	3	1.3 - 3.6	0	0	NA
Cobalt	73	--		4	1	2.8	0	NA	NA	4	1	1.8	0	NA	NA
Copper	150	1,300		4	0	NA	NA	NA	NA	4	1	5	0	0	NA
Iron	1,100	--		4	0	NA	NA	NA	NA	4	1	1320	1	NA	NA
Lead	15	15	50	4	3	1.2 - 1.6	0	0	0	4	0	NA	NA	NA	NA
Magnesium	--	--		4	2	44,000 - 45,600	NA	NA	NA	4	2	45,400 - 59,100	NA	NA	NA
Manganese	88	--		4	2	2,510 - 3,110	2	NA	NA	4	2	77 - 5,450	1	NA	NA
Nickel	73	--		4	3	4.5 - 6.3	0	NA	NA	4	1	4.9	0	NA	NA
Potassium	--	--		4	1	6,440	NA	NA	NA	4	1	3,740	NA	NA	NA
Selenium	18	50		4	2	2.4 - 4.6	0	0	NA	4	2	3 - 4.3	0	0	NA
Silver	18	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Sodium	--	--		4	3	133,000 - 151,000	NA	NA	NA	4	1	150,000	NA	NA	NA
Thallium	0.24	2		4	0	NA	NA	NA	NA	4	2	5.8 - 6.4	2	2	NA
Vanadium	3.6	--		4	0	NA	NA	NA	NA	4	2	12.9 - 15.1	2	NA	NA
Zinc	1,100	--		4	0	NA	NA	NA	NA	4	1	68.4	0	NA	NA
Total Petroleum Hydrocarbons (µg/L)															
TPH-gas range	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE ES-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

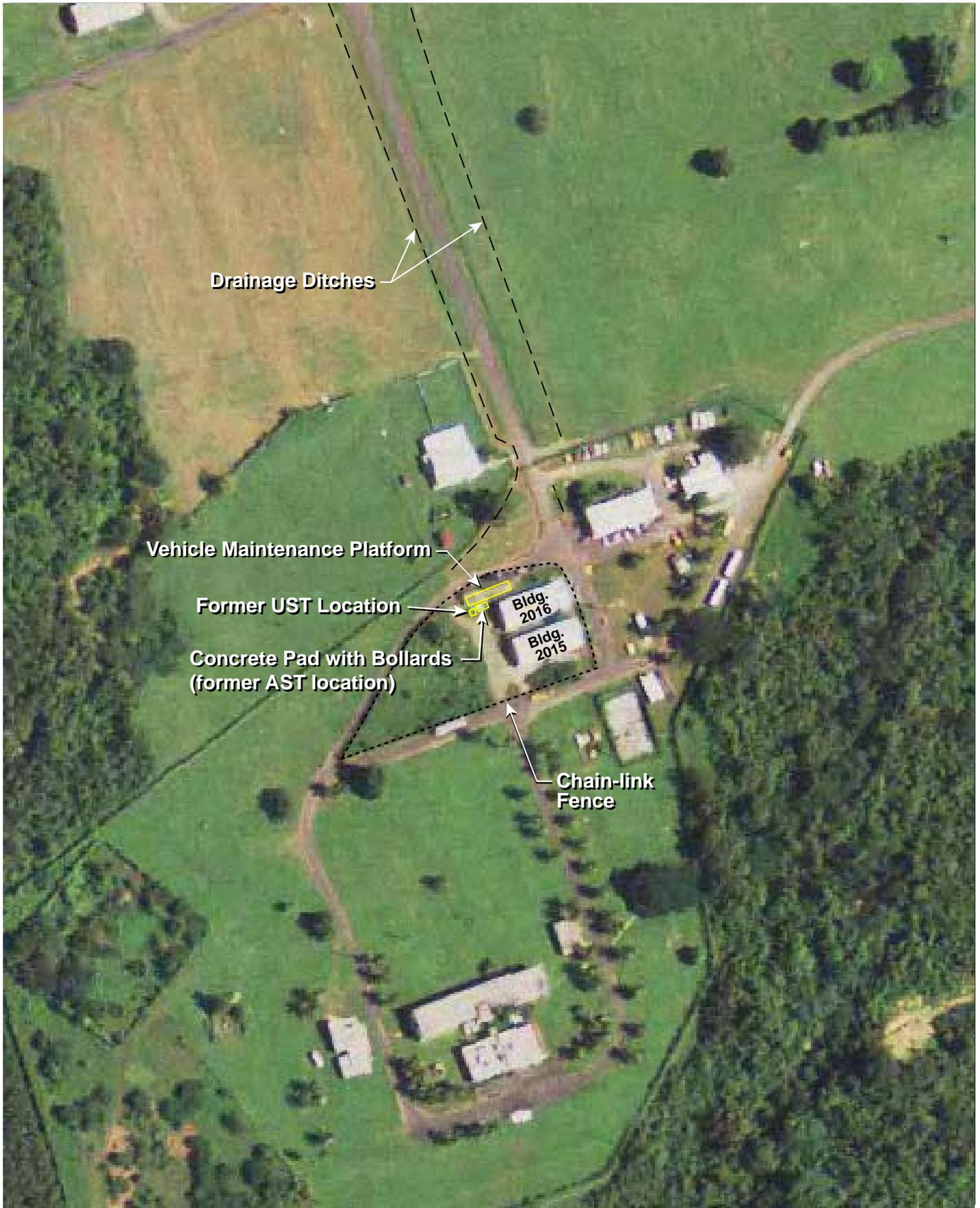
Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	2004						2005					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹	Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹
Volatile Organic Compounds (µg/L)															
1,2-Dichlorobenzene	37	600		7	3	3.7 - 4.6	0	0	NA	0	NA	NA	NA	NA	
1,2-Dichloroethane	0.12	5		7	2	0.59 - 7.2	2	1	NA	0	NA	NA	NA	NA	
Acetone	550	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Benzene	0.35	5	5	7	3	0.21 - 4.1	2	0	0	0	NA	NA	NA	NA	
Chlorobenzene	11	100		7	3	0.69 - 1.1	0	0	NA	0	NA	NA	NA	NA	
Chloroform	0.17	80		7	3	0.3 - 1.2	3	0	NA	0	NA	NA	NA	NA	
Cyclohexane	1,000	--		7	2	0.31 - 1.3	0	NA	NA	0	NA	NA	NA	NA	
Ethylbenzene	130	700	700	7	2	0.71 - 10.9	0	0	0	0	NA	NA	NA	NA	
Isopropylbenzene	66	--		7	2	0.22 - 6.3	0	NA	NA	0	NA	NA	NA	NA	
Methyl-tert-butyl ether (MTBE)	11	--		7	3	234 - 1,220	3	NA	NA	0	NA	NA	NA	NA	
Methylcyclohexane	520	--		7	3	0.61 - 2.9	0	NA	NA	0	NA	NA	NA	NA	
Toluene	230	1,000	1,000	7	2	0.21 - 0.3	0	0	0	0	NA	NA	NA	NA	
Xylene, total	--	10,000	10,000	7	2	1.8 - 26.2	NA	0	0	0	NA	NA	NA	NA	
m- and p-Xylene	21	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	
o-Xylene	21	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	
Semi-volatile Organic Compounds(µg/L)															
2-Methylnaphthalene	2.4	--		7	1	12	1	NA	NA	0	NA	NA	NA	NA	
Acenaphthene	37	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Acetophenone	61	--		7	1	8.1	0	NA	NA	0	NA	NA	NA	NA	
Butylbenzylphthalate	730	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Caprolactam	1,800	--		7	2	6.8 - 33	0	NA	NA	0	NA	NA	NA	NA	
Di-n-butylphthalate	360	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Diethylphthalate	2,900	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Fluorene	24	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Naphthalene	0.62	--		7	1	9.5	1	NA	NA	0	NA	NA	NA	NA	
Phenanthrene	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
bis(2-Ethylhexyl)phthalate	4.8	6		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Pesticide/Polychlorinated Biphenyls (µg/L)															
Dieldrin	0.0042	--		5	2	0.0019 - 0.027	1	NA	NA	0	NA	NA	NA	NA	
Total Metals (µg/L)															
Aluminum	3,600	--		7	6	147 - 287	0	NA	NA	0	NA	NA	NA	NA	
Amenable cyanide	--	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	
Antimony	1.5	6		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Arsenic	0.045	10		7	7	10.1 - 15.2	7	7	NA	0	NA	NA	NA	NA	
Barium	730	2,000		7	4	186 - 405	0	0	NA	0	NA	NA	NA	NA	
Beryllium	7.3	4		7	1	0.23	0	0	NA	0	NA	NA	NA	NA	
Cadmium	1.8	5		7	1	7.2	1	1	NA	0	NA	NA	NA	NA	
Calcium	--	--		7	3	81,200 - 117,000	NA	NA	NA	0	NA	NA	NA	NA	
Chromium	11	100		7	6	3.45 - 28	1	0	NA	0	NA	NA	NA	NA	
Cobalt	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Copper	150	1,300		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Cyanide	73	200		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Iron	1,100	--		7	7	130 - 3,190	3	NA	NA	0	NA	NA	NA	NA	
Lead	15	15	50	7	3	4.12 - 5.15	0	0	0	0	NA	NA	NA	NA	
Magnesium	--	--		7	4	48,700 - 61,800	NA	NA	NA	0	NA	NA	NA	NA	
Manganese	88	--		7	3	1,990 - 5,810	3	NA	NA	0	NA	NA	NA	NA	
Mercury	1.1	2		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Nickel	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Potassium	--	--		7	2	1,940 - 2,400	NA	NA	NA	0	NA	NA	NA	NA	
Selenium	18	50		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Silver	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Sodium	--	--		7	3	152,000 - 165,000	NA	NA	NA	0	NA	NA	NA	NA	
Thallium	0.24	2		7	2	0.232 - 0.237	0	0	NA	0	NA	NA	NA	NA	
Vanadium	3.6	--		7	4	13.9 - 17.1	4	NA	NA	0	NA	NA	NA	NA	
Zinc	1,100	--		7	4	2.99 - 5.2	0	NA	NA	0	NA	NA	NA	NA	
Dissolved Metals (µg/L)															
Aluminum	3,600	--		7	2	95.4 - 211	0	NA	NA	0	NA	NA	NA	NA	
Antimony	1.5	6		7	1	3.25	1	0	NA	0	NA	NA	NA	NA	
Arsenic	0.045	10		7	5	12.5 - 16.7	5	5	NA	0	NA	NA	NA	NA	
Barium	730	2,000		7	4	186 - 403	0	0	NA	0	NA	NA	NA	NA	
Beryllium	7.3	4		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Cadmium	1.8	5		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Calcium	--	--		7	4	62,600 - 114,000	NA	NA	NA	0	NA	NA	NA	NA	
Chromium	11	100		7	5	1.82 - 3.85	0	0	NA	0	NA	NA	NA	NA	
Cobalt	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Copper	150	1,300		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Iron	1,100	--		7	5	62.9 - 2,880	1	NA	NA	0	NA	NA	NA	NA	
Lead	15	15	50	7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Magnesium	--	--		7	4	42,200 - 60,600	NA	NA	NA	0	NA	NA	NA	NA	
Manganese	88	--		7	3	1,980 - 6,080	3	NA	NA	0	NA	NA	NA	NA	
Nickel	73	--		7	3	254 - 343	3	NA	NA	0	NA	NA	NA	NA	
Potassium	--	--		7	2	2,000 - 2,390	NA	NA	NA	0	NA	NA	NA	NA	
Selenium	18	50		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Silver	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	
Sodium	--	--		7	3	150,000 - 166,000	NA	NA	NA	0	NA	NA	NA	NA	
Thallium	0.24	2		7	1	0.344	1	0	NA	0	NA	NA	NA	NA	
Vanadium	3.6	--		7	4	13.4 - 17.8	4	NA	NA	0	NA	NA	NA	NA	
Zinc	1,100	--		7	4	4.26 - 15.5	0	NA	NA	0	NA	NA	NA	NA	
Total Petroleum Hydrocarbons (µg/L)															
TPH-gas range	--	--	50,000	0	NA	NA	NA	NA	NA	5	1	180	NA	NA	0
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	5	2	460 - 610	NA	NA	NA	0	NA	NA	NA	NA	
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	5	2	36 - 160	NA	NA	NA	0	NA	NA	NA	NA	
Total recoverable TPH	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

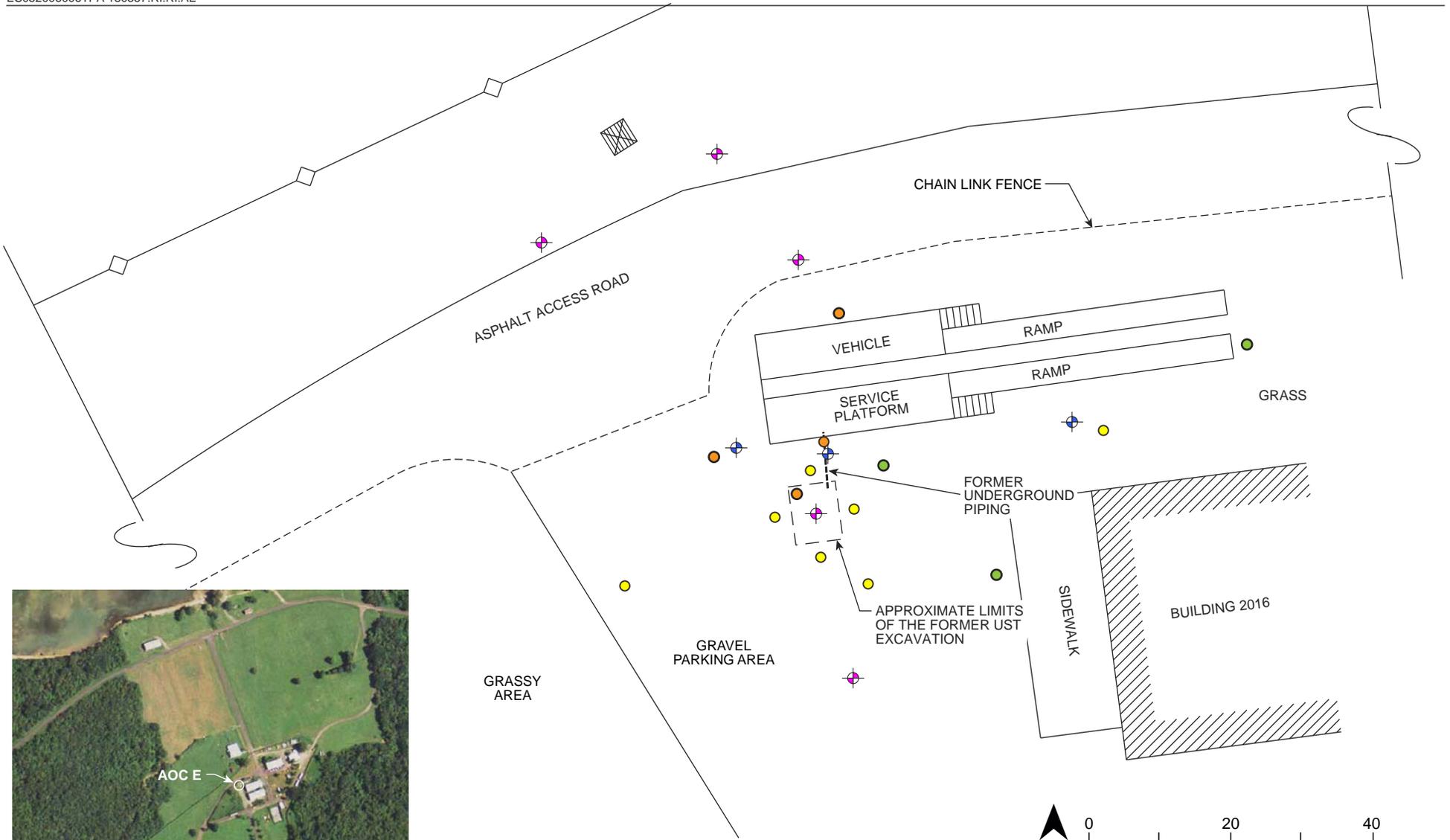
¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.



0 150 300 Feet



FIGURE ES-2
2004 Aerial Photograph of AOC E
AOC E Remedial Investigation Report
Vieques, Puerto Rico



2004 Aerial Photograph

LEGEND

- Subsurface Soil Location
- Surface Soil Location
- Surface and Subsurface Soil Location
- ⊕ Monitoring Well Location
- ⊕ Monitoring Well and Subsurface Soil Location

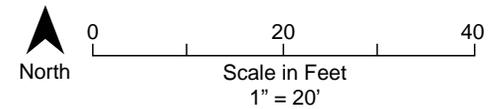
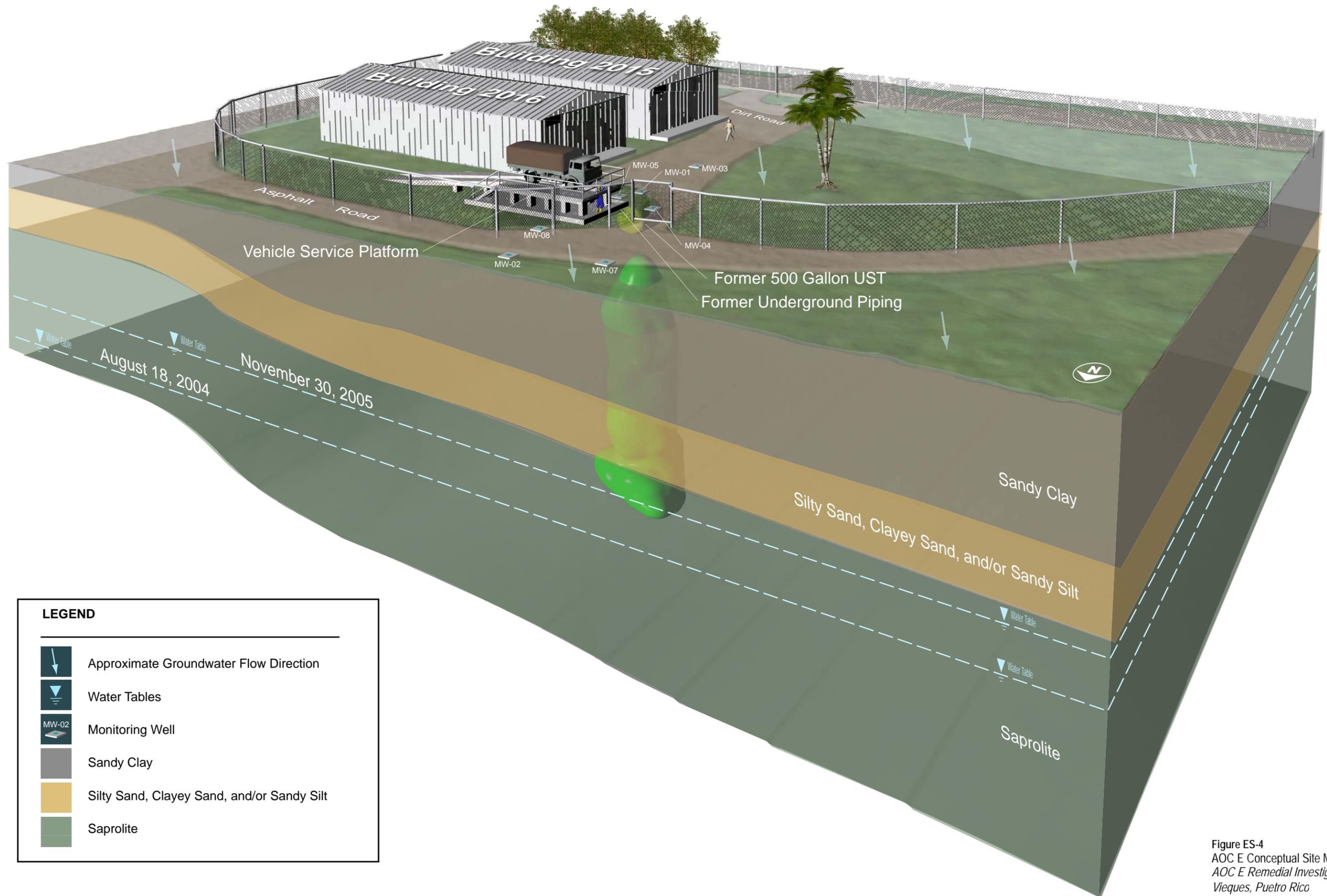


FIGURE ES-3
Surface Soil, Subsurface Soil,
and Monitoring Well Location Map
AOC E Remedial Investigation Report
Vieques, Puerto Rico



LEGEND

-  Approximate Groundwater Flow Direction
-  Water Tables
-  Monitoring Well
-  Sandy Clay
-  Silty Sand, Clayey Sand, and/or Sandy Silt
-  Saprolite

Figure ES-4
 AOC E Conceptual Site Model
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Introduction

This report is the Remedial Investigation (RI) Report for Area of Concern (AOC) E, located at the former Naval Ammunition Support Detachment (NASD), Vieques, Puerto Rico. The report summarizes the historical activities and investigations that took place at AOC E, as well as the nature and extent of the contamination and associated assessment of current and potential future risks to human health and the environment.

On March 14, 2005, Vieques was placed on the National Priority List (NPL), which required all subsequent environmental restoration activities for Navy Installation Restoration (IR) sites on Vieques be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) unless and until removed from CERCLA authority.

This RI report has been prepared on behalf of the Naval Facilities Engineering Command, Atlantic (NAVFAC, Atlantic) by CH2M HILL under Navy Contract N62470-02-D-3052, Navy Comprehensive Long-Term Environmental Action (CLEAN III), Contract Task Order 007.

1.1 Objective

The objective of this RI is to sufficiently delineate the nature and extent of potential contamination from the former 500-gallon underground storage tank (UST) such that the potential human health and ecological risks can be appropriately assessed and remedial action determinations made.

1.2 Scope of Work

The following scope of work was completed in order to achieve the objective of the RI:

- Review and incorporation of relevant results from previous investigations at AOC E. These investigations comprised the UST closure (Reliable Mechanical, Inc., 1997), the Site Characterization (CH2M HILL, 1999), the Environmental Baseline Survey (EBS) (Program Management Company, 2000), and the Expanded Preliminary Assessment/Site Investigation (PA/SI) (CH2M HILL, 2000a).
- Collection of surface soil, subsurface soil, and groundwater samples during the RI to sufficiently delineate the nature and extent of contamination.
- Collection of lithologic data during soil borings to characterize the site geology.
- Collection of groundwater level and aquifer permeability data to characterize the site hydrogeology.

- Quantitative assessment of potential human health risks in accordance with the Human Health Risk Assessment Protocol contained within the *Master Quality Assurance Project Plan, Environmental Restoration Program, Vieques, Puerto Rico* (CH2M HILL, 2007).
- Quantitative assessment of potential ecological risks in accordance with the Ecological Risk Assessment Protocol contained within the *Master Quality Assurance Project Plan, Environmental Restoration Program, Vieques, Puerto Rico* (CH2M HILL, 2007).

A multi-phase extraction (MPE) pilot study was also conducted during the RI to assess the effectiveness of this technology in mitigating subsurface free phase product accumulation near the source area.

The field data collection was completed in accordance with the following documents:

- *Closure Plan For Underground Storage Tank (UST) Systems, Naval Station Roosevelt Roads, Puerto Rico* (Dames & Moore, 1995).
- *Work Plan and Health and Safety Plan for Underground Storage Tank Sites Nos. 2016, 34, 229, 2016, 2842, 429R, 724, 1817 – Roosevelt Roads Naval Station, Ceiba, Puerto Rico* (CH2M HILL, 1998).
- *Site-Specific Work Plan for the U.S. Naval Ammunition Storage Detachment, Vieques, Puerto Rico* (CH2M HILL, 2000b).
- *Master Work Plan for the U.S. Naval Ammunition Storage Detachment, Vieques, Puerto Rico* (CH2M HILL, 2000c).
- *Remedial Investigation/Feasibility Study Work Plan for Area of Concern E at Former U.S. Naval Ammunition Support Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2002a).
- *Master Work Plan for the Former U.S. Naval Ammunition Support Detachment, Vieques, Puerto Rico* (CH2M HILL, 2001).
- *Supplemental Remedial Investigation Work Plan for Area of Concern (AOC) E, The Former U.S. Naval Ammunition Support Detachment (NASD), Vieques Island, Puerto Rico* (CH2M HILL, 2005).

1.3 Organization of the RI Report

The RI Report is organized as follows:

Section 1, Introduction, presents a summary of the objective and scope of the RI and the organization of the RI Report, as well as a discussion of the regulatory status of the site.

Section 2, Site History, Physical Setting, and Previous Investigations, presents general information about AOC E, such as its former uses, climate, topography, geology and hydrogeology, and natural and cultural resources.

Section 3, Summary of Field Investigations, presents site-specific descriptions and summaries of the various tasks completed as part of the RI for AOC E. In addition, Section 3 presents the data management and quality control (QC) measures used during collection of AOC E-related data and the data quality evaluation (DQE).

Section 4, Nature and Extent of Contamination, discusses the nature and extent of soil and groundwater contamination present at AOC E.

Section 5, Contaminant Fate and Transport, presents an evaluation of the fate and transport of potential contaminants at the site in the context of the conceptual site model (CSM).

Section 6, Human Health Risk Assessment Summary, summarizes the results of the human health risk assessment (HHRA) for AOC E.

Section 7, Ecological Risk Assessment Summary, summarizes the results of the ecological risk assessment (ERA) for AOC E.

Section 8, Summary, Conclusions, and Recommendations, summarizes the evaluation of information collected for the site and presents the conclusions drawn based on that evaluation. This section also provides the recommendations for a path forward.

Section 9, References, presents a list of sources used in the development of this RI Report.

Appendices

Appendix A – UST Closure Plans: The Closure Plan describes the procedures followed during the removal operations, and the removal, soil sampling, and disposal of the UST and the surrounding excavated soils.

Appendix B – Soil Boring Logs: Surface and subsurface lithologic logging and drilling information.

Appendix C – Well Completion Diagrams: Schematic diagrams of well completions, including survey information.

Appendix D – Well Development Logs: Logs of monitoring well development, including field parameters collected.

Appendix E – Groundwater Sampling: Data Sheets: Data sheets identifying volumes removed, rates, parameters collected, and other information collected during groundwater sampling.

Appendix F – In-Situ Permeability Test Data Sheets and Flow Velocity Information: Data recorded during permeability testing of selected wells, and evaluation of those data. Additionally included is backup data of flow velocity calculations.

Appendix G – Grain Size Analysis Data: Summary of grain size analytical data.

Appendix H – Multi-phase Extraction Pilot Test: Pilot test activities and results.

Appendix I – Survey Data: Summary of survey information for surface and subsurface soil sampling locations and monitoring wells.

Appendix J – Investigation-derived Waste Disposal Information: Records associated with IDW disposal.

Appendix K – Habitat Characterization Report: The habitat characterization report completed for seven sites, including AOC E.

Appendix L - Laboratory Data: Analytical data tables for surface and subsurface soil samples and groundwater samples.

Appendix M - Data Quality Evaluations: Data quality evaluation reports that assess the overall quality and usability of the data are included for the 2000 PA/SI, 2002 RI, 2004 additional RI, and the 2005 Supplemental RI.

Appendix N - Human Health Risk Assessment: Full, quantitative human health risk assessment upon which the summary in Section 6 is based.

Appendix O - Ecological Risk Assessment: Full, quantitative ecological risk assessment upon which the summary in Section 7 is based.

Appendix P - Groundwater Sampling Data from Soil Borings: Laboratory analysis data from three groundwater grab samples collected in monitoring wells MW-01, MW-02, and MW-03 prior to well installation.

Appendix Q- Validated Surface Soil and Subsurface Soil Pesticide Detected Analytical Results: West Vieques pesticide soil results with high and low concentrations identified.

Appendix R- Final Responses to EPA and EQB Comments on Revised Draft AOC E Report: Navy responses to EPA and EQB comments on the revised draft AOC E RI Report.

Site History, Physical Setting, and Previous Investigations

This section presents a summary of the history, physical setting, and previous environmental investigations conducted at AOC E. Also contained in this section are descriptions of natural and cultural resources as they pertain to AOC E.

2.1 Site Location and Description

Vieques, Puerto Rico, is located in the Caribbean Sea, approximately 7 miles southeast across the Vieques Passage from the eastern tip of the main island of Puerto Rico, as illustrated in Figure 2-1. This island is located on the Antillean Island Arc separating the Caribbean Sea from the Atlantic Ocean and is approximately 21 miles long and 4.5 miles wide, with an area of approximately 33,100 acres, or 51 square miles. The location of AOC E within the former NASD and with respect to other sites is presented in Figure 2-2.

AOC E is a former used oil UST located near the northwest corner of Building 2016 (the former vehicle maintenance and transportation shop) within the 21.7-acre main operational area (also referred to as the Public Works area after Navy turned over land to the Municipality of Vieques [MOV]) of the Former NASD (CH2M HILL, 2001). The 500-gallon UST was installed in 1970 during construction of the main operational area to store used oil generated from vehicle maintenance activities that took place at Building 2016. The UST was removed in 1996 (CH2M HILL, 1998). A vehicle maintenance platform, located immediately adjacent to the former UST location, was used for vehicle oil changes. Upon removal of the UST, a 500-gallon aboveground storage tank (AST) was installed on a concrete pad to store the waste oil. The AST was removed in 2001 and transported to Roosevelt Roads, but the concrete pad remains. Figure 2-3 shows the features associated with AOC E. Figure 2-4 shows three views of the AOC E area. The first photograph of Figure 2-4 identifies the area where the former UST was located.

2.2 Site History and Past Operations

The site (also known as Site 2016 under the Naval Station Roosevelt Roads [NSRR] UST program) is the former location of a 500-gallon fiberglass, single-walled, used oil UST, a reinforced concrete vehicle maintenance platform with associated reinforced concrete ramp, and a waste oil drain line that consisted of an underground single-walled steel pipe from the vehicle platform to the former UST. Vehicles would be driven up the ramp and the oil would be drained from them to the UST via the drain line.

2.2.1 AOC E Timeline

Table 2-1 lists the various studies and activities conducted at or relevant to AOC E. Each of these is summarized below.

- AOC E was initially identified as an AOC after the removal of the 500-gallon used oil UST in November 1996. Upon removal of the UST, confirmatory soil samples were collected for laboratory analysis from the ends of the UST pit, the bottom of the UST pit, below the piping trench, and the stockpiled soil. The site was investigated under the Puerto Rico Environmental Quality Board (PREQB) UST program as Site 2016 and closure activities were completed as part of the NSRR UST program. The UST and associated piping were removed and no indication of their condition was noted. However, the UST Removal Report (Reliable Mechanical, Inc., 1997) indicated contaminated soil was found below the UST. Petroleum hydrocarbon concentrations in soil beneath the tank were above the PREQB UST Corrective Action limit of 100 milligrams per kilogram (mg/kg) total petroleum hydrocarbons (TPH).

The UST Removal Report (Reliable Mechanical, Inc., 1997) is included in Appendix A. Because of the elevated TPH values, a site characterization was required under the PREQB UST program. Because the type of quality assurance (QA) program for the UST removal is unknown, the TPH results are not included in evaluations in this RI Report other than in general discussions. The data are included in Appendix A.

- The Site Characterization (CH2M HILL, 1999) of AOC E (known then as Site 2016 under the NSRR UST program), was accomplished in August/September 1998 as part of the PREQB UST program, to assess the horizontal and vertical extent of potential soil contamination left in place after UST removal, as well as to assess potential impacts to groundwater. The Site Characterization included the installation and sampling of three monitoring wells (MW-01, MW-02, and MW-03), collection of six subsurface soil samples from the monitoring well borings (two per boring), and collection of two subsurface soil samples from two additional soil borings (one per boring). Figures showing the locations of monitoring wells and soil samples are presented in Section 3 – Summary of Field Investigations. The associated analytical results are discussed in Section 4 – Nature and Extent of Contamination. In-situ hydraulic conductivity tests were completed at two of the monitoring wells (MW-02 and MW-03) to evaluate site-specific hydrogeologic characteristics, which are discussed in Section 2.3.4 below.

The Site Characterization Report concluded that the petroleum hydrocarbons in soil and groundwater were attributable to the former UST system. Laboratory analytical data indicated that concentrations of TPH in the soils were above the Puerto Rico UST Corrective Action level. No free product was encountered in the monitoring wells during the Site Characterization. The qualitative risk assessment conducted as part of the Site Characterization concluded that because there were not complete exposure pathways nor receptors to contamination present at the site, there were no threats to human health or the environment. The recommendation for the site was that no further corrective measures (no further action) be implemented at the site because the source had been removed and because natural biodegradation processes were expected to reduce the levels of hydrocarbon concentrations over time. Additional information

about the Site Characterization can be found in the *Site Characterization Report for Site No. 2016* (CH2M HILL, 1999).

- The EBS (Program Management Company, 2000) was performed in March 2000 by Environmental Resource Management (ERM) for the former NASD (including AOC E). The EBS Report documents the environmental conditions of the property in support of land transfer from the Navy to the MOV, Department of the Interior (DOI), and the Puerto Rico Conservation Trust. AOC E was identified during the EBS as a potentially contaminated area.

A site visit was conducted on March 15, 2000, during which the 500-gallon AST that replaced the 500-gallon UST was observed. The EBS Report noted that no significant spills were observed at the site. No further investigation was accomplished during the EBS because the site was already being investigated under the Navy's IR program. Additional information about the EBS can be found in the *Environmental Baseline Survey: Final, Naval Ammunition Support Detachment Vieques, Vieques Island, Puerto Rico* (Program Management Company, 2000).

- In April and May 2000, CH2M HILL conducted an Expanded PA/SI at AOC E to further assess impacts to site groundwater from releases from the former UST (CH2M HILL, 2000). The PA/SI at AOC E included the installation and sampling of three monitoring wells (MW-04, MW-05, and MW-06) downgradient of the UST and the collection of groundwater samples from two existing monitoring wells (MW-02 and MW-03). Monitoring well MW-01 was not re-sampled because a thin layer (0.1 ft) of free product was measured in this well. Figures showing the locations of monitoring wells are presented in Section 3 – Summary of Field Investigations. The associated analytical results are discussed in Section 4 – Nature and Extent of Contamination.

Results of the PA/SI confirmed that a release of petroleum hydrocarbons to groundwater occurred at the site. The PA/SI recommended additional site investigation via an RI to delineate the extent of the petroleum hydrocarbons at the site. In addition, removal of the free product was recommended. Institutional controls that comprised a chain-link fence around the site with signs to demarcate the site were put in place. Additional information about the Expanded PA/SI can be found in the *Expanded Preliminary Assessment/Site Investigation, U.S. Naval Ammunition Storage Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2000a).

- The Quitclaim Deed (Department of the Navy, 2001), which transferred the former NASD land to the MOV, DOI, and the Puerto Rico Conservation Trust, went into effect on April 30, 2001. The property that contains AOC E was transferred to the MOV.
- Based on the recommendations of the Expanded PA/SI, an initial RI sampling event was performed from May through August 2002 (including the MPE pilot study) and September 2003. The RI field work consisted of drilling 7 soil borings from which 20 soil samples were collected to assist in characterizing the horizontal and vertical extent of soil contamination. In addition, two monitoring wells were installed (MW-07 and MW08) and sampled, additional groundwater samples were collected from four existing monitoring wells (MW-02, MW-03, MW-04, MW-06), and in-situ hydraulic conductivity tests were performed on two monitoring wells (MW04 and MW-07) to further evaluate

site-specific hydrogeologic characteristics, which are discussed in Section 2.3.4 below. No groundwater samples were collected at MW-01 and MW-05 because of the presence of free phase product (0.42 foot [ft] and 0.28 ft, respectively). Figures showing the locations of monitoring wells and soil samples are presented in Section 3 – Summary of Field Investigations. The associated analytical results are discussed in Section 4 – Nature and Extent of Contamination.

In addition to the soil and groundwater sampling conducted during the RI, an MPE pilot study was accomplished to provide quantitative performance, cost, and design information to help evaluate the effectiveness of this technology in mitigating the free phase hydrocarbon product accumulation. The MPE pilot study design, implementation, and results are discussed in Appendix H.

The results of the initial RI sampling are documented in the *Draft Remedial Investigation/Feasibility Study Report, Area of Concern (AOC) E, Former Naval Ammunition Support Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2004a). However, based on the initial RI findings, it was concurred upon by the Navy and regulatory agencies that supplemental RI data collection was necessary to sufficiently characterize the site. Therefore, rather than finalize the RI Report, supplemental data were collected in accordance with Sampling and Analysis Plan for Additional Sampling (CH2M HILL, 2004b) and the Supplemental RI Work Plan (CH2M HILL, 2005). The additional supplemental data collection comprised collection of another round of groundwater samples from all eight monitoring wells in August/September 2004 and collection of surface soil samples from seven locations, subsurface soil samples from four locations, and groundwater samples from six existing monitoring wells (MW-02, MW-03, MW-04, MW-06, MW-07, and MW-08) in November/December 2005. No groundwater samples were collected at MW-01 and MW-05 in 2005 because of the presence of free phase product (1.17 ft and a sheen, respectively). Figures showing the locations of monitoring wells and soil samples are presented in Section 3 – Summary of Field Investigations. The associated analytical results are discussed in Section 4 – Nature and Extent of Contamination.

Although the title of this report is “Revised Draft,” because of the substantial revisions made since the Draft RI Report was submitted (e.g., changes to regulatory screening values, new risk assessment protocols, and additional data collection), the report represents an entirely new data evaluation, not simply an update of the Draft RI Report.

2.3 Physical Setting

This subsection summarizes the regional environmental setting of AOC E, including weather and climate, topography, geology and hydrogeology, surface water drainage, ecological setting, and cultural resources. A number of activities were conducted to develop an understanding of the physical setting of AOC E. These activities included historical document research; an ecological investigation by Geo-Marine, Inc.; and field data collection activities such as soil borings and slug testing. Information gathered during these activities is summarized below.

2.3.1 Weather and Climate

The climate of Vieques is tropical-marine. Temperatures are nearly constant at an annual average temperature of about 79°F; August is the warmest month, with an average temperature of 82°F and February the coolest, with an average temperature of 76°F (Greenleaf/Telesca *et. al.*, 1984). Vieques lies directly in the path of the prevailing easterly trade winds, which regulate the climate of Puerto Rico. The trade winds result in a rainfall pattern characterized by a dry season from December through July and a rainy season from August through November. Heavy precipitation may result from tropical storms from June to November, which is considered normal for this area of the Caribbean. The western part of the island, where AOC E is located, averages approximately 43 inches of rainfall per year (Geo-Marine, Inc., 2003).

2.3.2 Topography

The topography of the Former NASD is characterized by generally low hills and small valleys intersected by a series of ephemeral streams. The regional map (Figure 2-5) shows that the topography slopes from the hills to the south of AOC E northward to the Vieques Passage. Figure 2-5 also shows that the topography at AOC E is relatively flat, having been re-worked from construction of the main operational area in the early 1970s. The ground elevation at AOC E is approximately 43 ft (13 meters) above mean sea level (amsl).

2.3.3 Geology

The geology of Vieques is characterized by plutonic and volcanic rocks generally overlain by alluvial deposits and sedimentary rocks. The volcanic rocks, of Late Cretaceous age, were deposited in a marine environment. Later in the Cretaceous Period, a quartz-diorite/granodiorite plutonic complex intruded the volcanics, and is exposed over a large part of the island (U.S. Geological Survey [USGS], 1989).

In various locations on the former NASD, the bedrock is exposed and weathered. Because of the weathering of the bedrock, gravels, sands, and finer particles (silts and clays) have been transported downhill. Over the years, this material has gathered in valleys and near the ocean, forming alluvial deposits. The alluvial sedimentary deposits generally consist of a mixture of gravel, sand, silt, and clay. Based on the generalized geology of Vieques Island map (USGS, 1989), five general categories, based on geologic origin, are present in western Vieques:

1. Qa – Quaternary age alluvial deposits (sand, silt, and clay)
2. Qb – Quaternary age beach and dune deposits (calcite, quartz, volcanic rock fragments and minor magnetite)
3. Qs – Quaternary age swamp and marsh deposits, organic muck, sandy or silty, and peat
4. Tl – Tertiary age marine sedimentary rocks (report indicated variable limestones)
5. KTd – Cretaceous age plutonic rock made up largely of granodiorite and quartz diorite, locally deeply weathered

In addition, the following sixth category is mapped as outcropping on eastern Vieques:

6. Kv – Cretaceous age sandstone, siltstone, conglomerate, and volcanic rock (often andesite), tuff, and tuffaceous breccia.

The distribution of geologic zones in western Vieques is illustrated on Figure 2-6, which shows that AOC E lies within the Qa geologic grouping, near the boundary of the KTd zone. Soil borings and borings for monitoring wells installed in 1999 (Site Characterization), 2000 (PA/SI), 2002 (RI), and 2005 (supplemental RI) penetrated approximately 35 to 50 ft of sandy clays and silts, followed by a zone of primarily clay saprolite material consisting of rock fragments and remnant sands, silts and clays. It appears that the Qa sandy clay and silt unconsolidated deposits were deposited over the KTd granodiorite bedrock at AOC E, which is consistent with what is portrayed in Figure 2-6. Two cross sections were constructed through soil boring and monitoring well boring locations; the cross-section transects are shown on Figure 2-7. The cross sections are shown on Figures 2-8 and 2-9.

Rocks are the primary sources of the constituent materials that make up the unconsolidated deposits. Most rocks are formed from elements such as oxygen, silicon, aluminum, iron, magnesium, calcium, potassium, and sodium (USGS, 1997). Specifically, common bedrock types found on Vieques (granodiorite and quartz diorite) typically are composed of approximately 61 to 66 percent silicon dioxide, 16 to 17 percent aluminum oxide, 2 to 3 percent ferric oxide, 2 to 4 percent ferrous oxide, 1 to 3 percent magnesium oxide, 3 to 6 percent calcium oxide, 3 to 4 percent sodium oxide, and 2 to 3 percent potassium oxide (Travis, 1955).

Chemical and physical processes break down the rocks and form minerals that are characteristic of the parent material. The soil on Vieques is a direct product of the island's bedrock which, as indicated previously, consists mostly of granodiorite, quartz diorite, some volcanic lavas (commonly andesites), and marine sedimentary deposits such as limestone. Soils on Vieques are primarily residual, because of both climatic conditions (i.e., warm temperatures and considerable precipitation that promotes chemical weathering) and parent rock type susceptible to chemical weathering. The eastern side of the island has less developed soil due to the relatively impermeable volcanic rock, the greater chemical stability of volcanic rocks under surface conditions, and less precipitation than the west side. Human influences, such as agricultural processes and air pollution, and other natural process, such as vegetative decay, also likely contribute to the constituents found in the soil.

Based on the soil and well borings completed at AOC E during the Site Characterization, the Expanded PA/SI, and the RI, the unconsolidated deposits beneath AOC E generally consist of clays or sandy clays, with a 5- to 15-ft-thick bed of material ranging from silt to silty/clayey sand to poorly sorted fine to coarse sand (Figures 2-8 and 2-9). The sandy layer is generally above the water table, though the lowest sections of it are submerged at the highest recorded site water levels (November 2005). These deposits overlie a clay-rich saprolite (in-place weathered bedrock material consisting of clay with residual fragments of granodiorite bedrock). The top of the saprolite varies in elevation from 23 ft amsl to below -7 ft amsl. Boring logs for soil and monitoring well borings are in Appendix B. The majority of the saturated unconsolidated material at AOC E is clay-rich, and appears to be of relatively low permeability (see Section 2.3.4).

2.3.4 Hydrology and Hydrogeology

AOC E is relatively flat, with gentle regional slopes to the north. Regional surface water flow in the area is to the north toward Vieques Passage. There are drainage ditches located approximately 50 ft to the north of the site (see Figure 2-3) that collect stormwater runoff from the grassy fields and the asphalt access roads (CH2M HILL, 2006). This ditch system extends to the east for approximately 100 ft, then drains to the north toward the Vieques Passage, approximately 850 ft to the north. The drainage ditch was previously investigated as part of AOC C (CH2M HILL, 2006). Because the area including and immediately around AOC E is flat, surface runoff is likely negligible at the site. This observation is supported by the photographs in Figure 2-4, which show standing water at the site. Further, there were no erosional features observed at the site.

USGS (1989) described the Resolución Valley alluvial aquifer, composed of alluvial deposits averaging 30 ft in thickness, in the northwestern portion of Vieques (Figure 2-10). As shown in Figures 2-8 and 2-9, the saturated deposits at AOC E are composed predominantly of clay and clay-rich saprolite. So, while these deposits may be mapped as being within and near the northern edge of the Resolución Valley alluvial aquifer, no productive aquifer material was found at the site. The first water-bearing zone at AOC E was encountered within the saprolite zone of the bedrock at approximately 40 to 45 ft below land surface (bls) during drilling for monitoring well installation at well locations MW-01 through MW-08. The geologic profiles for AOC E (Figures 2-8 and 2-9) show the elevation of the measured potentiometric surface in August 2004 and November 2005, the lowest and highest of the recorded site water levels, respectively. This information suggests that the saprolite is the primary zone for groundwater flow, with some groundwater existing periodically in the lowest portion of the clayey material overlying the saprolite.

The groundwater flow direction at AOC E was estimated based on groundwater elevations from monitoring wells installed across the site. Groundwater level data were collected seven times (Table 2-2) since 1998 to assess fluctuations in groundwater elevations and variability in hydraulic gradient. As shown in Table 2-2, measured water levels in AOC E wells rose and fell fairly consistently relative to each other across the site. Between May 2000 and May 2002, the water levels in all wells dropped approximately 3 ft. Similarly, between May 2002 and August 2003, the water levels in all wells declined approximately 3 ft. By August 2004, water levels had rebounded to their approximate May 2002 levels. By November 2005, water levels across the site had risen an additional approximate 12 ft. By March 2006, water levels across the site had dropped an average of approximately 5 ft.

The estimated groundwater flow direction, based on data collected in May 2002, August 2003, November 2005, and March 2006 is shown in Figures 2-11, 2-12, 2-13, and 2-14, respectively, which are representative of all water level monitoring events. Even with the fluctuations observed in the water levels over time, the flow direction is consistently toward the Vieques Passage to the north-northwest. Based on the estimated potentiometric surfaces, the horizontal hydraulic gradient is relatively uniform across AOC E during any given measurement date. The estimated horizontal hydraulic gradient based on Table 2-2 is approximately a 0.038-ft drop of the potentiometric surface per foot horizontal distance (ft/ft) on September 1998 as measured between MW-03 and MW-02. The gradient drops to 0.014 ft/ft across the site in May 2000. It drops again to 0.009 ft/ft in May 2002, and again to an almost flat gradient of 0.002 ft/ft for the lowest recorded potentiometric surface,

measured in August 2003. The gradient rises back to 0.009 ft/ft in August 2004, and rises to 0.023 ft/ft for the highest measured potentiometric surface, measured in November 2005. The gradient then drops back down to 0.021 ft/ft in March 2006.

In-situ hydraulic conductivity (slug) tests were performed on monitoring wells MW-02 and MW-03 on September 11, 1998, during the Site Characterization, and on monitoring wells MW-04 and MW-07 on May 23, 2002, during the RI, to obtain estimates of the aquifer hydraulic conductivity. Because the tests conducted in MW-02 and MW-03 were falling head tests in wells screened across the water table, the data for these two wells are unreliable and therefore not included in the analysis. Details of hydraulic conductivity calculations for slug tests performed at AOC E are included in Appendix F. The mean hydraulic conductivity measured at well MW-04 is 0.2 ft/day and at MW07 it is approximately 0.056 ft/day, with a geometric mean of 0.105 ft/day. Based on the geometric mean hydraulic conductivity (0.105 ft/day), the geometric mean hydraulic gradient (0.012), and the assumed effective porosity (0.45), the estimated groundwater flow velocity is approximately 1 ft/year. It should be noted, however, that the mathematics of slug test analyses were designed to simulate conditions in a porous media aquifer, not saprolite. Hydraulic conductivity measurements via slug testing in saprolite are prone to a high degree of uncertainty because the flow likely does not simulate porous media flow for which the slug test analytical methods were designed.

Table 2-2 also shows the free product measurements in AOC E monitoring wells. These measurements are further discussed in Section 4.2.3.

2.4 Ecological Setting

Most of the former NASD property is undeveloped and heavily vegetated with trees and low-lying thorny brush. AOC E, on the other hand, was developed for industrial use, and is located in the NASD Public Works area. The area is mostly devoid of natural resource systems due to historical construction and site use activities. The small site is dominated by concrete structures, buildings, bare dirt, and paved areas. Vegetative cover is primarily grass and herbaceous species that are periodically maintained (e.g., mowed) in support of the ongoing public works activities. The herbaceous plant community is dominated by several species, including King Ranch Bluestem (*Bothriochloa ishaemu*), French Grass (*Commelina erecta*), Bermuda Grass (*Cynodon dactylon*), and Crabgrass (*Digitaria ciliaris*).

Wildlife observed at this site is typical for developed grassed areas on Vieques, though the small size of the site offers very limited habitat for any species. The only small mammal observed at the site was the Indian mongoose (*Herpestes auro-punctatus*); horses (*Equus caballus*) are frequent grazers outside the fence surrounding AOC E. Occasional common passerine birds such as northern mockingbird (*Mimus polyglottos*), gray kingbird (*Tyrannus dominicensis*), common ground dove (*Columbina passerine*), black faced grassquit (*Tiaris bicolor*), and bananaquit (*Coereba flaveola*) have been observed at or near AOC E.

No endangered or threatened species were observed within the AOC E area, nor are any expected to use the maintained habitat at the site. The threatened Arctic peregrine falcon has been observed at NSRR in Puerto Rico. This species uses open grassland areas for potential feeding areas. This habitat type is present immediately adjacent to the site. The brown

pelican, piping plover, and the roseate tern are not likely to use this terrestrial site but may be seen nearby due to the proximity of marine habitat to the north. (Geo-Marine, 2000).

2.5 Cultural Resources

Although 12 archeological sites and districts are listed on the National Register of Historic Places (NRHP) for western Vieques (Geo-Marine, 1996), no cultural resources are located at AOC E.

TABLE 2-1

Study/Activity Timeline
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Study/Activity	Author	Purpose of Study/Activity	Field Work Date(s)	Report Date
Underground Storage Tank (UST) closure at Site 2016	Reliable Mechanical Inc.	UST removal and closure.	November 1996	May 1997
Site Characterization for Site 2016	CH2M HILL	Assess the horizontal and vertical extent of potential impacts from the UST on soil and groundwater at Site 2016.	August and September 1998	April 1999
Environmental Baseline Survey (EBS)	Program Management Company	Document environmental conditions of property in support of land transfer from Navy.	March 2000	October 2000
Expanded Preliminary Assessment/Site Investigation (PA/SI)	CH2M HILL	Further assess potential releases at various sites, including AOC E.	April and May 2000	October 2000
Quitclaim Deed	Department of the Navy	To transfer former Naval Ammunition Support Detachment (NASD) property to the Municipality of Vieques (MOV), Department of the Interior (DOI), and the Puerto Rico Conservation Trust.	Not applicable	April 30, 2001
Remedial Investigation	CH2M HILL	To characterize the horizontal and vertical extent of soil and groundwater contamination such that potential human health and ecological risks can be appropriately assessed and the need for remedial action determined.	May 2002 through December 2005	February 2004 (Draft RI Report); December 2007 (Revised Draft RI Report)

TABLE 2-2

Summary of Monitoring Well Groundwater Elevations and Free Product Thicknesses
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Monitoring Well ID	Top-of-casing Elevation (ft amsl)	September 11, 1998			May 3, 2000			May 31, 2002			August 18, 2003			August 25, 2004			November 30, 2005			March 17, 2006		
		Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)	Depth to Water (ft below TOC)	Product Thickness (ft)	GW Elevation (ft amsl)
AOC E MW-01	43.93	42.14	0	1.79	38.39	0.4	5.90	41.34	0.42	2.96	45.35	1.06	-0.48	41.30	0.77	3.32	29.6	1.17	15.37	NM	0.1	NM
AOC E MW-02	42.68	42.23	0	0.45	37.28	0	5.40	40.22	0	2.46	43.25	0	-0.57	40.22	0	2.46	28.58	0	14.10	33.30	0	9.38
AOC E MW-03	44.06	41.08	0	2.98	37.72	0	6.34	40.97	0	3.09	44.5	0	-0.44	40.97	0	3.09	28.20	0	15.86	33.26	0	10.80
AOC E MW-04	43.60	NA	NA	NA	37.36	0	6.24	40.68	0	2.92	44.05	0	-0.45	40.41	0.01	3.20	28.30	0	15.30	33.16	0	10.44
AOC E MW-05	44.32	NA	NA	NA	38.05	0	6.27	41.60	0.28	2.97	44.78	0	-0.46	41.03	0.01	3.30	28.75	Sheen	15.57	33.63	0	10.69
AOC E MW-06	44.34	NA	NA	NA	38.10	0	6.24	41.30	0	3.04	Dry	NA	NA	41.30	0	3.04	28.68	0	15.66	33.72	0	10.62
AOC E MW-07	43.41	NA	NA	NA	NA	NA	NA	41.05	0	2.36	44.03	0	-0.62	41.05	0	2.36	29.54	0	13.87	34.23	0	9.18
AOC E MW-08	43.04	NA	NA	NA	NA	NA	NA	40.48	0	2.56	43.56	0	-0.52	40.48	0	2.56	28.53	0	14.51	33.34	0	9.70

Notes:

NA - Not applicable

NM - Not measured

On December 19, 2005, the product was removed from MW-01 with a bailer.

On March 17, 2006, 0.1 foot of product was measured in MW-01. The product was removed from the well with a bailer.

On March 14, 2007, approximately 1 cm (0.03 foot) of product was measured in MW-01. The product was removed from the well with a bailer.

Groundwater elevations for wells containing product were calculated by multiplying the product thickness by an estimated specific gravity of used motor oil (0.89), which was then added to the water elevation.

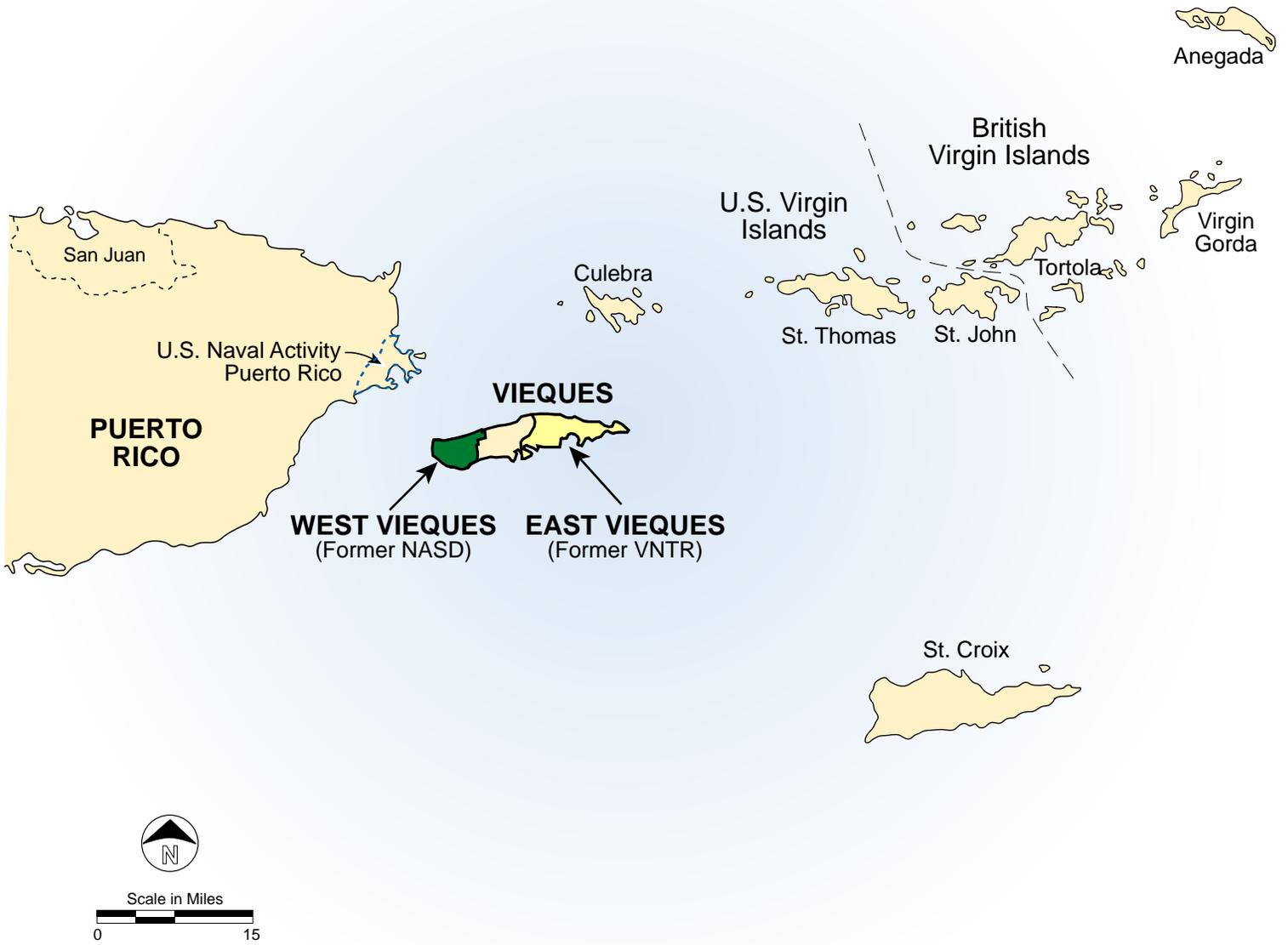


FIGURE 2-1
Regional Location Map
AOC E Remedial Investigation Report
Vieques, Puerto Rico

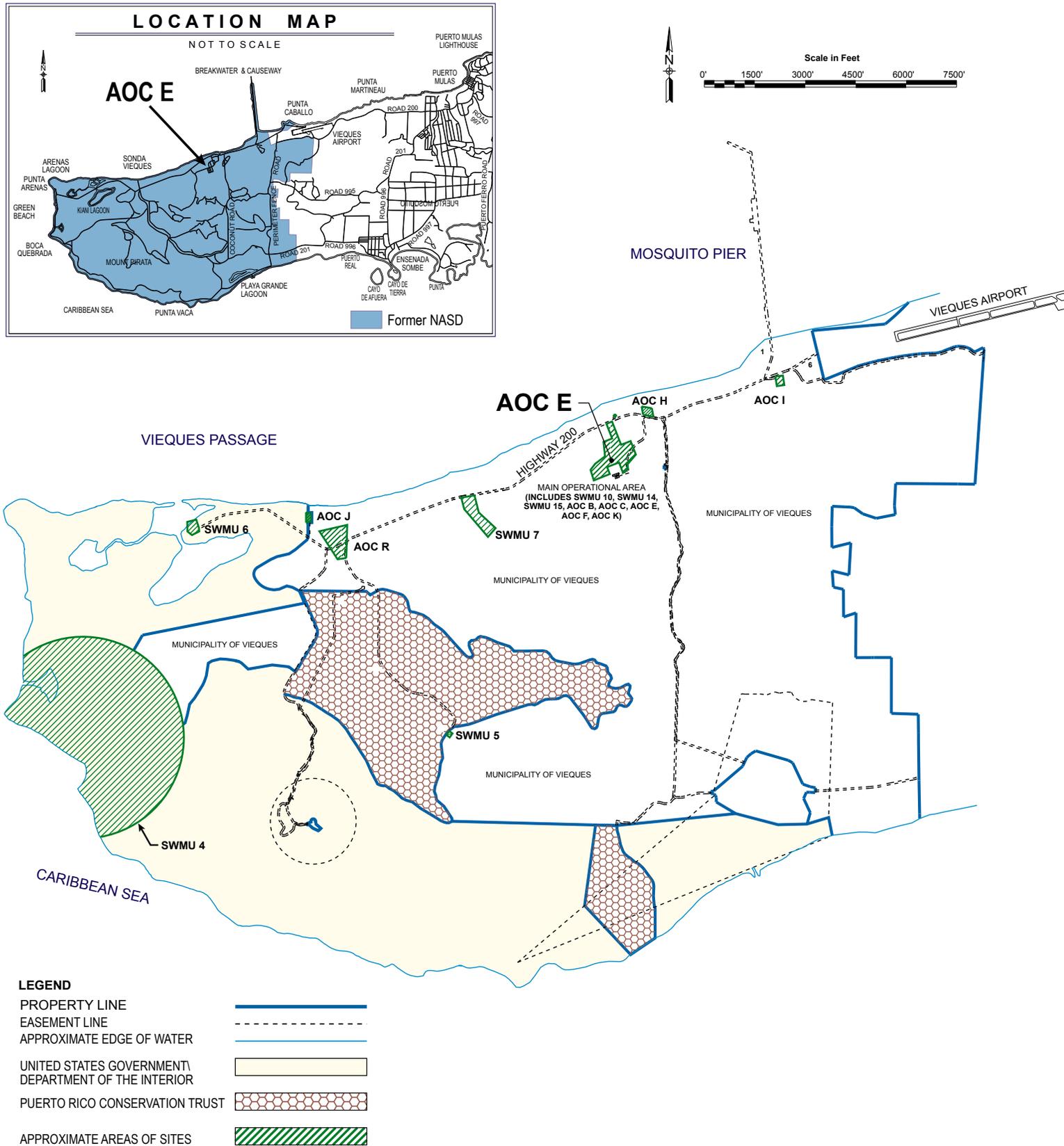
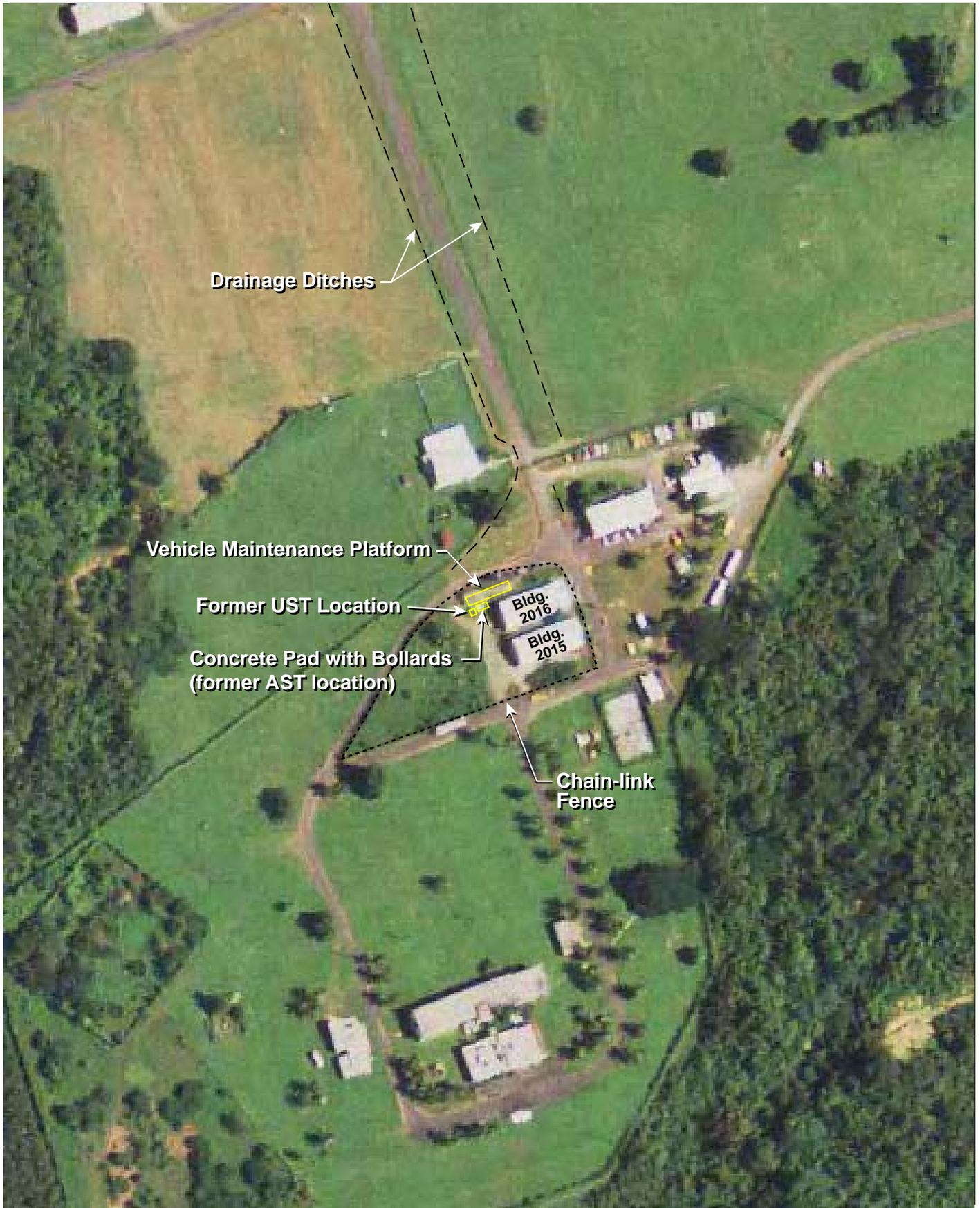


FIGURE 2-2
AOC E and Other Sites Location Map
AOC E Remedial Investigation Report
Vieques, Puerto Rico

SOURCE:
 VIEQUES NASD SURVEY LAND TRANSFER & DISPOSAL OVERALL LOCATION SURVEY
 PREPARED BY GLENN & SADLER AND LUIS BERRIOS MONTES & ASSOCIATES



0 150 300 Feet



FIGURE 2-3
2004 Aerial Photograph of AOC E
AOC E Remedial Investigation Report
Vieques, Puerto Rico



Picture 1: Looking east at the vehicle maintenance platform, Building 2016, concrete pad where the former above ground storage tank was located, and the former underground storage tank location. The former underground storage tank was located where monitoring well MW-01 is shown.

Source: Photograph taken during 2004 RI



Picture 2: Looking north at the vehicle maintenance platform.

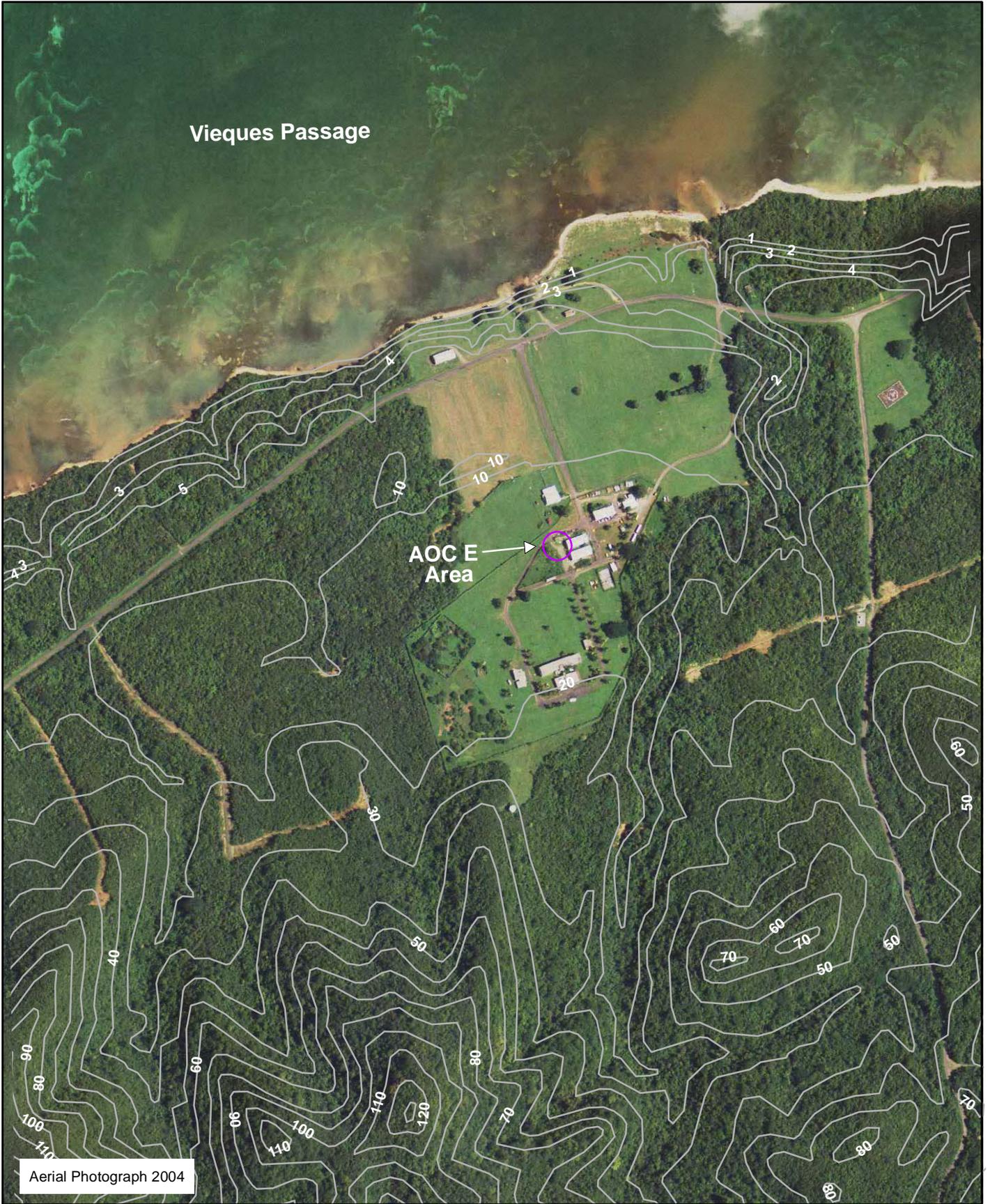
Source: Photograph taken during 2004 RI



Picture 3: Looking west at the vehicle maintenance platform.

Source: Photograph taken during 2004 RI

FIGURE 2-4
Site Photographs
AOC E Remedial Investigation Report
Vieques, Puerto Rico



Vieques Passage

AOC E Area

Aerial Photograph 2004

LEGEND

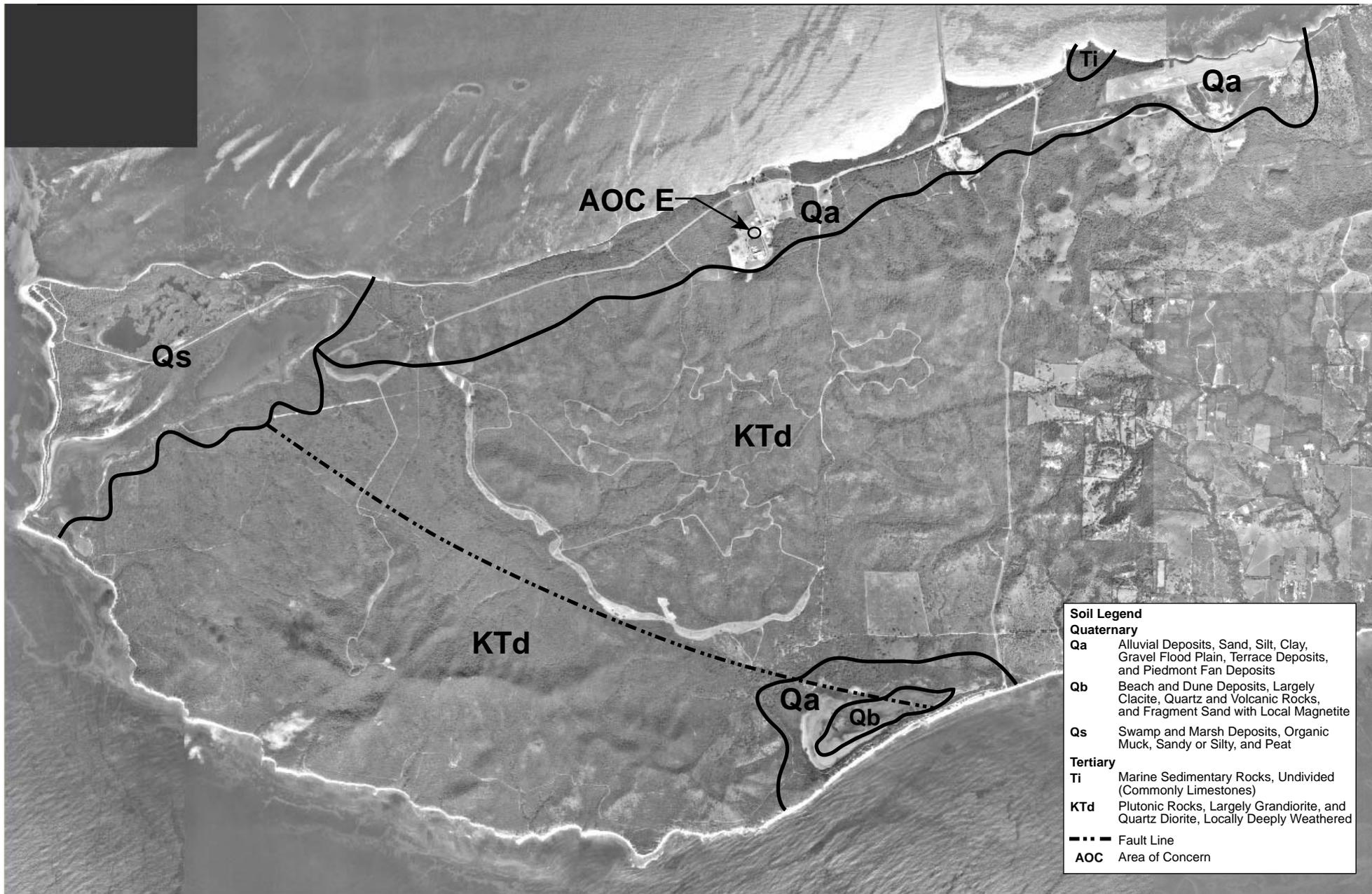
- Topographic Contour Lines (1 meter and 10 meter increments)
- Approximate Area of AOC E

Source: topographic contours from U.S. Geological 7.5 Minutes Quadrangle map of Vieques Island, Puerto Rico (1982).



0 325 650 Feet

FIGURE 2-5
Topographic Map
AOC E Remedial Investigation Report
Vieques, Puerto Rico

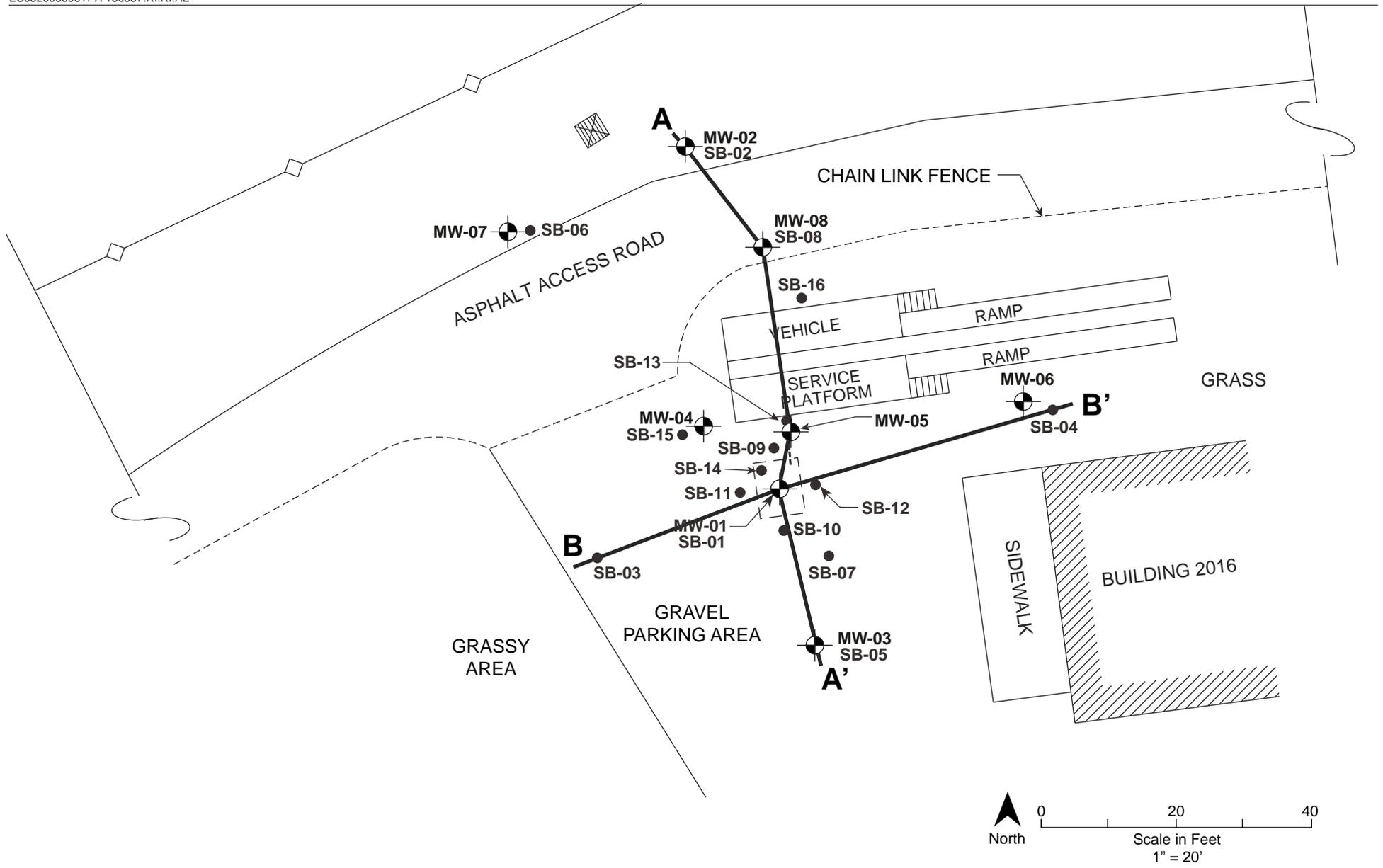


Soil Legend	
Quaternary	
Qa	Alluvial Deposits, Sand, Silt, Clay, Gravel Flood Plain, Terrace Deposits, and Piedmont Fan Deposits
Qb	Beach and Dune Deposits, Largely Clacite, Quartz and Volcanic Rocks, and Fragment Sand with Local Magnetite
Qs	Swamp and Marsh Deposits, Organic Muck, Sandy or Silty, and Peat
Tertiary	
Ti	Marine Sedimentary Rocks, Undivided (Commonly Limestones)
KTd	Plutonic Rocks, Largely Grandiorite, and Quartz Diorite, Locally Deeply Weathered
- - - -	Fault Line
AOC	Area of Concern



Generalized Geology Source: (USGS, 1989)

FIGURE 2-6
Generalized Geology of Former NASD
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico



LEGEND

-  Monitoring Well Location
-  Subsurface Soil Sample Location

FIGURE 2-7
Location of Geologic Cross Section A-A' and B-B'
AOC E Remedial Investigation Report
Vieques, Puerto Rico

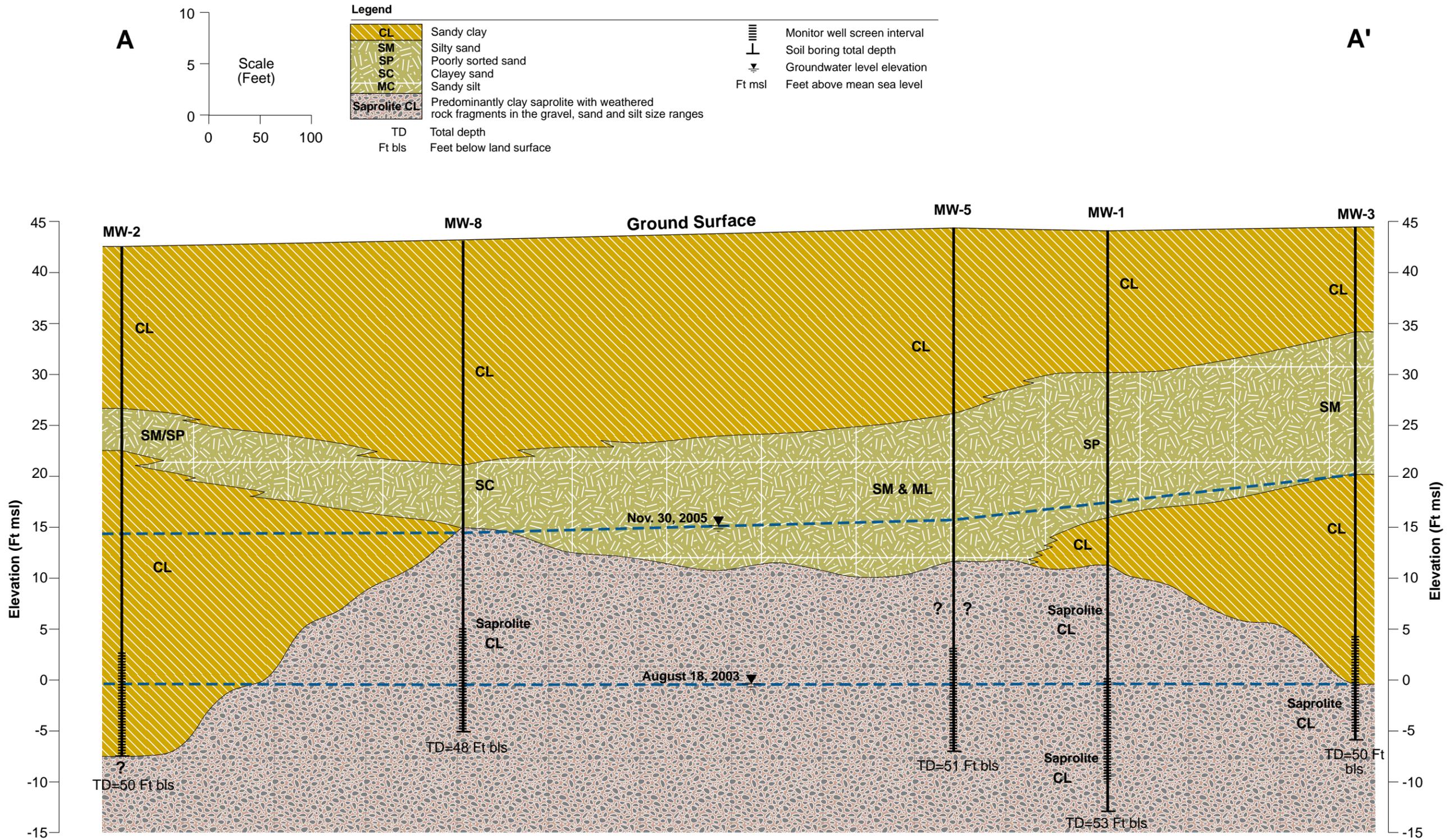
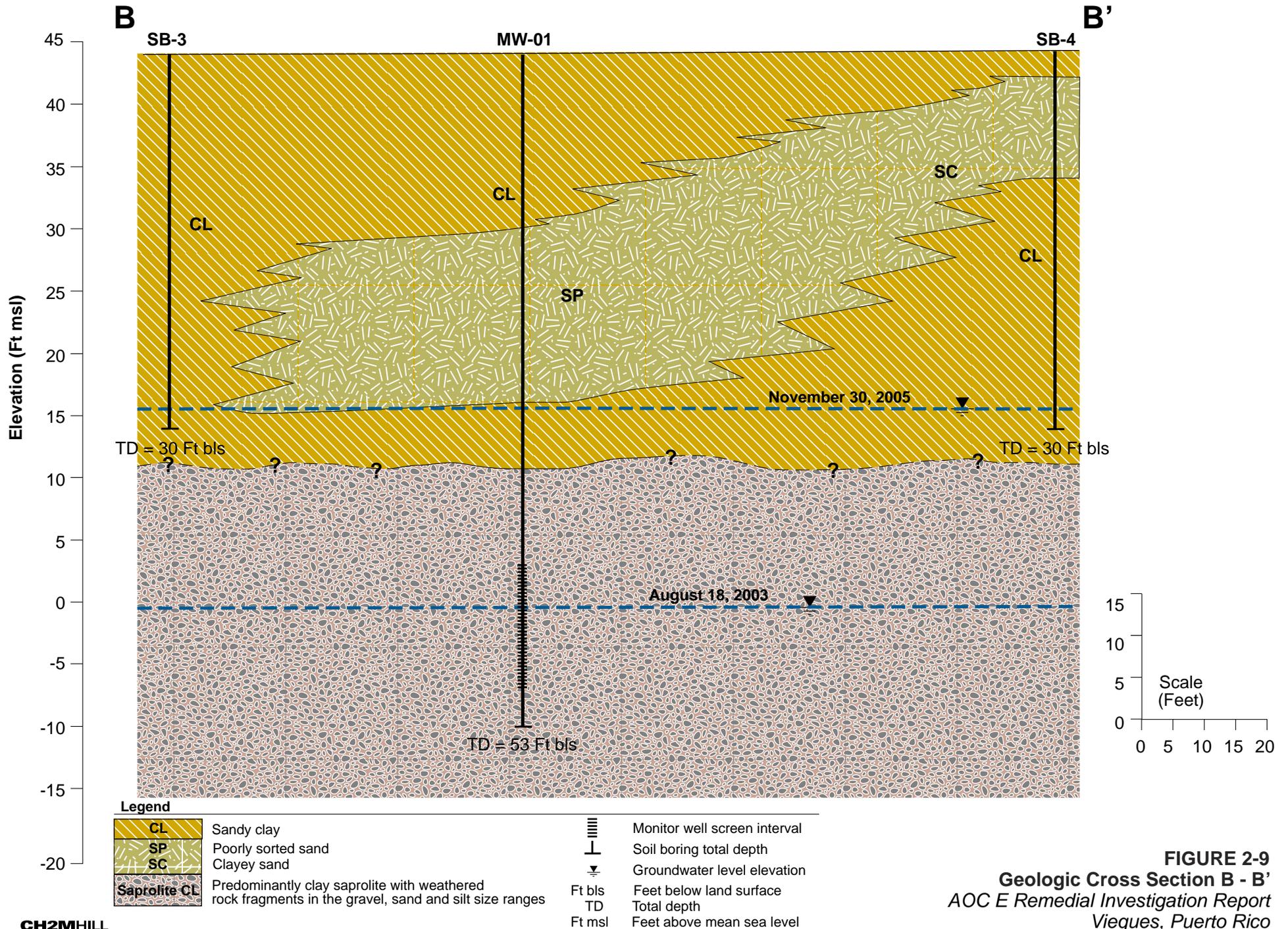
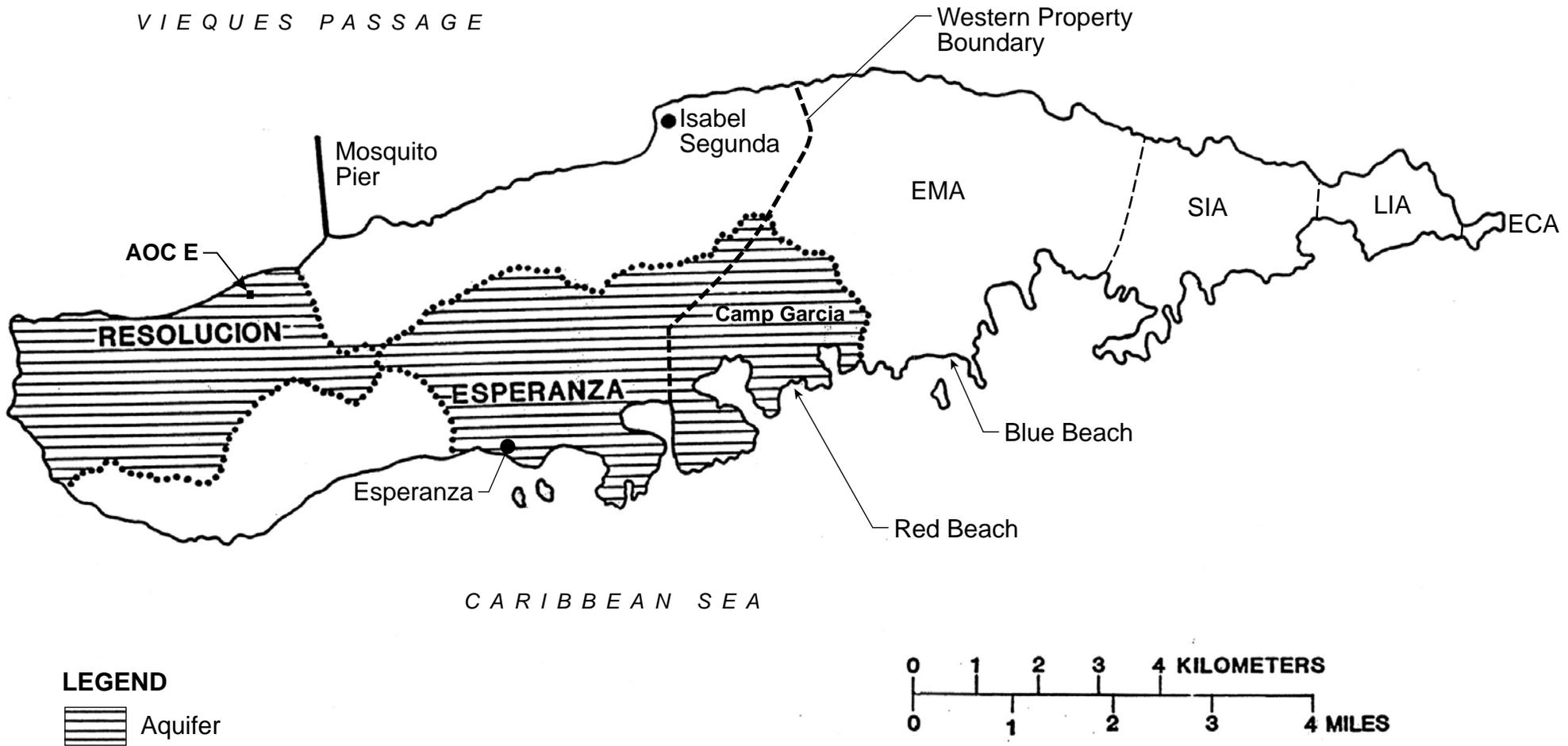


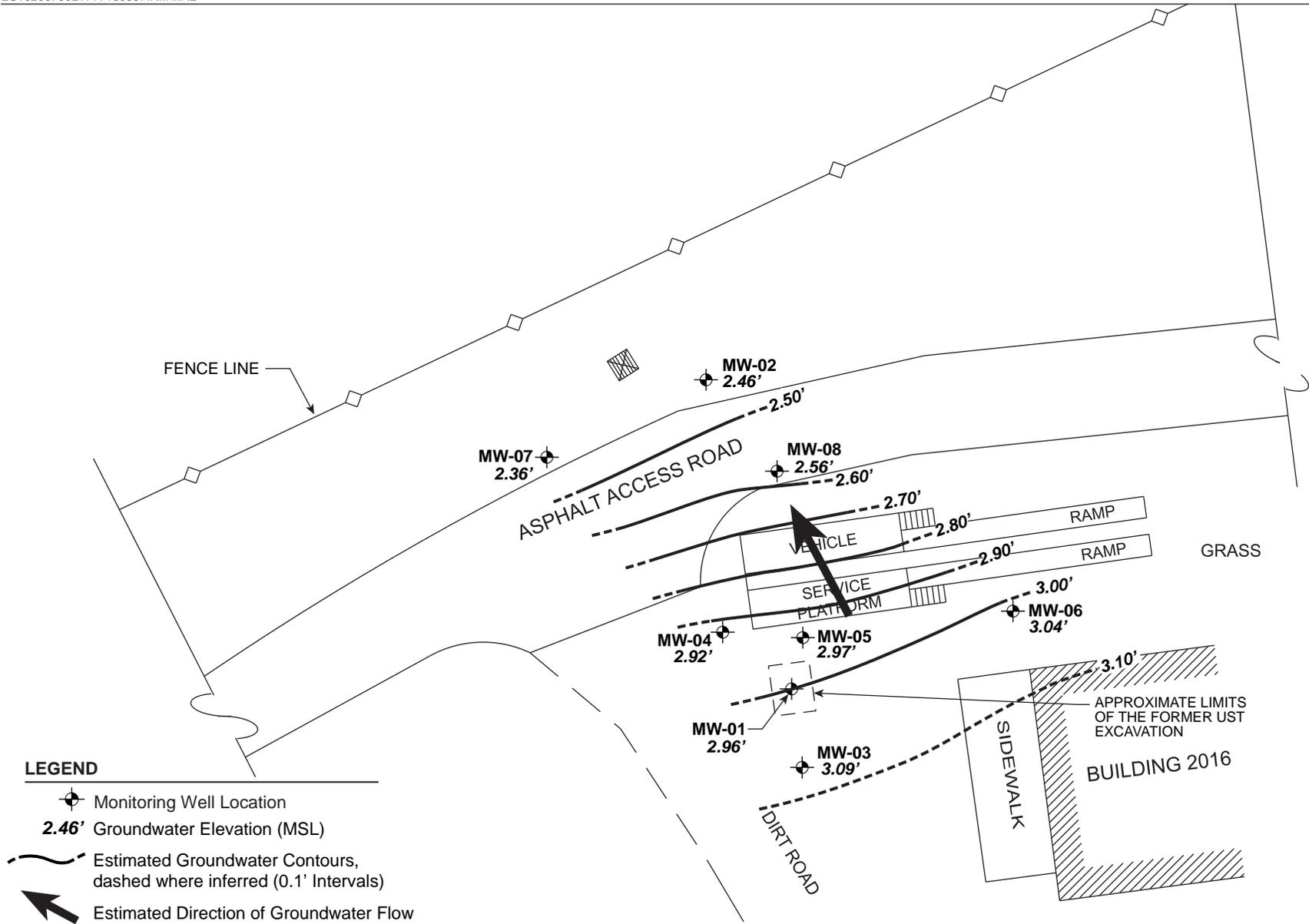
FIGURE 2-8
Geologic Cross Section A - A'
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico





(Reference: USGS, 1989)

FIGURE 2-10
Resolución and Esperanza Aquifers
AOC E Remedial Investigation Report
Vieques, Puerto Rico



LEGEND

- Monitoring Well Location
- 2.46'** Groundwater Elevation (MSL)
- Estimated Groundwater Contours, dashed where inferred (0.1' Intervals)
- Estimated Direction of Groundwater Flow

Groundwater Elevations in FT MSL

Note: Water elevation in MW-1 not used for contouring purposes because of interferences by free product layer.

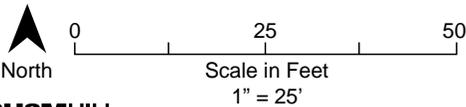


FIGURE 2-11
Estimated Potentiometric Surface, May 31, 2002
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

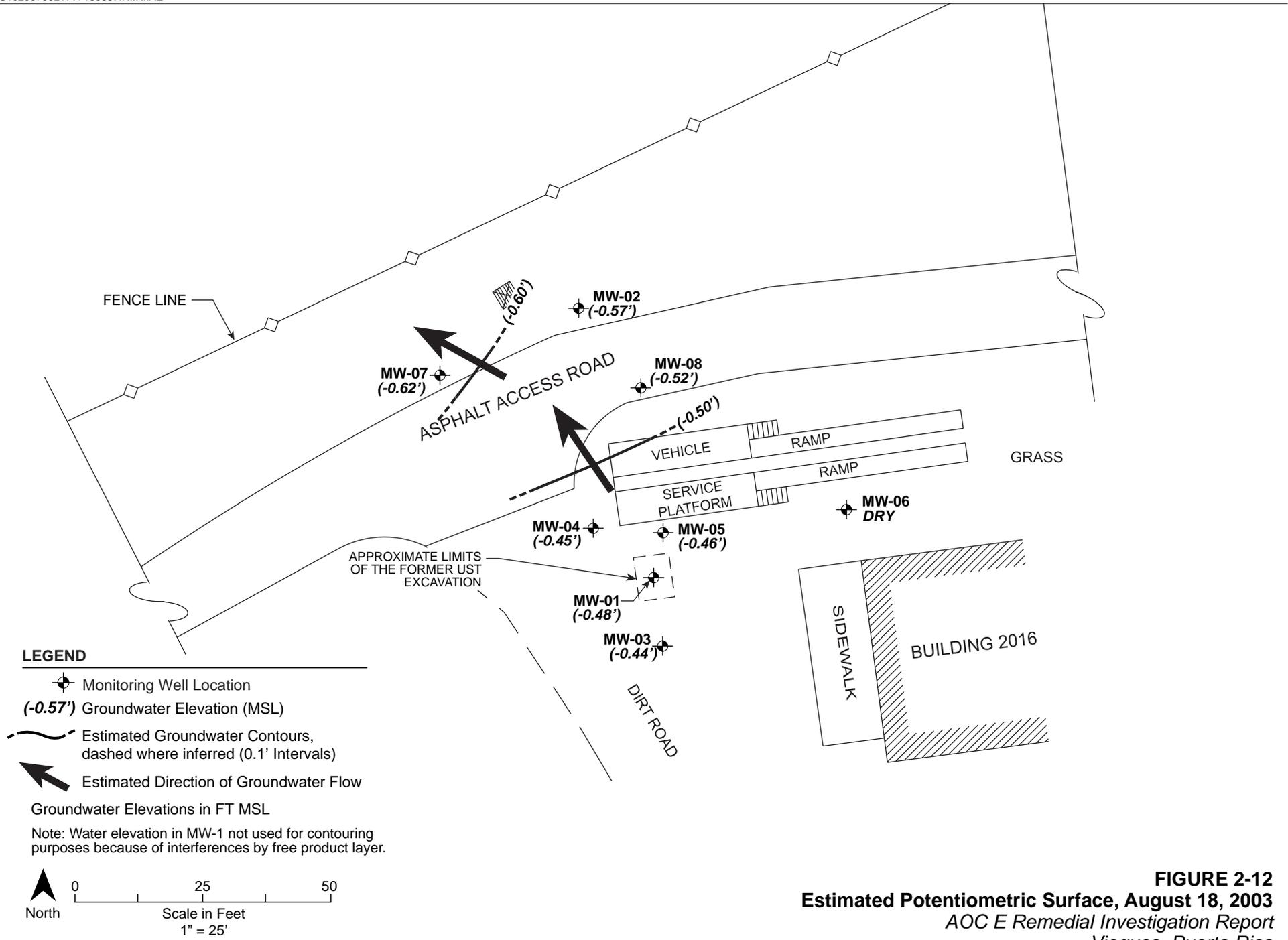
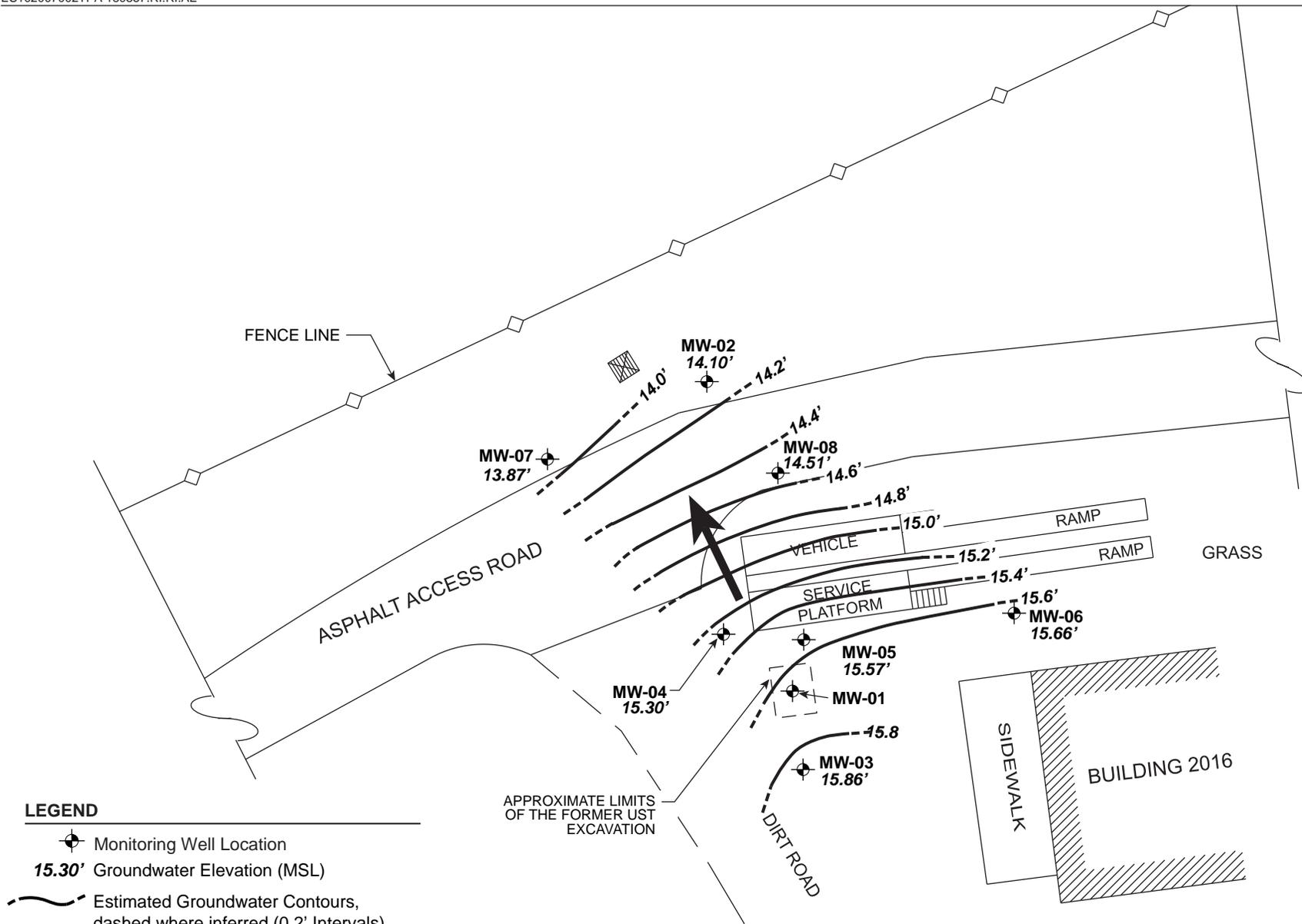


FIGURE 2-12
Estimated Potentiometric Surface, August 18, 2003
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico



LEGEND

-  Monitoring Well Location
- 15.30'** Groundwater Elevation (MSL)
-  Estimated Groundwater Contours, dashed where inferred (0.2' Intervals)
-  Estimated Direction of Groundwater Flow

Groundwater Elevations in FT MSL

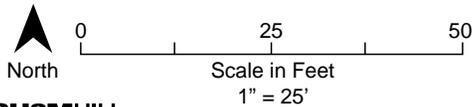
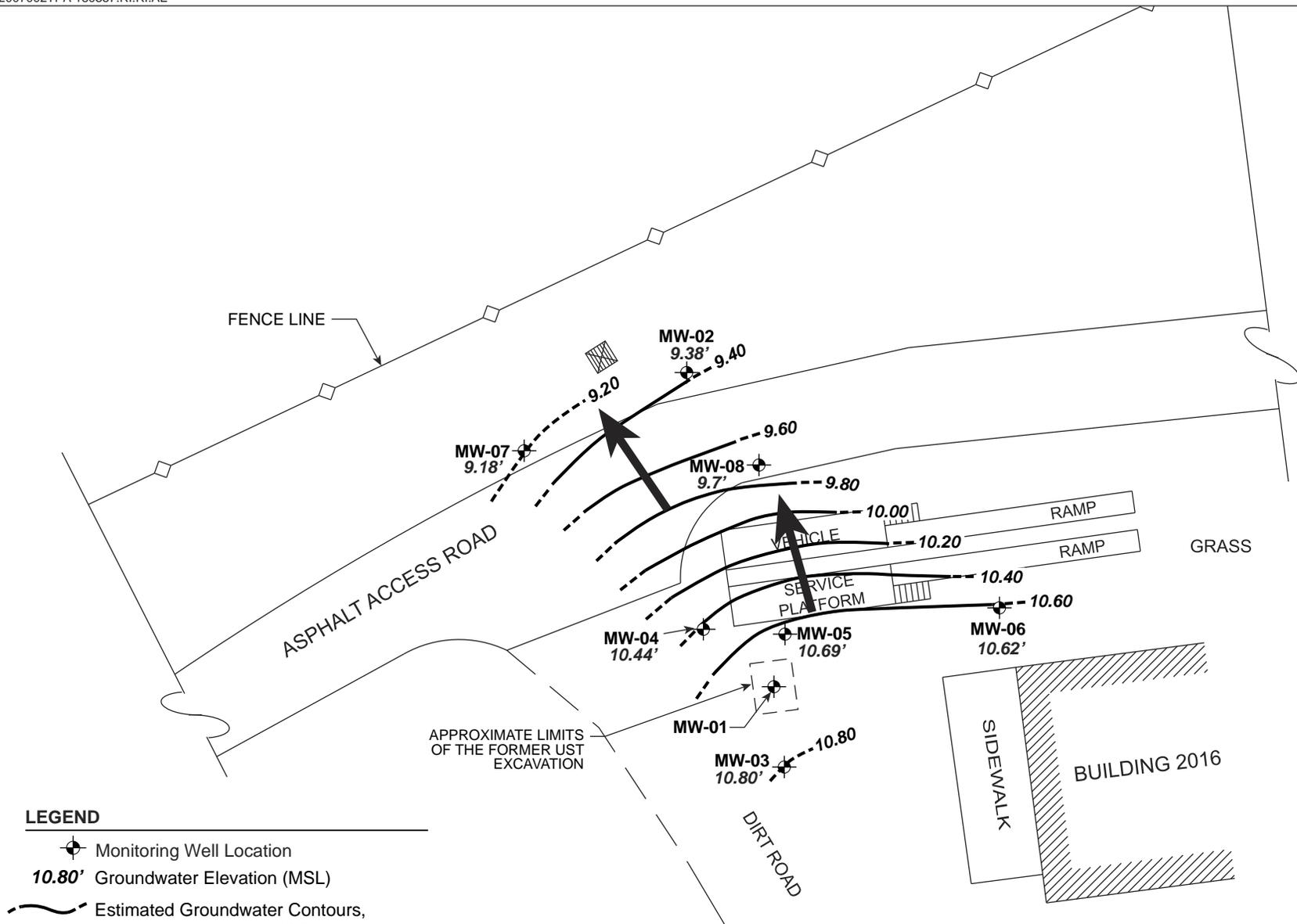


FIGURE 2-13
Estimated Potentiometric Surface, November 30, 2005
AOC E Remedial Investigation Report
Vieques, Puerto Rico



LEGEND

-  Monitoring Well Location
- 10.80'** Groundwater Elevation (MSL)
-  Estimated Groundwater Contours, dashed where inferred (0.2' Intervals)
-  Estimated Direction of Groundwater Flow

Groundwater Elevations in FT MSL

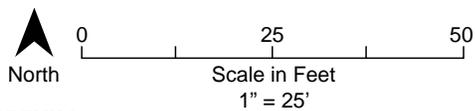


FIGURE 2-14
Estimated Potentiometric Surface, March 17, 2006
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Summary of Field Investigations

This section summarizes the procedures employed for data collection, analysis, and validation at AOC E during the UST Removal, Site Characterization, PA/SI, and RI. Figures 3-1, 3-2, and 3-3 display the surface soil, subsurface soil, and groundwater sampling locations, respectively.

Table 3-1 summarizes the investigations and associated samples that were collected, the media sampled, analyses performed, sample identifications, and depth of sampling (for soil samples).

To aid in readability, throughout this report samples are referred to using abbreviated nomenclature comprising the sample type designation (SS, SB, and MW) and sample number (e.g., surface soil sample WAE-SS13-0002 is referred to as SS-13 and monitoring well/groundwater sample NDAEMW01 is referred to as MW-01). Sample nomenclature assigned in the field and, therefore, used in the database, is shown in Appendix L.

In accordance with the Closure Plan for Underground Storage Tank (UST) Systems (Dames & Moore, 1995), the following environmental media data collection activities took place around the former UST and associated piping during tank removal in November 1996:

- Subsurface samples at four locations and one soil sample from staged soil (Appendix A); because it is not known whether the soil associated with these samples was removed during the UST removal activities and because the quality assurance/quality control (QA/QC) protocol for the UST removal sampling is unknown, the associated data are not included in the RI data evaluation.

In accordance with the Site Characterization Work Plan for AOC E (CH2M HILL, 1998), the following environmental media data collection activities took place at AOC E in August and September 1998:

- Subsurface soil sampling at five locations (SB-01 through SB-05 in Figure 3-2), installation of three monitoring wells (MW-01 through MW-03 in Figure 3-3), and groundwater sampling at each well.

In accordance with the PA/SI Work Plan for AOC E (CH2M HILL, 2000b), the following environmental media data collection activities took place at AOC E in April and May 2000:

- Installation of three monitoring wells (MW-04 through MW-06 in Figure 3-3) and groundwater sampling at those three wells and two previously installed monitoring wells (MW-02 and MW-03). A groundwater sample was not collected at MW-01 because a thin layer (0.10 ft) of product was measured in the well.

In accordance with the Remedial Investigation/Feasibility Study (RI/FS) Work Plan for AOC E (CH2M HILL, 2002a), the following environmental media data collection activities took place at AOC E in May 2002 and in September 2003:

- Subsurface soil sampling at seven locations (SB-06 through SB-12 in Figure 3-2), installation of two monitoring wells (MW-07 and MW-08 in Figure 3-3), and groundwater sampling at those two wells and four previously installed monitoring wells (MW-02 through MW-04 and MW-06 in Figure 3-3). Wells MW-01 and MW-05 were not sampled because product was measured in each (0.42 ft and 0.28 ft, respectively). The groundwater sample collected at MW-08 in 2002 was delivered by the courier to the incorrect address so the holding time was exceeded. Because of this, the well was re-sampled in September 2003 and its data are included in the data set.

In accordance with the Sampling and Analysis Plan for Additional Sampling at AOC E (CH2M HILL, 2004b), the following environmental media data collection activities took place at AOC E between August and September 2004:

- Groundwater sampling at the eight AOC E monitoring wells (MW-01 through MW-08 in Figure 3-3).
- Free product sample collected for laboratory analysis from monitoring well MW-01.

In accordance with the Supplemental RI Work Plan for AOC E (CH2M HILL, 2005), the following environmental media data collection activities took place at AOC E in November and December 2005:

- Surface soil sampling at seven locations (SS-13 through SS-19 in Figure 3-1), subsurface soil sampling at four locations (SB-13 through SB-16 in Figure 3-2), and groundwater sampling at six monitoring wells (MW-02 through MW-04, MW-06 through MW-08) in Figure 3-3). Groundwater samples were not collected from MW-01 or MW-05 because free product was present in the wells (1.17 ft and a sheen, respectively).

Prior to the PA/SI field work, a habitat characterization survey was completed to ensure no threatened or endangered species would be impacted by the sampling activities. The habitat characterization survey report was submitted in August 2000 and is included in Appendix K. No federally-protected species or preferred habitats were observed at AOC E.

Summaries of the various field activities during the 1996 UST removal, 1998 Site Characterization, 2000 PA/SI, and 2002 through 2005 RI are provided in the following subsections. Samples were collected in general accordance with the standard operating procedures (SOPs) presented in the Work Plans available at the times the investigations were conducted:

- *Closure Plan for Underground Storage Tanks (UST) Systems, Naval Station Roosevelt Roads, Puerto Rico* (Dames & Moore, 1995)
- *Work Plan and Health and Safety Plan for Underground Storage Tank Sites Nos. 2016, 34, 229, 2016, 2842, 429R, 724, 1817 – Roosevelt Roads Naval Station, Ceiba, Puerto Rico* (CH2M HILL, 1998) for the Site Characterization
- *Site Specific Work Plan, U.S. Naval Ammunition Storage Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2000b) and the *Master Work Plan for the U.S. Naval Ammunition Storage Detachment, Vieques, Puerto Rico* (CH2M HILL, 2000c) for the 2000 PA/SI
- *Remedial Investigation/Feasibility Study Work Plan for Area of Concern E at Former U.S. Naval Ammunition Support Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2002a) and the

Master Work Plan for the U.S. Naval Ammunition Support Detachment, Vieques Island, Puerto Rico (CH2M HILL, 2001) for the 2002 and 2003 RI sampling

- *Attachment 1, Sampling and Analysis Plan for the Additional Sampling at AOC E* (CH2M HILL, 2004b) and the 2001 Master Work Plan (CH2M HILL, 2001) for the 2004 RI sampling
- *Supplemental Remedial Investigation Work Plan for Area of Concern (AOC) E, The Former U.S. Naval Ammunition Support Detachment (NASD), Vieques Island, Puerto Rico* (CH2M HILL, 2005) and the 2001 Master Work Plan (CH2M HILL, 2001) for the 2005 RI sampling

Where deviations from the above plans occurred and/or were necessary, they are discussed within the various field activities summarized in the following subsections.

3.1 Soil Sampling

The locations of surface soil samples and subsurface soil samples collected during the RI and previous investigations are shown in Figures 3-1 and 3-2, respectively. The discussion in this subsection summarizes the soil sampling activities conducted during the UST removal, Site Characterization, PA/SI, and RI. For a more detailed summary of soil sampling activities conducted during the previous investigations (UST Removal, Site Characterization, and PA/SI), please refer to the *Closure Report of Area 2016* (Reliable Mechanical Inc, 1997) (Appendix A), *Site Characterization Report for Site No. 2016* (CH2M HILL, 1999), and the *Expanded Preliminary Assessment/Site Investigation, U.S. Naval Ammunition Storage Detachment, Vieques Island, Puerto Rico* (CH2M HILL, 2000a).

3.1.1 Soil Sampling, Analysis, and Validation

Soil samples were screened in the field with a photo-ionization detector (PID), also known as an organic vapor monitor (OVM), for the PA/SI and the 2002 RI sampling and a flame ionization detector (FID), also known as an organic vapor analyzer (OVA), for the Site Characterization and 2005 RI sampling. These instruments were used to provide qualitative data on the presence of potential contamination in the unsaturated zone during drilling and sampling activities, to aid in selecting soil sampling intervals, and to monitor the breathing zone during sampling activities. PA/SI and the 2002 RI breathing zone and above-borehole PID readings are recorded on the individual boring logs (Appendix B). Similarly, Site Characterization and 2005 RI headspace and breathing zone FID readings are recorded on individual soil boring logs included in Appendix B. The calibration and use of OVMs and OVAs during the PA/SI and RI were in general accordance with the Master Work Plan SOPs “Volatiles Monitoring with an OVM” and “Volatiles Monitoring with an OVA” (CH2M HILL, 2000c; CH2M HILL, 2001). Calibration and use of the OVA during the Site Characterization field work were in general accordance with the Health and Safety Plan (Appendix D of the Work Plan and Health and Safety Plan for UST Sites (CH2M HILL, 1998); the procedure used is described in Appendix D of the Site Characterization Report (CH2M HILL, 1999). No record of soil screening or air monitoring during the UST removal activities was found.

Surface Soil Sampling

Surface soil samples were collected during the supplemental RI in 2005. All surface soil samples, analyses, nomenclature, and sampling depths are shown on Table 3-1. The table also includes explanations for the sampling depth intervals selected. Boring logs for soil samples are included in Appendix B.

Supplemental RI (2005)

Surface soil samples were collected at AOC E using a 3-inch diameter stainless steel hand auger during the November/December 2005 sampling event. Seven surface soil samples (SS-13 through SS-19) were collected from the 0 to 2 ft bls. Please refer to Table 3-1 for the details regarding the media sampled, analyses performed, sample identification, and sample depths.

Surface soil samples were screened with a FID. No elevated FID readings were observed. Samples were collected with a 3-inch diameter stainless steel hand auger from the 0 to 2 ft bls interval. In order to collect soil samples for volatile organic compound (VOC) analysis from the target interval using the En Core™ sampler, soil from within that interval was first removed from the ground with a hand auger, placed into a stainless steel bowl, and then collected by pushing the En Core™ sampler into the soil several times to fill the sampler with soil from the target interval. After the VOC sample was collected, the soil in the bowl was homogenized with a stainless steel spoon, and soil for other parameters was then transferred into the appropriate sample containers.

Surface soil samples were collected in accordance with the SOPs "Soil Sampling," "Shallow Soil Sampling," "Soil Sampling for VOCs Using the EnCore Sampler," and "Homogenization of Soil and Sediment Samples." All soil borings were logged in the field using the Unified Soil Classification System (USCS) in accordance with the SOP "Logging of Soil Borings" (CH2M HILL, 2001).

Subsurface Soil Sampling

Subsurface soil samples were collected during the UST removal activities in 1996, the Site Characterization in 1998, and the 2002 and 2005 RI sampling activities. All subsurface soil samples, analyses, nomenclature, and sampling depths are shown on Table 3-1. The table also includes explanations for the sampling depth intervals selected. Boring logs for soil samples are included in Appendix B.

UST Removal (1996)

Subsurface soil samples were collected at AOC E once the UST and associated concrete pad below the UST were removed in November 1996. Subsurface soil samples were collected from four locations; one below the concrete pad that supported the UST (approximately 17 ft bls), one in the pipe trench that led from the vehicle maintenance platform to the UST (sample depth not recorded), and one at each end of the UST (approximately 6 ft bls). An additional soil sample was collected from excavated, stockpiled soil. Please refer to Table 3-1 for the details regarding the media sampled, analyses performed, sample identification, and sample depths.

The sample analysis was conducted in accordance with the Closure Plan (Dames & Moore, 1995). There is no record of the sampling method or SOPs followed during the soil sampling associated with removal of the UST. The UST Closure Report is included in Appendix A.

Site Characterization (1998)

Subsurface soil samples were collected at AOC E using 2-inch and 3-inch diameter stainless steel split spoons during the August/September 1998 sampling event. Subsurface soil samples were collected at three intervals: 4-6 ft bls, 43-45 ft bls, and 45-47 ft bls (Table 3-1). The depths of subsurface sample collection were based on collecting a sample from within the 2 to 6 ft bls depth and another just above the water table at each boring. Borings SB-3 and SB-4 had samples collected only at the 4-6 ft bls interval. Please refer to Table 3-1 for the details regarding the media sampled, analyses performed, sample identification, and sample depths.

Split-spoon soil samples were collected in accordance with the Standard Penetration Test Procedures, American Society for Testing and Materials (ASTM) D-1586 (Appendix B of the Site Characterization Work Plan [CH2M HILL, 1998]).

RI (2002)

Subsurface soil samples were collected at AOC E using 2-inch and 3-inch diameter stainless steel split-spoons or collected from cuttings generated during the air hammer drilling process during the April and May 2002 sampling event, as stated in the work plan (CH2M HILL, 2002a). Collection of subsurface soil samples near the depth of the saturated zone (i.e. greater than 30 ft bls) was sometimes necessary from the air hammer cuttings because the hollow stem augers and split-spoon reached refusal at depths shallower than the saturated zone. This was true for the deep subsurface soil samples from borings SB-06, SB-08, SB-09, SB-10, and SB-12. However, these deeper samples were used as a semi-qualitative evaluation of deep soil contamination, but were not used in the risk assessment. Based on the work plan protocol, 19 subsurface soil samples were collected from 7 soil borings (SB-06 through SB-12) between 2 and 48 ft bls. See Table 3-1 for an explanation of sampling depths. Please refer to Table 3-1 for the details regarding the media sampled, analyses performed, sample identification, and sample depths.

Subsurface soil samples were collected in accordance with the SOPs "Soil Sampling," "Shallow Soil Sampling," "Soil Boring Sampling - Split Spoon," and "Homogenization of Soil and Sediment Samples." All soil borings were logged in the field using the USCS in accordance with the SOP "Logging of Soil Borings" (CH2M HILL, 2001).

Supplemental RI (2005)

Subsurface soil samples were collected at AOC E using a 2-inch stainless steel split-spoon in December 2005. Eight subsurface soil samples from four soil boring locations (SB-13 to SB-16) were collected at 4-6 ft bls and at various intervals between 32 ft bls and 46 ft bls (Table 3-1). The subsurface soil sampling was done in accordance with the subsurface soil sampling protocol developed as part of the supplemental RI work plan. Subsurface samples were collected from 4-6 ft bls in each of the four borings. In addition, as applicable, a sample from the interval of highest OVM readings above the water table was collected for laboratory analysis, as well as a sample from the interval just below the highest reading interval. No OVM detections were encountered at boring SB-16; thus, only the 4-6 ft bls sample was collected. At the SB-15 location, an OVM reading of 100 parts per million (ppm) at the 4244 ft bls interval was detected but because the sample was described as wet and below the water table, a sample was not collected for laboratory analysis.

The work plan stated that water levels would be collected on the day of sampling in order to develop an understanding of the terminal depth of the soil borings (i.e., water table). Because the soil sampling took place over a 2-week period, the water levels were actually taken on November 30, 2005, which corresponds with the day the soil borings were started. Please refer to Table 3-1 for the details regarding the media sampled, analyses performed, sample identification, and sample depths.

Subsurface soil samples were collected in accordance with the SOPs "Soil Sampling," "Shallow Soil Sampling," "Soil Boring Sampling - Split Spoon," "Soil Sampling for VOCs Using the EnCore Sampler," and "Homogenization of Soil and Sediment Samples." All soil borings were logged in the field using the USCS in accordance with the SOP "Logging of Soil Borings" (CH2M HILL, 2001).

3.2 Drilling and Monitoring Well Installation, Testing, and Sampling

The locations of the eight monitoring wells installed at AOC E are shown in Figure 3-3. The discussion in this subsection summarizes the monitoring well installation and groundwater sampling activities conducted during the Site Characterization, PA/SI, and RI. All groundwater sample nomenclature and analyses are shown on Table 3-1.

3.2.1 Monitoring Well Installation

Eight monitoring wells (MW-01 through MW-08) were installed at AOC E to assess potential effects on groundwater from activities associated with the former UST. Monitoring wells MW-01 through MW-03 were installed in August 1998 (Site Characterization), wells MW-04 through MW-06 were installed in April 2000 (PA/SI), and wells MW-07 and MW-08 were installed in May 2002 (RI). A summary of the monitoring well construction details, including survey data, is provided in Table 3-2.

Drilling methods used at each boring for monitoring well installation comprised:

Site Characterization (MW-01, MW-02, and MW-03)

- Post hole digger from 0 to 4 ft bls to avoid possible underground utilities.
- Hollow stem auger from 4 ft bls to refusal depth below the water table. At MW-03, auger was advanced by hand from 4 to 8 ft bls prior to the use of the hollow stem auger.

PA/SI (MW-04, MW-05, and MW-06)

- Post hole digger from 0 to 4 ft bls for borings MW-04 and MW-06 to avoid possible underground utilities.
- Air rotary with air hammer drilling technique from surface for boring MW-05 and from 4 ft bls (MW-04 and MW-06) to below the water table. Post hole digger not used at MW-05 because the location was in close proximity to a previously drilled boring/well (MW-01).

RI (MW-07 and MW-08)

- Hollow-stem augers from 0 to refusal (24 ft bls at MW-07 and 34 ft bls at MW-08)
- Air rotary with air hammer drilling technique from 24 ft bls and 34 ft bls (MW-07 and MW-08 respectively) to below the water table.

Split spoon sampling of the unconsolidated material was performed from 4 to 20 ft bls at MW-01 and MW-02, 8 to 20 ft bls at MW-03, 12 to 24 ft bls at MW-07, and 12 to 34 ft bls at MW-08, in accordance with the associated work plans. Monitoring wells at AOC E were installed at the first encountered groundwater, which was within the saprolite. The soil boring logs are included in Appendix B. Appendix C presents well construction diagrams.

The Site Characterization monitoring wells (MW-01, MW-02, and MW-03) were constructed following the SOP “U.S. Navy Monitoring Well Construction Specifications” in Appendix C of the work plan (CH2M HILL, 1998). The PA/SI (MW-04, MW-05, and MW-06) and RI (MW-07 and MW-08) monitoring wells were constructed following the SOPs “General Guidance for Monitoring Well Installation” and “Installation of Bedrock Monitoring Wells,” contained in the Master Work Plan (CH2M HILL, 2000c; CH2M HILL, 2001). Each monitoring well was equipped with a concrete pad, 8-inch diameter flush mounted protective casing, and well cap.

The deviation from the work plans during monitoring well installation and construction at AOC E relates to the emplacement of the filter sand pack above the well screens. The SOP indicates a coarse-grained primary sand pack is to be installed up to 2 ft above the top of the screen, with a fine-grained secondary sand pack, 1 ft thick, above the primary sand pack. During the construction of all eight monitoring wells, only a coarse grained primary sand pack was installed to at least 2 ft above the top of the screen. A hydrated bentonite seal, at least 2 ft thick, was installed above the sand pack. The bentonite seal was allowed to hydrate for at least 45 minutes prior to placing the cement-bentonite grout above the seal.

The installation of a secondary, fine-grained sand pack is intended to help inhibit downward migration of the cement-bentonite grout through the bentonite seal and into the screened interval (referred to as grout contamination) before the grout sets up. However, allowing the bentonite seal above the sand pack to sufficiently hydrate (which was done at all AOC E wells) allows for an impermeable seal, and thus obviates the necessity of a secondary, fine grained sand pack. The absence of grout contamination was verified during well development (Section 3.2.2) and groundwater sampling (Section 3.2.3), as the pH measurements in all wells were not indicative of grout contamination (i.e., none significantly above pH 7, as shown in Table 3-3).

3.2.2 Monitoring Well Development

Well development was conducted a minimum of 24 hours after the grout used to construct the wells had been allowed to set up in accordance with the U.S. Navy Monitoring Well Construction Specifications (CH2M HILL, 1998) and SOP “General Guidance for Monitoring Well Installation (CH2M HILL, 2000c; CH2M HILL, 2001). Well development activities were performed in accordance with the U.S. Navy Monitoring Well Construction Specifications (CH2M HILL, 1998) and the SOP “Installation of Shallow Monitoring Wells” (CH2M HILL, 2000c; CH2M HILL, 2001). Well development information is included in Appendix D.

Monitoring well development was performed during the Site Characterization by surging the well with a bailer and pumping groundwater using a peristaltic pump. Well development was performed during the PA/SI by surging and pumping with a Whale® pump. Well development was performed during the RI by surging and pumping with a Grundfos® pump. Development water was containerized in 55-gallon drums. See Section 3.4 for a discussion of testing and disposal of IDW.

3.2.3 Monitoring Well Purging and Sampling

During groundwater sampling, indicator parameters were monitored to help determine when it was appropriate to collect the groundwater samples. Table 3-3 summarizes the indicator parameter values for the 1998, 2000, 2002, 2003, 2004, and 2005 sampling events.

Samples collected during the PA/SI (2002) and RI (2003, 2004, and 2005) for dissolved metals were field-filtered prior to preservation using a 0.45 micron filter and followed procedures outlined in the Master Work Plan SOP "Field Filtering" (CH2M HILL, 2001). Samples collected during the Site Characterization were not analyzed for dissolved metals.

The wells were sampled with a Teflon bailer during the Site Characterization (1998), a Grundfos® pump during the PA/SI (2000) and several of the RI sampling events (2002, 2003, and 2004), and a Monsoon® pump during the last RI sampling event in 2005. During the 2000 sampling event, new, dedicated Tygon® tubing was used for sampling each well; during the 2002, 2003, 2004, and 2005 events, new, dedicated Teflon® tubing was used for sampling each well during each event.

Water quality data, comprising temperature, conductivity, oxidation reduction potential (ORP), dissolved oxygen (DO), turbidity, and pH, were monitored during purging and each well was sampled after the parameters had stabilized except for the 1998 groundwater sampling event. No water quality data were collected during the 1998 groundwater sampling event because the wells were sampled after three well volumes were removed, as specified in the site-specific work plan. Appendix E includes monitoring well groundwater sampling data sheets. Parameter collection data for the different rounds of sampling are shown in Table 3-3. Exceptions to intended protocol are listed below.

- 2000 PA/SI groundwater sampling event
 - No parameters were collected in MW-04 because the well went dry and was sampled upon recharge, as stated in the low flow sampling SOP.
 - ORP and salinity were not measured in MW-05 due to instrument malfunction.
 - DO was not measured in MW-06 due to instrument malfunction.
- 2000 PA/SI and 2005 Supplemental RI groundwater sampling events
 - Salinity readings were collected although not required by the low flow sampling SOP.

Groundwater sampling performed during the Site Characterization followed the "Groundwater Sampling Procedures" section of the work plan (CH2M HILL, 1998). This protocol dictated three well volumes be removed prior to sampling. Other than the 2000 sampling event, groundwater sampling for the remaining events was performed in general

accordance with the SOP “Groundwater Sampling Procedure Low Stress (Low Flow) Purging and Sampling” in the Master Work Plan (CH2M HILL, 2000c; CH2M HILL, 2001), to the extent practicable (exceptions listed below). Low flow procedures were not followed during the 2000 sampling event. Pumping rates were higher than the specified low flow rates of 200 to 500 milliliters per minute (ml/min), three consecutive readings of parameters were not obtained, and drawdown was not recorded during sampling. However, the data from the 2000 sampling event, as well as the 1998 sampling event, are generally comparable to those collected during subsequent events. In addition, the groundwater data collected during the more recent events (i.e., 2002 and 2004) were used in assessing potential risks.

Notable deviations from the Low Flow sampling SOP during the 2002 groundwater sampling event are summarized below:

- A flow rate (643 ml/min) just above the maximum of 500 ml/min suggested by the Low Flow SOP was used during purging of well MW-06.
- Drawdown of the water table was not measured during sampling.
- All samples had three consecutive readings of pH within 0.1 except MW-07, which had readings of 6.74, 6.25, and 6.76; however, the other parameters (other than turbidity) had stabilized to within SOP limits.
- ORP readings were all within 10 millivolts (mV) during the last three readings except MW-06, which had readings of 236 mV, 245 mV, and 250 mV; however, the other parameters (other than turbidity) had stabilized to within SOP limits.
- DO readings were all within 10% during the last three readings except MW-03, which had readings of 4.10, 3.10, and 2.90; however, the other parameters (other than turbidity) had stabilized to within SOP limits.
- Turbidity readings in the five wells exceeded the 10% recommended limit, but at the relatively low turbidity values recorded (e.g., between 9 nephelometric turbidity units (NTUs) and 31 NTUs in the various wells), greater than 10% difference can occur at very small actual differences.
- Low Flow SOP rates for sampling (100 to 250 ml/min) were exceeded at wells MW-02, MW-06, and MW-07 (flow rates of 473 ml/min, 628 ml/min, and 340 ml/min, respectively) due to difficulty in keeping a reduced flow with the Grundfos® pump during the sampling of these wells.

Notable deviations from the Low Flow sampling SOP during the 2003 groundwater sampling event (MW-08 only) are summarized below:

- ORP readings were just outside the 10 mV SOP range during the last three readings (readings were 267 mV, 277 mV, and 279 mV).
- Turbidity readings were not within 10% of each other for the last three readings (34.7, 25.5, and 23.2); however, the remaining parameters (other than ORP) had stabilized to within SOP limits.

- Low Flow SOP rates for sampling (100 to 250 ml/min) were exceeded at well MW-08 (flow rate of 500 ml/min) due to difficulty in keeping a reduced flow with the Grundfos® pump during the sampling of this well.

Notable deviations from the Low Flow sampling SOP during the 2004 groundwater sampling event are summarized below:

- The Low Flow SOP rates of 200 to 500 ml/min were exceeded during purging of wells MW-01, MW-02, MW-03, MW-06, MW-07, and MW-08 (flow rates between 800 and 900 ml/min); however, recommended drawdown limits were met (other than for MW-01).
- The Low Flow SOP rates of 100 to 250 ml/min were exceeded during sampling (flow rates from 287 ml/min to 908 ml/min) because of the difficulty in reducing the Grundfos® pump flow rate without it overheating; however, recommended drawdown limits were met (other than for MW-01).
- The Low Flow SOP suggested maximum drawdown of the water table (less than 0.3 ft) was exceeded at well MW-01, which had a drawdown of approximately 2 ft during sampling. This was the only time the well was sampled using a pump because of the presence of free product in the well; wells containing free product are often not sampled.
- ORP readings were not within the 10 mV limit between the last three readings except for MW-03; however, the other parameters (other than for MW-05 DO readings) had stabilized to within SOP limits.
- DO readings were all within 10% during the last three readings except MW-05, which had the last three readings within 30%; however, the other parameters (other than turbidity) had stabilized to within SOP limits.
- Turbidity readings exceeded 10% for last three readings at wells MW-01, 02, 04, 05, 07, and 08; but at the relatively low turbidity values recorded (e.g., between 3 NTUs and 18 NTUs in the various wells), greater than 10% difference can occur at very small actual differences.

Notable deviations from the Low Flow sampling SOP during the 2005 groundwater sampling event are summarized below:

- The Low Flow rates of 200 to 500 ml/min were maintained in all wells except for one (MW-02) that was slightly higher (533 ml/min); however, recommended drawdown limits were met at this well.
- The Low Flow SOP rates of 100 to 250 ml/min were exceeded during the sampling (flow rates from 378 ml/min to 568 ml/min) of wells except at MW-08; however, recommended drawdown limits were met for wells other than MW-03, MW-4, and MW-08.
- The Low Flow SOP suggested maximum drawdown of the water table (less than 0.3 ft) was exceeded at wells MW-03, MW-04, and MW-08. Maximum drawdowns in the three wells were 1.37, 4.01, and 0.73, respectively. Recommended low flow rates were maintained at MW-08 (189 mg/min); therefore, the well could not sustain even

recommended low flow rates. The flow rates at wells MW-03 and MW-04 were approximately 378 ml/min, just above the recommended low flow rate maximum.

- DO readings were all within 10% during the last three readings except MW-03, in which the DO readings were 15% different within the last three readings (2.11, 1.91, and 1.84); however, the other parameters (other than turbidity) had stabilized to within SOP limits.
- Turbidity readings within 10% for last three readings were exceeded at wells MW-03, 04, and 07. Final readings were very low at 4.41 NTUs, 7.45 NTUs, and 2.00 NTUs, respectively. At these low levels, greater than 10% difference can occur at very small actual differences. However, the other parameters (other than DO for MW-03) had stabilized to within SOP limits.

Although there were deviations from the low flow sampling procedures, it is unlikely the sampling methodology affected the quality of the data such that conclusions would be affected. The most substantive deviation listed above is the water level drawdown during purging exceeded 0.3 ft. Because parameter readings were generally stable during sampling, it is unlikely that the sample results were adversely affected by the above deviations. Further, as discussed in Section 8, an additional round of groundwater samples is recommended, which will help confirm previous data as well as provide temporal variability information.

3.2.4 Groundwater Level Measurements

Groundwater level measurements were obtained from monitoring wells at AOC E on seven occasions: September 1998 (MW-01 through MW-03), May 2000 (MW-01 through MW-06), May 2002 (MW-01 through MW-08), August 2003 (MW-01 through MW-08), August 2004 (MW-01 through MW-08), November 2005 (MW-01 through MW-08), and March 2006 (MW-02 through MW-08). Table 2-2 summarized the groundwater level measurements and Section 2.3.4 discussed the potentiometric surface estimated from the water level measurements.

An electronic water level meter was used to measure the depth to water from the top of casing of each monitoring well to the nearest 0.01 ft. An oil/water interface probe was used to measure the free product thicknesses in monitoring wells MW-01, MW-05, and once in MW-04 (August 2005 event). Free product was not detected in the 1998 sampling of MW-01, but was identified in every sampling event after that in thicknesses ranging from 0.4 ft to 1.17 ft (thickness variations due to natural fluctuations and periodic bailing, as shown in Table 2-2). The free product thicknesses measured in MW-05 ranged from a sheen to 0.28 ft.

3.2.5 Hydraulic Conductivity Testing

In situ hydraulic conductivity (slug) tests were performed on monitoring wells MW-02 and MW-03 on September 11, 1998 during the Site Characterization and MW-04 and MW-07 on May 23, 2002, during the RI to obtain estimates of the aquifer hydraulic conductivity. Because the tests conducted in MW-02 and MW-03 were falling head tests in wells screened across the water table, the data are unreliable and, therefore, not included in the analysis. MW-04 was chosen to be slug tested over the well identified in the work plan (MW-05) because of free product found in MW-05. Other than this substitution, monitoring wells MW-04 and MW-07 were tested in accordance with the *Final RI/FS Work Plan for AOC E*

(CH2M HILL, 2002a) and in accordance with the SOP “Aquifer Slug Testing” of the Master Work Plan (CH2M HILL, 2001).

The static depth to water and total depth of the well were determined with an electronic water level indicator before testing began on each well. Each test included installing a 0-to-15-pound-per-square-inch (psi) pressure transducer with a data logger programmed to measure and record water levels. Rising head (slug-out) tests were performed in monitoring wells MW-4 and MW-7. For each slug-out test, after the initial water level was measured, a 1-inch-diameter by 5-ft-long solid polyvinyl chloride (PVC) slug was lowered into the monitoring well. The falling water level in the well was recorded until the water level recovered to within 90 percent of the original water level. The falling water level information is the “slug-in” or falling head slug test data. In this case, rising head information was required. The slug was then quickly removed from the monitoring well (slug-out test), causing the water level to drop rapidly in response to the removal of the slug, and then rise as the water level returned to equilibrium. The decline and rise of the water level in the well were recorded until the water level had recovered to within 90 percent of the original water level. The tests were performed multiple times at each well to determine reproducibility and verify results. Only reproducible data from the tests were used to calculate hydraulic conductivity, as shown in Table 3-4. Raw data from the hydraulic conductivity testing are also contained in Appendix F. Section 2.3.4 discusses the results of the testing.

It is noted that slug tests and the methodology developed to analyze slug test data are based on average flow through unconsolidated, porous media; therefore, data inferred or calculated from slug tests in wells installed in saprolite near fractured bedrock or fractured bedrock wells should be viewed as providing a qualitative estimate of hydraulic conductivity. Further, slug tests are influenced by well construction; therefore, differences in measurements among wells may reflect not only hydraulic conductivity differences between the wells, but well construction influences as well (Fetter, 1988).

3.3 Surveying

The three monitoring wells installed during the 1998 Site Characterization were surveyed by a licensed surveyor for top of casing elevation. However, the data appear to be erroneous data (based on subsequent surveying) and are not used in this report. The surveying work during subsequent investigations at AOC E was in general accordance with Master Work Plan SOP “Civil Surveying” (CH2M HILL, 2000c; CH2M HILL, 2001). Six of the monitoring well locations (MW-01 through MW-06) were surveyed by Glenn and Sadler for the 2000 PA/SI and again by TranSystems, Inc. (Glenn and Sadler was purchased by TranSystems, Inc.) for the 2002 RI. TranSystems used differential global positioning system (DGPS) techniques, and Glenn and Sadler used a transit. Monitoring wells MW-07 and MW-08 were surveyed by a CH2M HILL licensed surveyor in 2002 for elevation of the top of casing. The elevations of MW-07 and MW-08 were obtained by using existing top of casing elevations of nearby wells at AOC E. The survey established the spatial northing and easting coordinates for each well location. In addition, the elevation in ft amsl was established to the nearest 0.01 ft for the top of the monitoring well casings using traditional surveying techniques and

DGPS techniques. Survey data for the monitoring well locations are contained in Appendix I.

The underlying premise of DGPS requires that a GPS receiver, known as the base station, be set up on a precisely known location. The base station receiver calculates its position based on satellite signals and compares this location to the locations of the individual borings and wells. The difference is applied to the GPS data recorded by the roving GPS receiver. These data survey points are included in the database and used for plotting sample locations on figures created using a geographic information system (GIS).

3.4 Decontamination of Sampling Equipment and Investigation-derived Waste Management

During the UST removal, the 500 gallon tank was removed, cleaned out, capped and sent to the BFI landfill in Ponce, Puerto Rico. The 30 yards of soil from the excavation were temporarily placed on a diked plastic liner, sampled, and ultimately disposed of in the BFI landfill as a non-hazardous waste.

During the Site Characterization sampling, drill rigs, hollow-stem auger flights, split spoons, and bowls were decontaminated between sampling and monitoring well installation locations in accordance with the Site Characterization Work Plan for AOC E (CH2M HILL, 1998). Decontamination water evaporated on the decontamination pad before it could be pumped into 55-gallon drums. Well development water was contained in three 55-gallon drums and was later allowed to evaporate based on laboratory analytical data and the absence of free product. Drill cuttings were contained in 55-gallon drums. Based on analytical results, the soil from all borings except for SB-01 were non-hazardous and was spread on-site in the vicinity of the former UST. Cuttings from SB-01 were disposed of properly after analytical analyses.

During the PA/SI and 2002 RI sampling, drill rigs, hollow-stem auger flights, split spoons, hand augers, and bowls were decontaminated between sampling locations in accordance with the SOP "Decontamination of Drilling Rigs and Equipment" of the Master Work Plan (CH2M HILL, 2000c; CH2M HILL, 2001). During the PA/SI and the 2002 RI sampling events, decontamination of the well development and groundwater sampling equipment was conducted in accordance with the SOP "Decontamination of Personnel and Equipment" contained in the Master Work Plan (CH2M HILL, 2000c; CH2M HILL, 2001). Drill cuttings were contained in 55-gallon drums.

During the 2003 RI ground water sampling of MW-08, 16 gallons of purge water were placed into a 55-gallon drum. Subsequently, the drum was stolen before demobilization. However, analytical data for MW-08 suggest the well is not contaminated.

During the 2004 RI field event, soil and water IDW was collected in 55 gallon drums and temporarily stored in the Vieques Public Works Building 2016. Composite water samples were collected from all the drums (17 water drums from concurrent investigations at multiple sites), including the AOC E drums, and analyzed for the full toxicity characteristic leaching procedure (TCLP) list and reactivity, corrosivity, and ignitability parameters. Analytical results of the soil and water IDW samples are in Appendix J. A generator waste profile sheet was submitted to BFI in Ponce with the analytical data. The drums of IDW

were removed from Vieques on February 4, 2005, and transported to BFI in Ponce where they were disposed of as non-hazardous waste, as shown in the waste manifest in Appendix J.

The supplemental RI field effort ending in January 2006 generated soil cuttings, purge water, and decontamination water that was contained in 55 gallon drums and temporarily stored in the Vieques Public Works Building 2016. Composite soil and water samples were collected from all the drums (41 water and 22 soil drums from concurrent investigations at multiple sites), including the AOC E drums, and analyzed for the full TCLP list and reactivity, ignitability, and corrosivity. Analytical results of the soil and water IDW samples are in Appendix J. The analytical results indicated the water was non-hazardous; therefore, the drums were disposed of at the BFI Landfill facility in Ponce on May 2, 2006, along with soil from other investigations, as shown on the BFI Ponce drum receipt confirmation statements (Appendix J).

3.5 Field Sampling and Laboratory Analytical Protocol

Surface soil, subsurface soil, and groundwater samples collected for analyses were placed on ice and shipped via overnight courier to TEG Puerto Rico for the UST removal and the Site Characterization samples, and to Progress Environmental Laboratories located in Tampa, Florida, for the 2000 PA/SI, 2002 through 2004 RI samples. For the 2005 Supplemental RI field event, groundwater samples were sent to CompuChem Laboratories in Cary, North Carolina. Packaging, shipping and chain of custody procedures for the Site Characterization followed the work plan (CH2M HILL, 1998). Packaging, shipping and chain of custody procedures for the PA/SI and RI followed the Master Work Plan SOPs "Packaging and Shipping Procedures" and "Chain of Custody" (CH2M HILL, 2000c; CH2M HILL, 2001).

3.5.1 Sample Analysis and Quality Assurance/Quality Control

Samples were analyzed for constituents shown in Table 3-1. All analytical tests were conducted in accordance with the appropriate analytical methods described in the Data Quality Evaluation Reports (Appendix M). The samples sent to TEG during the Site Characterization followed quality assurance/quality control (QA/QC) procedures outlined in Appendix F "Groundwater Sampling Procedures" in the Site Characterization Report (CH2M HILL, 1999). Both Progress Environmental Laboratories and CompuChem laboratories fulfilled the requirements of the U.S. Navy's QA/QC Program Manual and followed procedures outlined in the Master Quality Assurance Project Plans (QAPPs) (CH2M HILL, 2000c; CH2M HILL, 2001).

The number and frequency of the QA/QC samples are also presented in the Data Quality Evaluation Reports. All raw laboratory data are included in Appendix L. Tables of detected constituents and screening value exceedances are included in Section 4 - Nature and Extent of Contamination. Preparation of equipment and field blanks was in accordance with the Master Work Plan SOPs "Equipment Blank and Field Blank Preparation" (CH2M HILL, 2000c; CH2M HILL, 2001).

3.6 Data Validation and Evaluation

Analytical data collected during the UST removal in 1996 and the Site Characterization in 1998 were not validated. Therefore, these data were not used in the risk assessment. Analytical data were validated by a third party validator in accordance with the U.S. Environmental Protection Agency (EPA) Functional Guidelines for Evaluating Data (EPA, 1994) for the 2000 PA/SI. The 2002 RI analytical data were validated in accordance with the EPA guidance documents *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999) and *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2002). The 2003 RI groundwater sample analytical data at MW-08 were not validated by a third party validator because it was the only sample collected in 2003; however, data validation was performed by a qualified CH2M HILL chemist. The 2004 RI and the 2005 Supplemental RI analytical data were validated in accordance with the EPA guidance documents *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 2005) and *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2002). The data validation process used during the validation of the 2000 PA/SI, 2002, 2004 and 2005 RIs included a laboratory data review covering (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 Region 2 data review worksheet was completed for each method of each data package and any non-conformance was documented. This data review and validation process was independent of the laboratory's checks and focused on the usability of the data to support the project data interpretation and decision-making processes. Data that were not within acceptance limits were appended with a qualifying flag. Data Quality Evaluation Reports are included in Appendix M.

The surface soil samples were collected during only one sampling event (Supplemental RI, 2005) as discussed in *Section 3.1.1 Surface Soil Sampling, Supplemental RI (2005)*. Subsurface samples were collected during the UST Removal, Site Characterization, RI, and Supplemental RI as discussed in *Section 3.1.1 Subsurface Soil Sampling, UST Removal (1996), Site Characterization (1998), RI (2002), and Supplemental RI (2005)*. The methods used to collect the samples were generally similar from one investigation to the next (especially for the samples used in the quantitative risk assessments). It is common practice for data collection at a particular site to be step-wise, ultimately culminating into a comprehensive dataset comprising multiple investigation phases. All samples were collected using well-established, commonly accepted sampling methods.

Regarding changes in analytical methodology, unless a particular analytical method was found to provide unreliable results, the particular analytical method by which one dataset is analyzed is irrelevant with respect to its comparability with a dataset resulting from a different analytical method. The data resulting from a particular analytical method are just as available for use as those from another analytical method. For AOC E, the analytical method for thallium used prior to the 2004 RI groundwater sampling was shown to provide potentially unreliable results. However, this thallium analytical method tended to provide falsely elevated results, so use of the data from this method most likely overestimates thallium concentrations. A new analytical method for thallium (SW-846 7841) was utilized

during the 2004 RI, which provided an order-of-magnitude improvement (decrease) in the thallium reporting limit (i.e., to below the adjusted PRG). In addition, thallium in soil was analyzed only in 2005, during which the analytical method used (ILM05.3) provided non-detect reporting limits (between 0.54 and 0.57 mg/kg) approximately equal to the adjusted PRG (0.52 mg/kg).

What should also be taken into consideration are the reporting limits associated with a particular dataset compared to the reporting limits of a different dataset that is being combined for evaluation purposes. It is important to note that for the datasets generated at AOC E, there is very little overlap of analyses between events for soil, so comparability among particular constituents in different datasets is not applicable. As shown in Table 3-1, with respect to the major analyses (i.e., those included in risk assessment - VOCs, SVOCs, pesticides, PCBs, and metals), surface soil was analyzed only during one event (i.e., 2005 Supplemental RI). For subsurface soil, only BTEX and TPH constituent analyses were performed during multiple events. In general, reporting limits improved over time. For the subsurface soil, BTEX methods used comprise 8020 in 1998 and 8021 in 2002. The methods are very similar, except more detector options were available in 2002. Reporting limits go down from 1998 to 2002. In 2005, the method used changed to CLP, so the reporting limits went back up slightly but the reporting limits among all events are generally comparable among the BTEX constituents.

For groundwater, the non-detect quantitation limits for metals across multiple sampling events (2000, 2002, 2003, and 2004) are comparable. This is understandable given that the methods were the same from year to year except that 200.7 was used for metals in 2000 and 7841 was used for thallium in 2004. As noted previously, switching to 7841 was marked by an order-of-magnitude decrease in the thallium reporting limit. The non-detect reporting limits for VOCs, SVOCs, pesticides, and PCBs are comparable among the various years of groundwater sampling, primarily because the analytical methods were consistent from year to year (except in 1998 PAHs were analyzed by 610). TPH methods in groundwater did not change from year to year except 418.1 was used in only 1998 and its particular analyte was not repeated across years.

The 2000, 2002, 2003, 2004, and 2005 analytical data were validated using Region II guidelines and worksheets. Therefore, from a data validation standpoint, there are not comparability issues among the various datasets. In addition, all datasets met data availability targets.

TABLE 3-1
 Site Sample Summary
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Site	Investigation Field Work and Associated Report	Media Samples ¹	Analytes	Sample Identification	Soil Sample Depth (ft bls)
AOC E	UST Removal sample collection November 18, 1996 (Reliable Mechanical, Inc., 1997)	5 SB	BTEX, TRPH	2016 Pipe Trench, 2016 Under Slab, 2016-E, 2016-W, 2016 Stock Pile	approx. 2' (2016 Pipe Trench); 17' (2016 Under Slab); approx. 6' (2016-E, 2016-W)
	Site Characterization sample collection August/September 1998 (CH2M HILL, 1999)	8 SB	BTEX, TRPH, TPH-GRO, TPH-DRO, TPH-motor oil	2016-SB1a, 2016-SB1b, 2016-SB2a, 2016-SB2b, 2016-SB3, 2016-SB4, 2016-SB5a, and 2016-SB5b	4 - 6' (SB1a, SB2a, SB3, SB4, SB5a); 43 - 45' (SB2b); 45 - 47' (SB1b, SB5b) in accordance with the work plan sampling depths chosen based on: one sample from within the 2 to 6 ft bls interval and one just above the water table at each boring. SB-3 and SB-4 only had one sample collected in each boring at the 4 to 6 ft interval.
		3 GW	BTEX, TRPH, TPH-GRO, TPH-DRO, TPH-motor oil, and PAH	2016-MW1, 2016-MW2, 2016-MW3	
	PA/SI sample collection April/May 2000 (CH2M HILL, 2000)	5 GW	TCL VOCs, SVOCs, Pesticides, PCBs, and TAL Total and Dissolved Metals	AOC-E-MW02, AOC-E-MW03, AOC-E-MW04, AOC-E-MW05, AOC-E-MW06	
	RI sample collection May 2002 (CH2M HILL, 2004)	19 SB	BTEX, TPH-GRO, TPH-DRO, TPH-oil and grease	AOCE-SB-06 (DSSB06-12, DSSB06-14, DSSB06-44); AOCE-SB-07 (DSSB07-2); AOCE-SB-08 (DSSB08-32, DSSB08-46); AOCE-SB-09 (DSSB09-12, DSSB09-22, DSSB09-28, DSSB09-42); AOCE-SB-10 (DSSB10-12, DSSB10-24, DSSB10-30); AOCE-SB-11 (DSSB11-12, DSSB11-28); AOCE-SB-12 (DSSB12-12, DSSB12-26, DSSB12-28, DSSB12-42)	2 - 4' (DSSB07-2); 12 - 14' (DSSB06-12, DSSB09-12, DSSB10-12, DSSB11-12, DSSB12-12); 14 - 16' (DSSB06-14); 22 - 24' (DSSB09-22); 24 - 26' (DSSB10-24); 26 - 28' (DSSB12-26); 28 - 30' (DSSB09-28, DSSB11-28, DSSB12-28); 30 - 32' (DSSB10-30); 32 - 34' (DSSB08-32); 42 - 44' (DSSB09-42, DSSB12-42); 44 - 46' (DSSB06-44); 46 - 48' (DSSB08-46). In accordance with the work plan, a minimum of two samples were collected from each boring except SB-07 which had only one sample collected because it was an additional non-scoped boring. Many of the samples were collected at the 12-14' depth which corresponds to the depth of the bottom of the former UST. Other samples were collected at high OVM readings, or where odor or visual observations suggested potential contamination. Deeper samples target the soil just above the saturated zone at the time of drilling.
		5 GW	TCL VOCs and SVOCs; TAL Metals and Cyanide	AOC-E-MW02, AOC-E-MW03, AOC-E-MW04, AOC-E-MW06, and AOC-E-MW07	
		1 GW	TCL VOCs, TCL SVOCs, TAL Metals and cyanide	AOC-E-MW08 (previous sample in 2002 was not analyzed)	
	RI sample collection September 2003 (CH2M HILL, 2004b)	1 GW	TCL VOCs, TCL SVOCs, TAL Metals and cyanide	AOC-E-MW08 (previous sample in 2002 was not analyzed)	
	RI sample collection August/September 2004	2 GW	TCL VOCs, SVOCs, and Pesticides/PCBs; TAL Total and Dissolved Metals and Cyanide; TPH (C6 - C10) and TPH (C10 - C28)	NDAEMW01, NDAEMW05	
		3 GW	TCL VOCs and SVOCs; TAL Total and Dissolved Metals and Cyanide; TPH (C6 - C10) and TPH (C10 - C28)	NDAEMW02, NDAEMW03, NDAEMW07	
		1 GW	TCL VOCs, SVOCs, and PCBs; TAL Total and Dissolved Metals and Cyanide; TPH (C6 - C10) and TPH (C10 - C28)	NDAEMW04	
		1 GW	TCL VOCs, SVOCs, and Pesticides; TAL Total and Dissolved Metals and Cyanide	NDAEMW06	
		1 GW	TCL VOCs and SVOCs; TAL Total and Dissolved Metals and Cyanide	NDAEMW08	
		1 GW	TCL VOCs, SVOCs, and Pesticides/PCBs; TAL Total Metals; TPH (C10-C28), TPH (C12-C28), TPH (C6-C10), and TPH (C6-C12)	NDAEMW01 (free product sample)	
	Supplemental RI sample collection November/December 2005	7 SS	TCL VOCs, SVOCs, and Pesticides/PCBs; TAL Metals including Cyanide; TPH-GRO, TPH-DRO, and TPH-ORO; and TOC; and grain size analysis for SS-14	WAE-SS13-0002 through WAE-SS19-0002	0 - 2'; depth in accordance with Work Plan.
8 SB		TCL VOCs, SVOCs, and Pesticides/PCBs; TAL Metals including cyanide; TPH-GRO, TPH-DRO, TPH-ORO, and TOC	WAE-SB13-0406, WAE-SB13-3234, WAE-SB13-3436, WAE-SB14-0406, WAE-SB14-4244, WAE-SB14-4446, WAE-SB15-0406, WAE-SB16-0406	4 - 6' (WAE-SB13-0406, WAE-SB14-0406, WAE-SB15-0406, WAE-SB16-0406); 32 - 34' (WAE-SB13-3234); 34 - 36' (WAE-SB13-3436); 42 - 44' (WAE-SB14-4244); 44 - 46' (WAE-SB14-4446). In accordance with the work plan, samples collected from the 2-6' interval for HHRA and others chosen by highest OVA readings.	
6 GW		TPH-GRO, TPH-DRO, TPH-ORO, and TDS	WAE-MW02, WAE-MW03, WAE-MW04, WAE-MW06, WAE-MW07, WAE-MW08		

Reliable Mechanical, Inc Closure Report is located in Appendix A. Data are not included in the Section 4 Screening Tables.

¹ SS = surface soil sample, SB - subsurface soil sample, GW - groundwater sample.

TABLE 3-2

Summary of Monitoring Well Construction Details

AOC E Remedial Investigation Report

Vieques, Puerto Rico

Well ID	Date Installed	Ground Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Boring Depth (ft bls)	Well Depth (ft bls)	Screen Interval Depth (ft bls)	Screen Interval Depth (ft amsl)	Depth to Bentonite (ft bls)	Depth to Sand Pack (ft bls)	Northing UTM NAD 83 Meter	Easting UTM NAD 83 Meters
MW-01	8/17/1998	43.93	43.93	50	50	40-50	3.93 to -6.07	38	36	232797.520	2005684.767
MW-02	8/20/1998	42.68	42.68	50	50	40-50	2.68 to -7.32	35	32	232790.248	2005701.614
MW-03	8/20/1998	44.06	44.06	50	50	40-50	4.06 to -5.94	37	35	232799.796	2005679.684
MW-04	4/17/2000	43.60	43.60	51	50	40-50	3.60 to -6.40	38	36	232793.297	2005687.006
MW-05	4/17/2000	44.32	44.32	50	50	40-50	4.32 to -5.68	38	36	232798.483	2005687.310
MW-06	4/26/2000	44.34	44.34	50	46	36-46	8.34 to -1.66	34	32	232808.824	2005691.678
MW-07	5/21/2002	43.41	43.41	50	50	40-50	3.41 to -6.59	38	37	232778*	2005704*
MW-08	5/28/2002	43.04	43.04	50	50	40-50	3.04 to -6.96	38	37	232792*	2005698*

ft amsl = feet above mean sea level (NGVD 1929)

ft bls = feet below land surface

Northing and Easting coordinates in UTM meters

* Coordinates were obtained by CH2M HILL in 2007 using a hand held GPS unit.

TABLE 3-3

Summary of Final Water Indicator Parameters Prior to Groundwater Sample Collection

AOC E Remedial Investigation Report

Vieques, Puerto Rico

Event	Well ID	Purged Volume (gallons)	pH	Conductivity μ mhos/cm	Temp. °C	DO mg/L	ORP mV	Turbidity NTUs	Salinity
Site Characterization (1998)	MW-01	3.9	NA	NA	NA	NA	NA	NA	NA
	MW-02	3.9	NA	NA	NA	NA	NA	NA	NA
	MW-03	4.5	NA	NA	NA	NA	NA	NA	NA
PA/SI (2000)	MW-01	NS	NS	NS	NS	NS	NS	NS	NS
	MW-02	21	6.98	1099	29.07	3.53	89.9	795	0.50
	MW-03	7.5	7.19	1031	28.7	4.39	98	1340	0.51
	MW-04	6.5	NA	NA	NA	NA	NA	NA	NA
	MW-05	7	6.92	1328	34.65	2.93	NA	220	NA
	MW-06	4.5	7.14	1029	30.58	NA	102.3	36	0.45
RI (2002/2003)	MW-01	NS	NS	NS	NS	NS	NS	NS	NS
	MW-02	5	7.17	301	32.6	3.76	109	20	NA
	MW-03	5	6.94	1030	32.93	2.9	180	11.8	NA
	MW-04	5	6.87	1450	34.7	1.51	-112	13.6	NA
	MW-05	NS	NS	NS	NS	NS	NS	NS	NS
	MW-06	5	6.92	1120	30.58	4.1	250	31.1	NA
	MW-07	5	6.76	790	32.1	4.3	103	9	NA
	MW-08	16	6.98	928	31.9	5.4	279	23.2	NA
RI (2004)	MW-01	7.35	9.96	1458	36.16	0.55	-59.9	3.38	NA
	MW-02	13.6	6.87	1040	31.7	4.21	451	8.21	NA
	MW-03	9.5	7.08	1148	31.7	2.19	311	0.61	NA
	MW-04	5.46	7.01	1477	38.4	1.51	138.2	18.3	NA
	MW-05	6.63	7.1	1324	32.6	0.93	-14.3	6.7	NA
	MW-06	10.3	6.93	1073	30.5	2.01	455	3.2	NA
	MW-07	12.6	6.88	918	31.2	3.95	409	6.9	NA
	MW-08	11.5	6.92	1029	29	4.5	511	10.3	NA
Supplemental RI (2005)	MW-01	NS	NS	NS	NS	NS	NS	NS	NS
	MW-02	14.25	7.03	1049	28.78	3.09	227.8	6.38	0.48
	MW-03	7	6.99	1168	29.63	1.84	171.8	4.41	0.53
	MW-04	6.75	6.77	1462	29.65	0.63	-143.3	7.45	0.66
	MW-05	NS	NS	NS	NS	NS	NS	NS	NS
	MW-06	8	6.94	1117	28.97	3.06	243.2	17.1	0.51
	MW-07	10.5	6.95	996	29.3	3.71	198.6	2.00	0.45
	MW-08	11.25	6.95	1061	29.6	3.06	232	10.4	0.48

Notes:

°C = Degrees Celsius

 μ mhos/cm = micromhos per centimeter

DO = Dissolved Oxygen

mg/L = milligrams per liter

mV = millivolts

NA = Not Available

NS = Not Sampled

NTUs = Nephelometric Turbidity Units

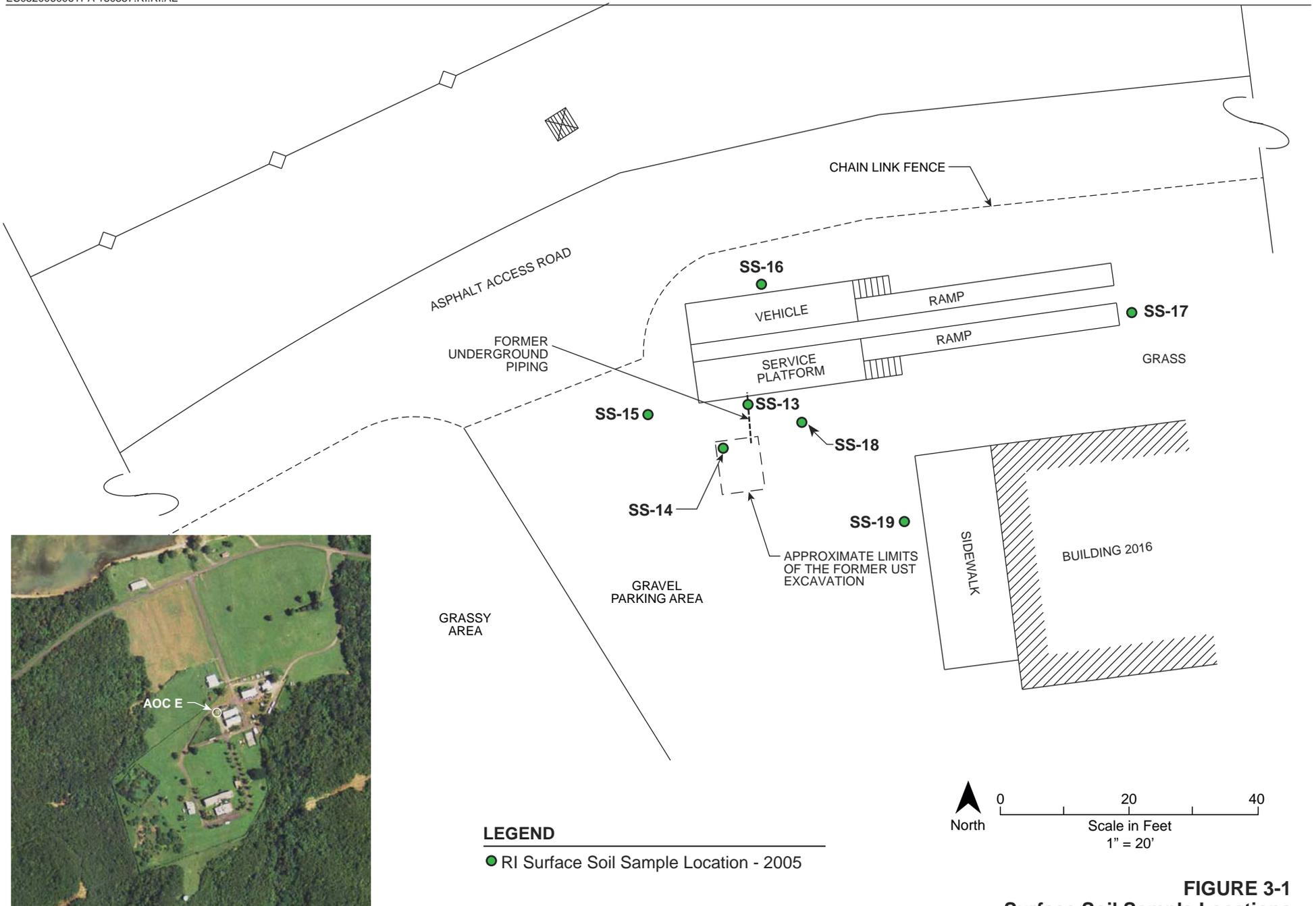
ORP = Oxidation-Reduction Potential

Temp. = Temperature

TABLE 3-4

Monitoring Well Hydraulic Conductivity Test Results
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Monitoring Well & Test Type	Test Date	Test Duration	Depth to Water (feet)	Hydraulic Conductivity (feet/day)
MW-04 Slug Out 1	5/23/2002	15 min 40 sec	40.04	0.17 ft/day
MW-04 Slug Out 2	5/23/2002	15 min 30 sec	40.38	0.23 ft/day
MW-07 Slug Out 1	5/23/2002	6 min 00 sec	32.18	0.055 ft/day
MW-07 Slug Out 2	5/23/2002	5 min 30 sec	31.11	0.057 ft/day



LEGEND

● RI Surface Soil Sample Location - 2005

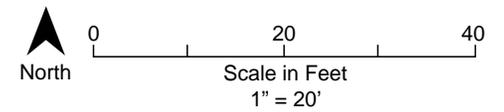
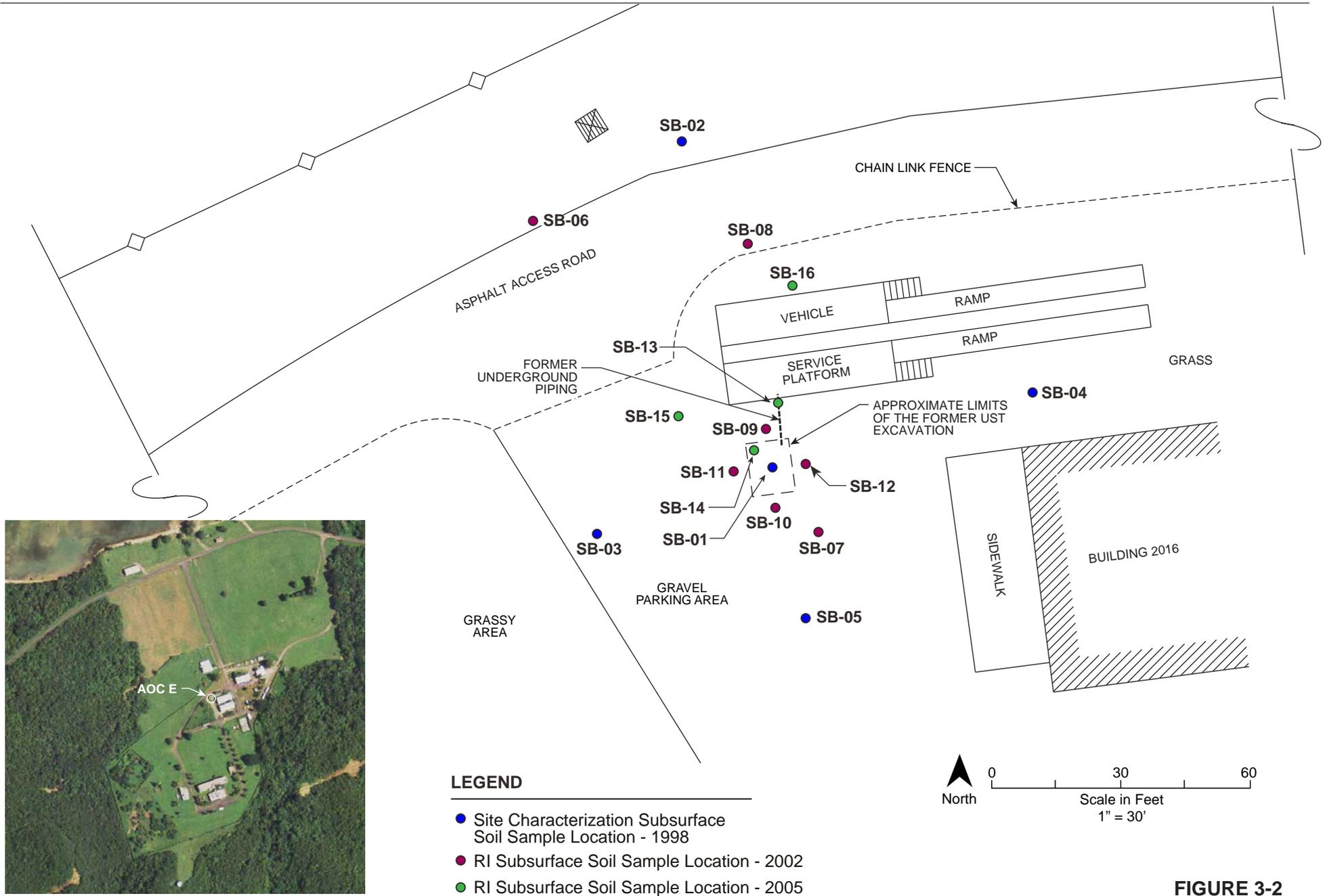


FIGURE 3-1
Surface Soil Sample Locations
AOC E Remedial Investigation Report
Vieques, Puerto Rico



2004 Aerial Photograph

LEGEND

- Site Characterization Subsurface Soil Sample Location - 1998
- RI Subsurface Soil Sample Location - 2002
- RI Subsurface Soil Sample Location - 2005

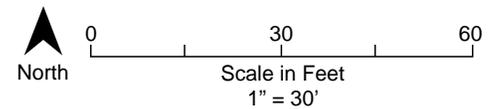
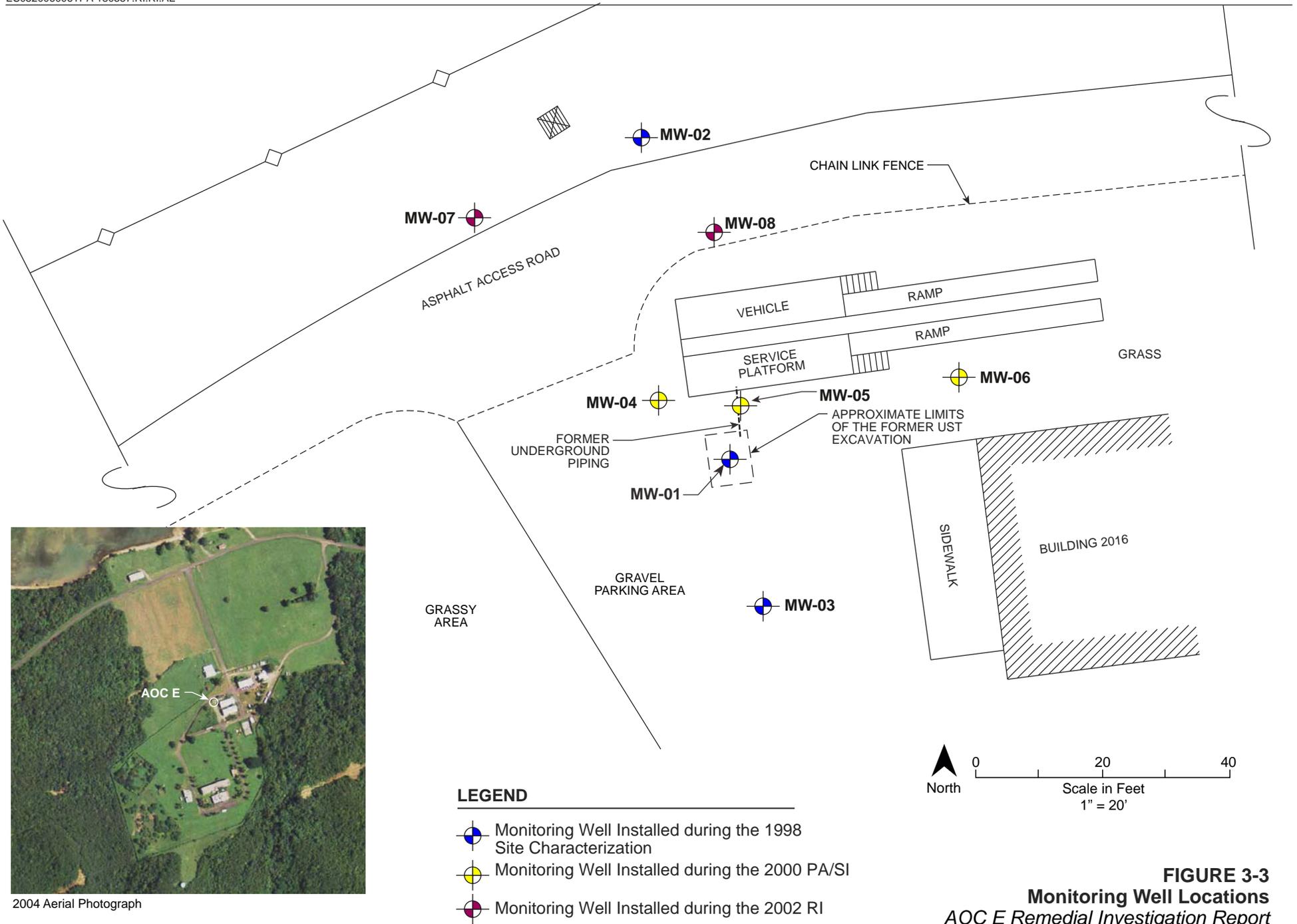


FIGURE 3-2
Subsurface Soil Sample Locations
AOC E Remedial Investigation Report
Vieques, Puerto Rico



2004 Aerial Photograph

FIGURE 3-3
Monitoring Well Locations
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Nature and Extent of Contamination

This section discusses the nature and extent of contamination detected in AOC E media. While the discussion touches upon all constituents detected at the site, it focuses primarily on those constituents potentially attributable to contamination. Inorganic constituents exceeding background levels and organic constituents that are potential contaminants are identified, with particular emphasis on those constituents that exceed regulatory screening values. It is noted here that although background is incorporated into the evaluation of the nature and extent of contamination in order to distinguish background inorganics concentrations from those potentially attributable to contamination, background is not considered in the risk assessment process (Section 6 – Human Health and Section 7 – Ecological) until the conservative screening components of the risk assessments are completed. In other words, all detected constituents above screening levels are considered in the risk assessments, regardless of whether they exceed background.

4.1 Summary of Detected Constituents

Analytical results are summarized in Tables 4-1 through 4-4 (surface soil, subsurface soil, groundwater, and free-product results, respectively). The tables also identify screening value exceedances (exceeding background values for inorganics). Appendix L contains the raw analytical data for the soil and groundwater samples.

The screening values provided in Tables 4-1 through 4-3 are those documented in the Master QAPP (CH2M HILL, 2007). Since the Master QAPP was submitted, several screening values have been updated, so they have been substituted for the screening values provided in the Master QAPP. Table 4-5 provides a list of the updated screening values used for data screening in this RI Report. The screening values provided in Tables 4-1 through 4-3 comprise, as applicable:

- Preliminary Remediation Goals (PRGs), adjusted as appropriate
- Ecological screening values
- Site-specific soil screening levels (SSLs), as discussed in Section 3
- Federal Maximum Contaminant Levels (MCLs)
- Soil screening values for TPH provided in the *Underground Storage Tank Control Regulation* (PREQB, 1990)
- West Vieques background soil inorganics upper tolerance limits (UTLs) (CH2M HILL, 2002b)

Site-specific SSLs were calculated for AOC E. Information on how the site-specific SSLs and dilution attenuation factor (DAF) of 2.4 were developed is shown in Tables 4-6 and 4-7. The DAF calculation (also known as the Summers Model) is a mass balance approach that dilutes the soil leachate (infiltrating rainwater) by the lateral flow through the groundwater-bearing unit. The following is a brief discussion of the uncertainties of the model:

- A primary component of the model is the rate of infiltration, which is based on soil type and precipitation. The algorithm used is an empirical solution based on a broad range of soil types. The soil at AOC E is described as “clays,” “sandy clays,” “silt,” or a “silty clayey sand;” small percentages of silt or clay will have large effects on the rate of infiltration. Therefore, it is conceivable that the calculated rate of infiltration is different. The DAF is inversely proportion to the rate of infiltration; therefore, overestimating the infiltration will reduce the DAF.
- The thickness of the water-bearing unit is directly related to the DAF. As the thickness increases, more water is available for dilution from lateral flow. Therefore, as thickness increases so does the DAF. A relatively low thickness of 20 ft was chosen as a conservative value for thickness.
- The affected area, represented in the equation as the length of the site relative to the direction of groundwater flow, is inversely proportional to the DAF. As the length decreases, the DAF increases. The maximum distance (minimal DAF) was chosen as a conservative estimate of the affected area. The application of the DAF to the whole area assumes that there is an equal distribution of the chemicals of concern across the whole area. This assumption most likely overestimates the contaminant mass entering the groundwater-bearing unit.

4.2 Nature and Extent of Contamination

This subsection discusses the nature and extent of contamination based on the summary of analytical results presented in Tables 4-1 through 4-4. The spatial distribution of samples collected at AOC E (Figures 3-1 through 3-3) provides sufficient coverage of the environmental media at the site to assess the nature and extent of contamination. As shown on Figure 3-1, the RI surface soil sampling strategy involved collection of samples across the area of suspected contamination based on the site history, a visual inspection, and previous activities at the site (e.g., UST removal). The sampling targeted the location of the former UST and associated piping, the vehicle service platform, and the surrounding area. The subsurface soil sampling strategy (Figure 3-2) involved the same general approach, but included additional sampling around the former UST because the removal depth was limited to the approximate depth of the UST (i.e., 12 to 16 ft). Subsurface soil samples were collected at various depths to the approximate maximum depth of the water table (approximately 44-48 ft bls across the site). Monitoring wells, installed and sampled during the Site Characterization, PA/SI, and RI, were spatially located to represent upgradient and downgradient groundwater conditions, as well as conditions immediately within the former location of the used oil UST and associated piping.

4.2.1 Soil

Tables 4-1 and 4-2 show the VOCs, SVOCs, pesticides, PCBs, TPH, and inorganics that were detected in the surface and/or subsurface soil at AOC E and identify screening value exceedances. The nature and extent of these constituents are discussed below.

Volatile Organic Compounds

No VOCs were detected in surface soil at AOC E (Figure 4-1). This is likely due to the probable subsurface nature of the releases (i.e., leaks from the former UST and associated subsurface piping), as well as that soil around the former UST and piping was excavated during the removal activities.

Several VOCs were detected in subsurface soil samples (Figure 4-2). It is noted that only benzene, toluene, ethylbenzene, and xylenes (BTEX) were analyzed in the VOC samples collected prior to 2005. Soil samples collected during the 2005 RI investigation were analyzed for the full suite of VOCs. Nine VOCs were detected in subsurface soil in samples collected in 1998, 2002, and/or 2005: 1,2-dichlorobenzene (1,2-DCB), acetone, benzene, ethylbenzene, isopropylbenzene, methylcyclohexane, toluene, xylenes, and methyl-tert-butyl ether (MTBE). Of these nine VOCs, benzene, ethylbenzene, xylenes, and MTBE were detected at levels exceeding one or more of the screening values. Subsurface soil VOC detections exceeding screening levels were restricted to three locations (SB-09, SB-13, and SB-14, as shown in Figure 4-2), which were collected within and immediately adjacent to the former UST and associated piping locations. Additionally, there were no screening value exceedances in the upper 6 ft of soil.

Benzene was detected in samples from four subsurface sample locations (SB08, SB09, SB12 and SB13 as shown in Figure 4-2), three of which (SB09, SB12, and SB13) were located within the former tank and piping locations. The fourth (SB-08) was located adjacent to an asphalt road. The highest benzene concentration (4,150 $\mu\text{g}/\text{kg}$) was detected in the 12 ft to 14 ft bls sample from location SB-09, which is located adjacent to the former piping. The benzene concentration detected in the duplicate sample from this station at the same depth is considerably lower (2,560 $\mu\text{g}/\text{kg}$); however, both the parent and duplicate sample results from this location exceed the human health screening value (640 $\mu\text{g}/\text{kg}$) and the site-specific SSL (17.5 $\mu\text{g}/\text{kg}$). Considerably lower concentrations of benzene were detected at deeper intervals. The benzene concentrations slightly exceed the site-specific SSL screening value in the 32 ft to 34 ft (26 $\mu\text{g}/\text{kg}$) and 34 ft to 36 ft (70 $\mu\text{g}/\text{kg}$) samples from SB-13 and the 28 ft to 30 ft (25.8 $\mu\text{g}/\text{kg}$) sample from SB-09. The other detections of benzene are estimated values below all corresponding screening values. No benzene concentrations exceed the Puerto Rico UST Corrective Action value (5,000 $\mu\text{g}/\text{kg}$). It is noted that benzene was detected in groundwater in the vicinity of soil sample location SB-09 above the MCL, tap water PRG, and Puerto Rico UST Corrective Action value.

Ethylbenzene was detected in samples from six subsurface sample locations at various depth intervals. The only sample concentration that exceeds a screening value is the 12 ft to 14 ft sample from SB-09 (14,200 $\mu\text{g}/\text{kg}$), which is the same sample in which the highest benzene concentration was detected. This concentration exceeds the UST Corrective Action value (10,000 $\mu\text{g}/\text{kg}$) and the site-specific SSL (7,216 $\mu\text{g}/\text{kg}$). Ethylbenzene was detected at concentrations less than screening values in the vicinity of the former tank location (SB-01, SB-12, and SB-14). In this area, concentrations of ethylbenzene are highest at depth intervals near the water table (between 42 and 47 ft bls); however, no ethylbenzene concentrations exceed the human health screening value. Further, although ethylbenzene was detected in groundwater, none of the concentrations exceeds its MCL, tap water PRG, or Puerto Rico UST Corrective Action value.

Xylenes were detected in soil samples from five subsurface sample locations. The highest concentration of xylenes was detected in the 12 ft to 14 ft bls sample from station SB-09 (90,600 µg/kg), which is the same sample in which the highest benzene and ethylbenzene concentrations were detected. This concentration exceeds the UST Corrective Action value (10,000 µg/kg), the human health screening value (27,000 µg/kg), and the site-specific SSL (88,511 µg/kg). The duplicate sample concentration (55,500 µg/kg) is less than the site-specific SSL. Total xylene concentrations also exceeded the UST Corrective Action value in the 22 ft to 24 ft (17,000 µg/kg) and 28 ft to 30 ft (11,100 µg/kg) samples from SB-09 and the 34 ft to 36 ft (18,000 µg/kg) sample from SB-13. Xylene concentrations nearly an order of magnitude lower were detected in subsurface soil samples collected in the vicinity of the former UST. Only one detection of xylenes in groundwater exceeds its tap water PRG; none exceeds the MCL or Puerto Rico UST Corrective Action value.

MTBE was detected in a sample from one sample location (SB-14) at a concentration (4 µg/kg) exceeding its SSL of 2 µg/kg, in the sample from 44 ft to 46 ft. MTBE was analyzed, but not detected, in the remaining 2005 RI samples, but was not analyzed in any of the samples collected during previous sampling events (i.e., the other samples adjacent to the former UST). MTBE was detected in groundwater in the vicinity of the former UST and associated piping above the tap water PRG.

Several other VOCs, comprising 1,2-DCB, acetone, isopropylbenzene, methylcyclohexane, and toluene were detected in the vicinity of the former tank and piping at concentrations less than screening values.

The VOCs detected in subsurface soil at AOC E are likely attributable to used oil or other fuel products associated with the historical oil-changing activities at the site. In general, the highest concentrations of these VOCs were detected in subsurface soil around the former tank and piping at depths approximately consistent with the water table. The exception to this is the samples collected from SB-09, in which relatively high concentrations were detected between 12 ft bls and the water table. This sample location, which is adjacent to the former piping, likely represents unsaturated soils that were contaminated as a result of leaking from the piping leading to the former UST. Soil around the former UST was excavated to the approximate depth of the UST (i.e., between 12 and 16 ft bls). However, it is likely that considerably shallower excavation was performed for the piping removal, which may account for the higher concentrations detected at sample location SB-09.

It is also important to note that, as shown in Figure 2-8, water table fluctuations between 15 and 20 ft were observed at AOC E. Therefore, in addition to soil contamination present as a result of vertical leaching beneath the area of excavation, soil contamination may also be present in a "smear zone" along the vertical extent of water table fluctuation in the area where groundwater contamination exists.

Semivolatile Organic Compounds

Soil samples collected during the RI were analyzed for the full suite of SVOCs. SVOCs were not analyzed in soil samples collected during previous investigations. Table 4-1 and Figure 4-3 show that only three SVOCs were detected in surface soil and in only one sample. The SVOCs were detected in surface soil sample SS-17, which is located east of the service platform ramp (Figure 4-3). As discussed above for VOCs, the general absence of SVOCs in

surface soil may be due to the nature of releases (i.e., likely subsurface) and that surficial soil around the former UST and piping were excavated during the removal activity.

SVOCs detected in surface soil sample SS-17 consist of acetophenone (88 J $\mu\text{g}/\text{kg}$), di-n-octylphthalate (350 J $\mu\text{g}/\text{kg}$), and bis(2-ethylhexyl)phthalate (330 J $\mu\text{g}/\text{kg}$). Only the concentration of acetophenone exceeds a screening value (i.e., the site-specific SSL of 0.046 $\mu\text{g}/\text{kg}$). In the case of acetophenone and di-n-octylphthalate, concentrations were detected in the parent sample or the duplicate sample, but not both. Bis(2-ethylhexyl)phthalate was detected in both the parent and duplicate samples. Phthalates are typically found in various types of plastics, lubricants, and hydraulic fluids. Acetophenone is a chemical found in various products, including solvents, resins, perfumes, cigarettes, paint thinners, and food additives. It can also form when ethylbenzene is oxidized. Contamination in surface soil appears to be limited to the area just east of the service platform ramp. Because the parent and duplicate sample concentrations are relatively low and variable at this location, widespread contamination is unlikely, especially considering SVOCs were not detected in any of the other five surface soil samples collected at the site.

SVOC analysis was performed on the four subsurface soil samples collected during the 2005 RI sampling event. SVOCs were detected only in the two subsurface soil sample locations adjacent to the former UST and associated piping. Fourteen SVOCs were detected in the two subsurface soil sample locations (Figure 4-4): 1,1-biphenyl, 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, butylbenzylphthalate, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, and bis(2-ethylhexyl)phthalate. However, only two SVOCs, naphthalene and 2-methylnaphthalene, were detected at concentrations exceeding a screening value. Naphthalene was detected at two different depth intervals at sample station SB-13 at concentrations of 3,500 $\mu\text{g}/\text{kg}$ (32 to 34 ft bls) and 3,100 $\mu\text{g}/\text{kg}$ (34 to 36 ft bls), exceeding the site-specific SSL of 239 $\mu\text{g}/\text{kg}$. It was also detected in groundwater above its tap water PRG. 2-methylnaphthalene was detected in soil boring SB-13 at 6,000 $\mu\text{g}/\text{kg}$ (32 to 34 ft) and 5,200 $\mu\text{g}/\text{kg}$ (34 to 36 feet), exceeding the site-specific SSL of 358 $\mu\text{g}/\text{kg}$. 2-methylnaphthalene was also detected in SB-14 (42 to 44 ft) at 1,200 $\mu\text{g}/\text{kg}$, also exceeding site-specific SSL. 2-methylnaphthalene was not detected in groundwater above its tap water PRG (24 micrograms per liter [$\mu\text{g}/\text{L}$]). The remaining subsurface soil SVOCs were detected at concentrations less than their respective screening values.

Naphthalene and 2-methylnaphthalene are polycyclic aromatic hydrocarbons (PAHs), which are components of petroleum products. The remaining SVOCs detected are either PAHs or phthalates with the exception of 1,1-biphenyl, which can be used in the formation of plastics and can be used in hydraulic fluids.

In general, SVOCs were detected in subsurface soil in the vicinity of the former UST and associated piping. Concentrations were highest at depths generally consistent with the water table. While the only subsurface soil samples analyzed for SVOCs were those collected during the 2005 RI sampling event, all subsurface soil samples were analyzed for petroleum hydrocarbons, which are a mixture of VOCs and SVOCs. The extent of TPH contamination is discussed in the next subsection.

Total Petroleum Hydrocarbons

Table 4-1/Figure 4-5 and Table 4-2/Figure 4-6 show the concentrations of the various TPH designations detected in surface and subsurface soil samples, respectively, collected at AOC E and identify screening value exceedances of the Puerto Rico UST Corrective Action Criterion of 100 mg/kg. There are no Federal human health or ecological screening values for TPH.

During the 1998 investigation, samples were analyzed for total recoverable TPH, TPH-GRO, TPH-DRO, and TPH-ORO. During the 2002 investigation, samples were analyzed for TPH containing between 6 and 10 carbon atoms, TPH containing between 10 and 28 carbon atoms, and TPH containing greater than 28 carbon atoms (oil and grease). During the 2005 sampling event, samples were analyzed for TPH-GRO (between 6 and 12 carbon atoms), TPH-DRO (between 12 and 28 carbon atoms), and TPH-ORO (between 28 and 35 carbon atoms). Because of their similarity, the TPH results for between 6 and 10 carbon atoms are included, as applicable, in the discussion about TPH-GRO; the TPH results for between 10 and 28 carbon atoms are included in the discussion about TPH-DRO, and the TPH results for oil and grease (greater than 28 carbon atoms) are included in the discussion about TPH-ORO.

As noted in Table 4-1, TPH-GRO was not detected in samples collected from any of the seven surface soil locations. TPH-DRO was detected in one sample collected at station SS-17 at a concentration of 11 mg/kg, while TPH-ORO was detected in samples from five of the locations at concentrations ranging between 46 mg/kg (SS-19) and 270 mg/kg (SS-16). TPH-ORO concentrations exceed the Puerto Rico UST Corrective Action screening value (100 mg/kg) in two surface soil samples: SS-16 (270 mg/kg) and SS-18 (190 mg/kg). These sampling locations were north and south of the vehicle service platform, respectively. These detections of oil range petroleum at the ground surface may be the result of minor drips or spills of oil associated vehicle maintenance. Because TPH-ORO was detected in the fill material in the area of the tank excavation (SS-14), it is also possible that occasional leaks from vehicles that park on or drive through the site are the source, which may or may not be related to historical site activities.

In subsurface soil, petroleum hydrocarbons were detected at one or more depths at 13 of the 16 sampling stations. TPH-GRO (including C6-C10) was detected at one or more depth intervals at 7 of 16 locations, comprising SB-01, SB-06, SB-09, SB-10, SB-12, SB-13, and SB-14 (Figure 4-6). TPH-GRO concentrations at four of these locations (SB-01, SB-09, SB-10, and SB-12) exceed the Puerto Rico UST Corrective Action level of 100 mg/kg. Of the two samples collected at station SB-01 (i.e., beneath the former UST), the concentration in only the sample from the 45 to 47 ft interval (42,000 mg/kg) exceeds the Puerto Rico UST Corrective Action level. TPH-GRO concentrations in samples from three depth intervals at SB-09 (adjacent to the former piping), comprising 12 to 14 ft (2,150 J mg/kg), 22 to 24 ft (370 J mg/kg) and 28 to 30 ft (154 mg/kg) exceed the Puerto Rico UST Corrective Action value. Of the samples collected at SB-10, the TPH-GRO concentration in only the sample collected in the 12 to 14 ft interval (538 J mg/kg) exceeds the Puerto Rico UST Corrective Action value. The TPH-GRO concentration from only the 42 to 44 ft depth interval exceeds the Puerto Rico UST Corrective Action value at SB-12 (149 J mg/kg). The TPH-GRO data show that the highest concentrations were detected beneath the former UST and adjacent to the former piping.

Generally lower to non-detect TPH-GRO concentrations were found in the subsurface soil adjacent to the former UST excavation (e.g., SB10, SB11, and SB12).

TPH-DRO (including C10-C28) was detected at one or more depths at 5 of the 16 subsurface soil sample stations (SB-08, SB-09, SB-12, SB-13, and SB-14). There are no exceedances of the Puerto Rico UST Corrective Action value (100 mg/kg) in samples collected at SB-08; in fact, the petroleum hydrocarbons detected at this location are likely attributable to its proximity to the asphalt road. This is also true of the petroleum hydrocarbons detected at locations SB-02 and SB-06. The highest TPH-DRO concentrations were detected at location SB-09, where all four depth intervals sampled contain concentrations above the Puerto Rico UST Corrective Action level. TPH-DRO concentrations at this location decrease with depth; the highest concentration (3,780 J mg/kg) is at the 12 to 14 ft interval, whereas the lowest concentration (438 J mg/kg) is at the 42 to 44 ft interval. TPH-DRO was detected directly below the former piping excavation (location SB-13) in the 32 to 34 ft (310 mg/kg) and 34 to 36 ft (490 mg/kg) intervals above the Puerto Rico UST Corrective Action level. TPH-DRO was also detected at a concentration exceeding the Puerto Rico UST Corrective Action level at the 42 to 44 ft interval (340 mg/kg) at SB-14 and the 28 to 30 ft (805 J mg/kg) and 42 to 44 ft (1,110 mg/kg) intervals at SB-12. Similar to the TPH-GRO results, concentrations of TPH-DRO are generally higher at depth, with the exception of samples collected at SB-09. The TPH-DRO distribution at location SB-09 (as well as the other petroleum constituents detected at this location) likely represents a source area leaching profile, while the distribution at other locations (e.g., SB-12 and SB-13) is more likely reflective of a smear zone profile.

TPH-ORO (including oil and grease) was detected at 9 of the 16 sample locations (SB-01, SB-06, SB-07, SB-08, SB-09, SB-10, SB-12, SB-13, and SB-14) at one or more depth intervals. Concentrations do not exceed the 100 mg/kg Puerto Rico UST Corrective Action value at SB06 or SB08; as noted previously, the petroleum constituents in these samples are not likely site-related. The TPH-ORO concentrations at the remaining locations exceed the Puerto Rico UST Corrective Action value in at least one sample. The TPH-ORO concentration profile with depth at the majority of locations in the vicinity of the former UST and associated piping (SB-01, SB-09, SB-13, and SB-14) are similar to the depth profiles discussed above for TPH-DRO and TPH-GRO.

At the five locations analyzed for TRPH (SB-01 through SB-05), detections were identified at all five locations in the 4 to 6 ft depth interval. These locations are dispersed across the site. Detections were also identified at the three locations (SB-01, SB-02 and SB-05) where samples were collected at the water table interval (around 45 ft bls). Concentrations in the shallow depth intervals (4 to 6 ft bls) range from 230 mg/kg to 590 mg/kg. There is no Puerto Rico UST Corrective Action value for TRPH, but as a conservative measure, all values were screened against the Puerto Rico UST Corrective Action value for TPH (100 mg/kg). At the water table depth interval, concentrations at SB-02 (80 mg/kg) and SB-05 (87 mg/kg) are below the Puerto Rico UST Corrective Action value, whereas the concentration from SB-01 (beneath the former UST) is 36,000 mg/kg. The samples analyzed for TRPH were also analyzed for TPH-GRO, TPH-DRO, and TPH-ORO during the same round of sampling. For all samples other than the 45 to 47 ft interval sample at SB-01, there were no detections of these parameters. Because TRPH was detected, but not within the carbon ranges represented by GRO, DRO, and ORO, it is possible that there are petroleum

hydrocarbons present that have less than 6 or greater than 35 carbons. Petroleum hydrocarbons with less than 6 carbons are unlikely because they are only commonly found in aviation fuels. Hydrocarbons with greater than 35 carbons are found in mineral and crankcase oils and greases.

As noted previously, in general, TPH concentrations are highest at the approximate water table depth, with the exception of the location adjacent to the former piping. This suggests that most of the contamination is likely associated with a smear zone attributable to water table fluctuations. The concentration depth profile adjacent to the former piping (SB-09) is likely representative of source zone leaching. It is noted that no soil samples were collected at location SB-01 in the interval between the bottom of the former UST and the approximate depth of the water table. However, while contamination in this interval may represent a continuing leaching threat to groundwater, it would not be available for human or ecological exposures because of its depth (i.e., greater than about 12 ft bls).

Pesticides/PCBs

Pesticide analysis was conducted on soil samples collected at AOC E during the 2005 RI sampling event. Tables 4-1 and 4-2 show the pesticides detected in AOC E soil samples. In accordance with their intended use, pesticides and herbicides were commonly applied to the soil at Department of Defense (DoD) facilities to control pests and weeds, which may have resulted in pesticides and herbicides accumulating in environmental media. This type of pesticide presence is distinct from pesticide contamination that is the result of a spill, or from improper storage, disposal, or use. A Public Works Technical Bulletin prepared by the U.S. Army Corps of Engineers (USACE) addresses DoD procedures regarding management of pesticide-contaminated soil (USACE, 2004). Although it specifically references chlordane, the process is equally applicable to other pesticides registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). It states:

“Not all chlordane in the environment is required to be remediated under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) or Resource Conservation and Recovery Act (RCRA). The requirements for managing chlordane contaminated soil will depend upon whether it was legally applied or whether it was illegally disposed or ‘released’ into the environment.”

The memo further states:

“Concentrations of chlordane should not be used as the basis for concluding whether a spill occurred. It was DoD practice to periodically reapply pesticide, thus chlordane may have accumulated without being indicative of a spill. The location of chlordane, rather than its concentration, should be used as the basis for determining whether it is reasonably present due to intentional use.”

It also states that “[l]egally applied chlordane is not required to be remediated under either CERCLA . . .” and that:

“It is not appropriate to undertake a CERCLA response for legally applied chlordane. This is because courts have found that normal application of pesticide does not constitute a release or disposal under

CERCLA. Section 107(i) of CERCLA specifically addresses application of registered pesticide product by stating, 'No person may recover under the authority of this section for any response costs or damages resulting from the application of a pesticide product registered under FIFRA' This has been found to mean that contamination caused by the application of a pesticide product registered under FIFRA, such as chlordane, is explicitly exempted from CERCLA liability. So not only is a CERCLA response not required for legally applied chlordane, but because there is no liability, there is no ability to expend environmental restoration funds under CERCLA for legally applied chlordane."

RCRA has similar guidance that can be found at 42 USC 6901 through 6992.

The three most common pesticides found at multiple Vieques sites are dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyldichloroethane (DDD). Both DDE and DDD are contaminants in technical grade DDT as well as breakdown products of DDT (ATSDR, 2002). Numerous studies have been performed on global DDT concentrations and its persistence in the environment. In 1975, EPA published a report entitled: "DDT: A Review of Scientific and Economic Aspects of the Decision to Ban Its Use as a Pesticide." In this report, EPA indicates that DDT degradation rates are highly variable because they are dependent on such factors as rate of pesticide application, mode of application, soil type, climatic conditions, and several other factors. Studies cited by EPA indicated that in the early 1970s, average DDT concentrations in soils from eight major US cities were between 6,000 micrograms per kilogram ($\mu\text{g}/\text{kg}$) and 350 $\mu\text{g}/\text{kg}$ and that significant variations in DDT degradation rates had been measured (EPA, 1975). ATSDR noted that half of the DDT initially present can remain after 30 or more years (ATSDR, 2002). EPA also noted that as levels of DDT decline, the ratio of DDE to DDT should increase (EPA, 1975).

Six pesticides were detected in AOC E surface soil and/or subsurface soil (Tables 4-1 and 4-2). With the exception of alpha-BHC detected in subsurface soil at AOC E, all the other pesticide concentrations detected are comparable to pesticide concentrations detected in soil at other west Vieques sites (see Appendix Q) and none exceeds a screening value. Alpha-BHC was detected only at AOC E, and its two detections exceed its site-specific SSLs. However, alpha-BHC was not detected in AOC E groundwater (Table 4-3). As indicated above, pesticide concentrations should not be used as the sole basis to determine whether a pesticide release has occurred at a site because of the nature of pesticide application (e.g., targeted application, periodic reapplication). In addition, none of the historical information for AOC E indicates that the site was used for pesticide handling, storage, or disposal. This information, coupled with the nature of the site (former used oil UST) and the fact that pesticides would likely have been applied to control weeds or other pests there, suggests the pesticides are present as a result of normal pesticide application associated with the maintenance of the facility when it was active. Therefore, pesticides in soil are not further discussed.

PCB analysis was conducted on soil samples collected at AOC E during the 2005 RI sampling event. Tables 4-1 and 4-2 show the PCBs detected in AOC E soil samples. Aroclor-1260 was the only PCB isomer detected in surface soils; it was detected at 12 $\mu\text{g}/\text{kg}$ in the

surface soil sample from boring SS-18, located in an area east of the former UST location, at an order of magnitude lower than its lowest screening value (110 µg/kg PRG). In subsurface soils, the only PCB isomer detected was Aroclor-1258, at 15 µg/kg in soil sampling station SB-14 at a depth of 4-6 ft bls. This concentration is also an order of magnitude below the human health screening value (110 µg/kg). SB-14 was located within the former UST area, and the depth interval represents a sample from the excavation fill material. PCBs were not detected in surface and subsurface samples collected from sample stations surrounding SS-18 or SB-14. PCBs were once used in hydraulic fluids, sealants, adhesives, and paints that may have originated from vehicles serviced at the site.

Inorganic Constituents

The inorganics (also referred to as “metals” in this RI Report) detected at AOC E may have both non-site-related origins as well as a potential site-related source. The concentrations of those inorganics that may be associated with site-specific releases are determined by comparing the site concentrations to concentrations from the applicable background inorganics dataset. For AOC E, which lies within the Qa geologic zone, the inorganics concentrations from the site samples were compared to the Qa dataset from the former NASD background soil inorganics study (CH2M HILL, 2002b). The remainder of this discussion focuses on those inorganics potentially attributable to site-related contamination.

Figures 4-7 and 4-8 display the concentrations of the inorganics in surface and subsurface soil, respectively, above background UTLs (not including magnesium). The figures also identify screening value exceedances. As shown in Figure 4-7 and Table 4-1, only three inorganics (cadmium, lead, and zinc) were detected in surface soil above background UTLs. Cadmium was detected in two samples (SS-13 and SS-18) at concentrations (0.82 mg/kg and 0.58 mg/kg, respectively) above its background UTL (0.036 mg/kg). However, neither concentration exceeds a screening value. Lead exceeds its background UTL of 6.9 mg/kg in five surface soil samples (SS-13 through SS-16 and SS-18) at concentrations between 11.6 mg/kg (SS-14) and 52 mg/kg (SS-16). Of these detections, the concentrations in three samples (SS-13, SS-15, and SS-16) exceed the site-specific SSL criterion (21.5 mg/kg), and the concentration in one sample (52 mg/kg in SS-16) is just above the Puerto Rico UST Corrective Action value (50 mg/kg). These three sampling locations are on the south, southwest, and north side, respectively, of the vehicle service platform. The locations of these exceedances of lead in surface soil suggest a possible association with minor drips and spills of leaded fuels. Additionally, the lead concentration in sample SS-13 may be associated with leaks from the former piping associated with the UST.

A single zinc concentration (83 mg/kg), associated with a sample collected in the location of the former piping (SS-13), slightly exceeds its background UTL of 71 mg/kg and the ecological screening value of 50 mg/kg. Zinc is often used as an additive in paints. However, because the concentration is just greater than the background concentration, the level detected may be a result of normal background variation.

Figure 4-8 and Table 4-2 show that four constituents (copper, iron, lead, and silver), not including magnesium, were the only inorganics detected in subsurface soil above background UTLs. However, none of the concentrations of copper, lead, or silver exceed any screening values. Iron was detected at concentrations exceeding its background UTL of 39,000 mg/kg, its site-specific SSL (672 mg/kg), and its human health screening value

(2,300 mg/kg) in two subsurface soil samples from the same location (SB-14). These elevated concentrations were detected at the 42 to 44 ft depth interval (43,000 mg/kg) and the 44 to 46 ft depth interval (39,800 mg/kg). These isolated and relatively low exceedances of the background UTL may be attributable to variation in natural background and not to a site-specific release.

Based on the above discussion, it is likely that the only inorganic detected in soil that is attributable to contamination is lead, and that other inorganics results at the site are reflective of background conditions. Further, the lead contamination is limited primarily to the upper several feet of soil and is below screening levels.

4.2.2 Groundwater

Table 4-3 shows the VOCs, SVOCs, pesticide, TPH, and inorganics that were detected in groundwater at AOC E and identifies screening value exceedances. The nature and extent of these constituents are discussed below. It is noted that well MW-01 was not sampled in 2000, 2002, and 2005 and well MW-05 was not sampled in 2002 and 2005 due to the presence of free product. However, the discussion below provides an understanding of how constituent concentrations varied over time. In addition, all AOC E wells were sampled in 2004 despite the presence of free product in wells MW-01, MW-04, and MW-05, so the data from that round of sampling provide a good indicator of site-wide “current conditions” for the time period when the wells were being sampled (i.e., 1998 – 2005). In addition, as discussed in Section 8, another round of groundwater samples is proposed for the feasibility study to provide up-to-date conditions

Volatile Organic Compounds

Fifteen VOCs were detected in groundwater at AOC E (Figure 4-9). These VOCs fall into one or both of two categories: petroleum-related constituents and solvents. The majority of the VOCs (i.e., at least 11 of the 15 VOCs) are components of petroleum-related products, including additives and contaminants. The remaining four VOCs (1,2-DCB; 1,2-dichloroethane [1,2-DCA]; acetone; and chloroform) are solvents that may have been used during the vehicle maintenance activities. However, trace amounts of chlorinated solvents have been detected in used engine oil (Irwin et al., 1997). Of the detected VOCs, 1,2-DCA, benzene, chloroform, and MTBE were detected at concentrations exceeding applicable screening criteria in monitoring wells at AOC E, with the vast majority of VOCs and the highest concentrations being detected at and immediately downgradient of the former UST and associated piping (Figure 4-3).

Although chloroform was detected in samples from four locations (MW-02, MW-03, MW-07, and MW-08) at concentrations exceeding the tap water PRG of 0.17 µg/L, the highest concentration is relatively low (1.4 µg/L). The locations in which these samples were collected are downgradient and upgradient of the source area, but not in the source area itself. Chloroform is a common laboratory contaminant and is not likely to be related to this site based on the historical site use, its spatial distribution in groundwater, and the fact that it was not detected in soil at the site.

1,2-DCA was detected in samples from two monitoring wells. MW-05 sample concentrations from 2000 (32 µg/L) and 2004 (7.2 µg/L) exceed the tap water PRG (0.12 µg/L) and the MCL (5 µg/L). MW-04 sample concentrations from 2002 (4.9 µg/L) and 2004

(0.59 µg/L) exceed the tap water PRG only. The 1,2-DCA concentrations in both wells exhibited an order-of-magnitude decline between 2000 and 2004 (MW-05) and 2002 and 2004 (MW-04). Approximately 0.28 foot of free product was measured in well MW-05 in 2002, so it is possible that its concentration of 1,2-DCA was higher in 2002 than in 2000 or 2004. However, free product (0.01 foot) was also measured in the well in 2004, but its 1,2-DCA concentration was less than that in 2000 when no free product was observed. Free product (0.01 foot) was also measured in well MW-04 in 2004, but its 1,2-DCA concentration was less in 2004 than in 2002, when no free product was observed. It is noted here that no 1,2-DCA was detected in the free product sample collected from well MW-01 in 2004, although the detection limit was elevated due to necessary dilution.

Benzene was detected in samples collected from MW-01, MW-04, and MW-05 during multiple rounds of sampling. Although concentrations detected during early rounds of sampling were as high as 17 µg/L (1998 sample from MW-01), concentrations were either below screening values (MW-04) or were greater than only the tap water PRG during the 2004 round of sampling (4.1 µg/L in MW-01 and 1.2 µg/L in MW-05).

MTBE was analyzed during the 2004 round of sampling, but not during previous rounds. This chemical was detected in samples from MW-01 (260 µg/L), MW-04 (234 µg/L), and MW-05 (1,220 µg/L). These concentrations are in exceedance of the tap water PRG of 11 µg/L.

As displayed in Figure 4-9, VOC groundwater contamination is localized to a relatively small area around the former UST and associated piping. The only volatile constituent detected in wells as little as 30 ft downgradient of the source area was chloroform, a common laboratory contaminant, which was not detected in the source area or site soil. Additionally, the data show a general decline in VOC concentrations with time.

Semivolatile Organic Compounds

Figure 4-10 displays the concentrations of the SVOCs detected in groundwater at AOC E and identifies screening value exceedances. Eleven SVOCs were detected in groundwater at AOC E: 2-methylnaphthalene, acenaphthene, acetophenone, butylbenzylphthalate, caprolactam, di-n-butylphthalate, diethylphthalate, fluorene, naphthalene, phenanthrene, and bis(2-ethylhexyl)phthalate, all of which are likely associated with petroleum products that were part of historical site activities. Of these, the following three were detected at concentrations exceeding screening values during at least one sampling event: 2-methylnaphthalene, naphthalene, and bis(2-ethylhexyl)phthalate.

2-methylnaphthalene and naphthalene, PAH components of petroleum products, were detected only in the 2000 sample from MW-05 (14 µg/L and 15 µg/L, respectively) and the 2004 sample from MW-01 (12 µg/L and 9.5 µg/L, respectively). These concentrations exceed the tap water PRGs of 2.4 µg/L. However, it should be noted that these SVOCs were not detected in the sample from MW-05 during the 2004 round of sampling even though free product (0.01 foot) was detected in the well. A sheen of free product was detected in this well in 2005 and no samples were collected. However, the data from 2004 likely reflect the affect the presence of free product has on dissolved phase SVOCs in this well. Similarly, well MW-01 was not sampled in 2005 due to the presence of free product (1.17 feet).

However, the data from 2004, during which 0.77 foot of free product was measured, likely reflect the affect the presence of free product has on dissolved phase SVOCs in this well.

The only other SVOC detected in groundwater at a concentration greater than a corresponding screening value is bis(2-ethylhexyl)phthalate, which was detected in the 2000 sample from background well MW-03 at a concentration of 5 J $\mu\text{g/L}$. This concentration is just above tap water PRG of 4.8 $\mu\text{g/L}$. This chemical was not detected in groundwater in any subsequent rounds of monitoring. Its presence primarily in the upgradient well, the relatively low concentrations detected, and the general absence of this SVOC in other wells (MW-02 only) and other rounds of sampling suggest it may be present in groundwater samples as a result of laboratory contamination.

All other SVOCs were detected at concentrations below screening values and were generally detected in only one well. Acenaphthene and diethylphthalate were detected in only MW-04 and both were detected only prior to the 2004 sampling event. Acetophenone was detected in only MW-01. Butylbenzylphthalate, fluorene, and phenanthrene were detected in only MW-05 and none was detected after the 2000 sampling event. Di-n-butylphthalate was detected in MW-03 and MW-08, but only prior to the 2004 sampling event. Caprolactam was detected during the 2004 round of sampling in samples from three sample locations (MW-03, MW-05, and MW-07) at concentrations ranging from 4.5 J $\mu\text{g/L}$ (MW-03) to 33 J $\mu\text{g/L}$ (MW-05).

In summary, the groundwater results indicate that naphthalene and 2-methylnaphthalene are the only two SVOCs in groundwater around the former UST and associated piping detected at concentrations exceeding their screening values. These constituents are PAHs and are common components of petroleum products. Much like the interpretation based on the VOC data, the area of SVOC contamination attributable to historical site activities appears to be localized in the immediate vicinity of the source area.

Total Petroleum Hydrocarbons

TPH was detected in groundwater samples from wells MW-01, MW-04, and MW-05 during events between 1998 and 2005. Detections of TPH consisted of diesel and gasoline range hydrocarbons at concentrations orders of magnitude below the Puerto Rico UST Corrective Action level of 50,000 $\mu\text{g/L}$ (i.e., 610 $\mu\text{g/L}$ diesel range in well MW-01, 180 $\mu\text{g/L}$ gas range in MW-04, and 460 $\mu\text{g/L}$ diesel range and 24 $\mu\text{g/L}$ gas range in MW-05), as shown in Figure 4-11. MW-01, MW-04, and MW-05 are the three wells located in or just downgradient of the former UST and piping as shown in Figure 4-11. It is noted, however, that light non-aqueous phase liquid (LNAPL) has been periodically detected in these three wells, as discussed in Section 4.2.3 below.

Pesticides/PCBs

PCBs were not detected in groundwater. The pesticide dieldrin was detected in two wells, MW-02 and MW-06. However, as noted in Section 4.2.1.4, pesticide presence at AOC E is not related to historical vehicle maintenance activities at the site.

Inorganic Constituents

While upgradient well MW-03 was used for comparisons of groundwater inorganics at AOC E, it is important to note that the inorganics data for this well represent a single point

in a range of inorganic concentrations representative of background groundwater conditions. Therefore, other information, such as soil data, other constituents detected or not detected, and the constituent type, is used to help interpret the site-specific groundwater inorganics data.

As shown in Table 4-3, most inorganics (total) exceed their respective background well concentrations and tap water PRGs (adjusted as appropriate) in at least one well, and several exceed MCLs. However, in addition to the fact that there is only a single well representing background inorganic concentrations, variations in well sampling, as discussed in Section 3, can also present some uncertainty with respect to inorganics data interpretation. When there is a large discrepancy between total inorganics and dissolved inorganics, the turbidity is relatively high (i.e., greater than about 10 NTU), and the sampling procedures are likely to have been the cause of the high turbidity, the dissolved inorganics data likely are more representative of inorganics concentrations migrating in groundwater. As shown in Table 3-3, the turbidity measurements made during well sampling in 2000 and 2002/2003 were all above 10 NTUs (except for well MW-07 in 2002). Conversely, the majority of turbidity readings in 2004 were below 10 NTUs. Examination of Table 4-3 shows that there is generally a better correlation between the total and dissolved inorganics concentrations (by well) in the 2004 sampling event than in the previous sampling events. This suggests that non-ideal well sampling resulted in the elevated turbidity and, hence, elevated total metals concentrations (Section 3.2.3 discusses the inability of maintaining low-flow sampling rates and target drawdowns), especially considering the aquifer characteristics (e.g., "tight" characteristic of water-bearing unit; low permeability and velocity; contamination relatively localized within the immediate vicinity of the source) indicate there would not likely be appreciable suspended solids or colloids under normal circumstances. It is important to note that for the AOC E RI, total inorganics were used in the HHRA, and that the dissolved inorganics are emphasized in this section to better represent what is being transported in the aquifer under normal flow conditions. Further, as discussed in Section 8, an additional round of groundwater data are proposed, during which emphasis will be placed on sampling procedures to conform with low-flow protocol, to the extent practical.

Figures 4-12 and 4-13 display the concentrations of dissolved inorganics and total inorganics, respectively, which exceed background and HHRA and/or MCL criteria. As stated above, the dissolved inorganics data likely better represent the inorganics concentrations migrating through AOC E groundwater. Only the dissolved concentrations of antimony, arsenic, iron, manganese, nickel, thallium, and vanadium were detected in at least one well above tap water PRGs (adjusted as appropriate). Further, only the dissolved concentrations of arsenic and thallium were detected above their respective MCLs. These constituents are further discussed below and their concentrations are shown in Figure 4-12.

Dissolved antimony has been detected only once and in only one well (MW-07 at 3.25 µg/L in 2004), exceeding its background value (non-detect at a reporting limit of 2.5 µg/L) and adjusted tap water PRG (1.5 µg/L) but below its MCL (6 µg/l). Antimony was detected in several surface and subsurface soil samples at concentrations below background levels. Therefore, the antimony in groundwater is likely attributable to background.

Dissolved arsenic was detected in monitoring wells MW-02 and MW-05 through MW-08 at concentrations between about 13 µg/L and 17 µg/L, which are above background (11.3 µg/L), the tap water PRG (0.045 µg/l), and the MCL (10 µg/l). However, arsenic was not detected in site soil above the background UTL. Further, the arsenic concentrations detected in site wells are within several µg/L of the single background well concentration. This information suggests arsenic in groundwater is likely attributable to background conditions.

Dissolved iron was detected at concentrations above the adjusted tap water PRG (1,100 µg/L) and background values only twice (in 2004 in well MW-01 [2,880 µg/L] and in 2002 in well MW-04 [1,320 µg/L]). Iron mobility in groundwater is highly dependent on geochemistry, as discussed in Section 5. Detections of this metal fluctuate from one round to the next, indicating there may not be a contaminant source of iron at the site. It is noted that two subsurface soil concentrations of iron at the location of the former UST exceed the background UTL. However, these concentrations may be due to natural variability in the background concentrations. In addition, the concentrations may be attributable to the groundwater level fluctuations at this depth.

Dissolved manganese concentrations were detected in samples from three wells (MW-01, MW-04, and MW-05) above background and the adjusted tap water PRG (88 µg/L). However, manganese was detected ubiquitously in surface and subsurface soil samples, but at concentrations below its background UTL of 1,200 mg/kg. This information suggests the manganese present in AOC E groundwater is either attributable to background.

Like dissolved manganese, dissolved nickel was detected in samples from three monitoring wells (MW-02, MW-06, and MW-08) above background and the adjusted tap water PRG (73 µg/L). However, none of these wells is located at or immediately downgradient of the former UST and associated piping, where no nickel exceedances occurred (i.e., for wells MW-01, MW-04, and MW-05). Further, no other contamination likely attributable to historic site-related activities was found in wells MW-02, MW-06, and MW-08. In addition, nickel was detected ubiquitously in surface and subsurface soil samples at AOC E at concentrations lower than the background UTL. Consequently, the nickel concentrations in groundwater are likely attributable to background.

Thallium is the only other dissolved inorganic detected in groundwater above its MCL. It was detected in wells MW-02 (5.8 µg/L in 2002) and MW-04 (6.4 µg/L in 2002) above background (5 µg/L) and the MCL of 2 µg/L. These two detections, as well as a single detection in MW-05 (0.34 µg/L), also exceed the adjusted tap water PRG (0.24 µg/L). However, the thallium analytical method utilized during these sampling events was prone to falsely elevated results. Further, thallium was not detected in AOC E soil, was detected sporadically in groundwater, and other site-related contamination was not detected in well MW-02. This information suggests the thallium concentrations are either falsely elevated or attributable to background.

Dissolved vanadium was detected in four wells (MW-02, MW-06, MW-07, and MW-08) above background and the adjusted PRG (3.6 µg/L). Similar to the observations for nickel, these four wells are not located within the source area or immediately downgradient and they did not contain other contaminants likely attributable to historic site-related activities. Further, vanadium was detected ubiquitously in surface and subsurface soil samples at

AOC E at concentrations lower than the background UTL. Consequently, the vanadium concentrations in groundwater are likely attributable to background.

In summary, none of the inorganics concentrations detected in AOC E groundwater is likely attributable to releases from historic site-related activities. This is consistent with the findings for AOC E soil, where no inorganic (other than potentially lead) was found at concentrations likely attributable to historic site-related activities. It is notable that lead, whose concentrations in soil, at least in part, may be attributable to historic site-related activities, was not detected in groundwater above background, the lead action level, or the Puerto Rico UST Corrective Action level.

4.2.3 Free Phase Product

Floating free product (i.e., LNAPL) has been observed in three monitoring wells during sampling conducted between 1998 and 2005 (Table 2-2). LNAPL has been most often detected and at the greatest thickness in the well installed directly beneath the former UST (i.e., MW-01). Table 2-2 shows the thicknesses of LNAPL detected in this well, as well as the other two wells (MW-04 and MW-05). Thicknesses up to 1.17 ft (measured in November 2005) have been detected in MW-01. The product was bailed from the well in December 2005. Since that time, considerably less product has been measured in that well (see notes in Table 2-2). Figure 4-14 depicts the estimated extent of LNAPL in groundwater prior to the Multi Phase Extraction Pilot Test (May 31, 2002). Figure 4-15 depicts the estimated extent of LNAPL based on the most current measurements taken from all site wells (November 30, 2005). MW-05 had a sheen on November 30, 2005 and no measurable product on March 17, 2006; MW-01 had 1.17 feet of free product measured on November 25, 2005, but was not measured on March 17, 2006.

A sample of the free product from monitoring well MW-01 was collected in September 2004. The sample was analyzed for TCL VOCs, SVOCs, pesticides, and PCBs; TAL total inorganics; TPH-aliphatics; TPH-aromatics; and other TPH carbon ranges. Analytical results, summarized in Table 4-4, are consistent with the types of constituents detected in groundwater samples from this well and other wells around the former UST and associated piping. It should be noted that the relatively high concentrations of the constituents detected in the free product may mask the presence of other constituents. Therefore, there is not necessarily a good correlation between what was detected in the free product and what was detected in the groundwater at AOC E. However, as shown in Table 4-4, five VOCs (cyclohexane, ethylbenzene, isopropylbenzene, methylcyclohexane, and total xylenes) were detected in the free product. All of these constituents can be associated with petroleum products. In addition, several PAHs and phthalates, often associated with petroleum products, including hydraulic fluids, were detected in the free product. No pesticides or PCBs were detected in the free product sample. All metals on the TAL, other than thallium, were detected in the free product sample. Table 4-4 shows that there were higher concentrations of the higher carbon chain TPH and aliphatics than lower carbon chain TPH and aromatics. This is consistent with the historical information that suggests the UST was used to store waste oil.

TABLE 4-1
 Surface Soil Detection Summary
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Surface Soil Sample	Site Specific	Vieques	Vieques	PREQB UST	Vieques (West)	SS - 13	SS - 14	SS - 15	SS - 16	SS - 17	SS - 18	SS - 19	
Station ID	SSL - DAF	HHRA SO	Eco SO	Corrective	Background Zone	WAE-SO13	WAE-SO14	WAE-SO15	WAE-SO16	WAE-SO17	WAE-SO18	WAE-SO19	
Sample ID	2.4			Action	Qa SO	WAE-SS13-0002	WAE-SS14-0002	WAE-SS15-0002	WAE-SS16-0002	WAE-SS17-0002	WAE-SS18-0002	WAE-SS19-0002	
Sample Date				Criteria		11/30/05	11/30/05	12/01/05	12/01/05	11/30/05	11/30/05	11/30/05	
Chemical Name													
Volatile Organic Compounds (µg/kg)													
No Detections													
Semi-volatile Organic Compounds (µg/kg)													
Acetophenone	0.046	780,000	--	--	--	350 U	360 U	360 U	370 U	360 U	88 J	350 U	370 U
Di-n-octylphthalate	2,600,000	240,000	--	--	--	350 U	360 U	360 U	370 U	350 J	360 U	350 U	370 U
bis(2-Ethylhexyl)phthalate	1,700,000	35,000	10,000	--	--	350 U	360 U	360 U	370 U	76 J	330 J	350 U	370 U
Pesticide/Polychlorinated Biphenyls (µg/kg)													
4,4'-DDD	5,374	2,400	10	--	--	3.5 U	3.6 U	2.1 J	3.7 U	3.6 U	3.6 U	3.5 U	3.7 U
4,4'-DDE	17,159	1,700	10	--	--	3.5 U	3.6 U	3.6 U	3.7 U	8.4	8	3.5 U	3.7 U
4,4'-DDT	10,096	1,700	10	--	--	3.5 U	3.6 U	3.6 U	3.7 U	3.5 J	3.6	3.5 U	3.7 U
Aroclor-1260	1,987	110	40,000	--	--	35 U	36 U	36 U	37 U	36 U	36 U	12 J	37 U
Total Metals (mg/kg)													
Aluminum	1,000,000	7,600	--	--	29,000	9,650	10,600	7,640	7,560	5,950	5,840	10,500	10,100
Antimony	1.082	3.1	78	--	2.3	0.34 J	0.56 J	0.59 J	0.35 J	0.41 J	0.42 J	0.64 J	0.51 J
Arsenic	0.746	0.39	18	--	2.2	0.36 J	1.1 U	1.1 U	0.53 J	1.1 U	1.1 U	0.34 J	1.1 U
Barium	250	1,600	330	--	320	79.3	74	40.5	63.4	65.8	58.9	79.1	56
Cadmium	103	3.7	32	--	0.036	0.82	0.55 U	0.55 U	0.56 U	0.54 U	0.54 U	0.58	0.56 U
Calcium	--	--	--	--	45,000	7,190	5,700	9,020	8,970	2,220 J	2,280 J	7,260	2,520 J
Chromium	1,000,000	210	0.4	--	74	13.1	14.7	11.7	7	5.4 R	4.9 R	18.7	6
Cobalt	24.69	140	13	--	33	9.1	8.7	7.1	6.7	7.4	6.7	9.7	7.3
Copper	125	310	70	--	68	51.9	29.6	24.3	20.2	17.5	16.5	38.6	21.1
Iron	672	2,300	--	--	39,000	15,800	18,500	13,800	11,200	9,780	9,690	18,800	13,800
Lead	21.5	400	120	50	6.9	29.9 J	11.6 J	30.2 J	52.1 J	6.6 J	6.4 J	19.7 J	2.9 J
Magnesium	--	--	--	--	12,834	3,090	3,320	3,740	1,680 R	1,200 R	1,470 R	4,010	2,290 R
Manganese	137	180	220	--	1,200	605	479	382	480	730	662	569	397
Mercury	0.96	2.3	0.1	--	0.031	0.028 J	0.11 U	0.11 U	0.027 J	0.11 U	0.11 U	0.11 U	0.11 U
Nickel	3,400	160	38	--	40	7.3 J	6.4 J	7 J	3.7 J	4.7 J	4.2 J	8 J	4 J
Potassium	--	--	--	--	1,700	1,020	1,500	566	779	855	749	1,170	1,060
Sodium	--	--	--	--	1,200	110 J	86.2 J	171 J	86.7 J	61.8 J	69.8 J	116 J	77 J
Vanadium	62	7.8	2	--	130	44	53	42.1	31.9	26.1	25.2	55.3	35.9
Zinc	14,000	2,300	120	--	71	82.7	57.1	30.9	40.2	26.4	25.7	60.7	25.8
Wet Chemistry (mg/kg)													
Total organic carbon (TOC)	--	--	--	--	--	7,340	2,320	3,110	3,390	3,330	3,300	7,010	2,750
Total Petroleum Hydrocarbons (mg/kg)													
TPH-diesel range	--	--	--	100	--	11 U	11 U	54 U	11	11 U	11 U	11 U	11 U
TPH-oil range	--	--	--	100	--	70 J	51 J	250 U	270 J	21 U	20 U	190 J	46 J

- Notes:
- NA - Not analyzed / Not Applicable
 - U - Analyte not detected
 - J - Result may be estimated
 - R - Unreliable result
 - Criteria not established

Exceeds Background and Eco Criteria
Exceeds Background and Site Specific SSL Criteria
Exceeds PREQB UST Corrective Action Criteria
Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria

TABLE 4-2
Subsurface Soil Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Subsurface Soil Sample	Site Specific SSL - DAF 2.4	Vieques HHRA SO	PREQB UST Corrective Action Criteria	Vieques (West) Background Zone Qa SO	SB - 01			SB - 02		SB - 03	SB - 04	SB - 05		SB - 06				SB - 07	SB - 08	
					2016-SB1-A	2016-SB1	2016-SB1-B	2016-SB2		2016-SB3	2016-SB4	2016-SB5		AOCE-SB-06				AOCE-SB-07	AOCE-SB-08	
					08/04/98	2016-DUPE1	08/10/98	2016-SB2-A	2016-SB2-B	2016-SB3	2016-SB4	2016-SB5-A	2016-SB5-B	DSSB06-12	DSSB06-14	FD205-14	DSSB06-44	DSSB7-2	DSSB08-32	DSSB08-46
Sample ID	Sample Date	Sample Depth	Chemical Name	2016-SB1-A	2016-DUPE1	08/10/98	2016-SB2-A	2016-SB2-B	2016-SB3	2016-SB4	2016-SB5-A	2016-SB5-B	DSSB06-12	DSSB06-14	FD205-14	DSSB06-44	DSSB7-2	DSSB08-32	DSSB08-46	
				4 - 6'	4 - 6'	45 - 47'	4 - 6'	43 - 45'	4 - 6'	4 - 6'	4 - 6'	45 - 47'	12 - 14'	14 - 16'	14 - 16'	44 - 46'	2 - 4'	32 - 34'	46 - 48'	
Volatle Organic Compounds (µg/kg)																				
1,2-Dichlorobenzene	5,255	110,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Acetone	1,406	1,400,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Benzene	17.5	640	5,000	--	50 U	50 U	50 U	50 U	NA	NA	NA	NA	5.2 U	NA	0.31 J	6.4 UJ				
Ethylbenzene	7,216	190,000	10,000	--	50 U	50 U	240	50 U	50 U	50 U	50 U	50 U	NA	NA	NA	NA	5.2 U	NA	0.25 J	6.4 UJ
Isopropylbenzene	10,644	57,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	2.04	17,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylcyclohexane	71,583	260,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5,490	630,000	10,000	--	50 U	50 U	50 U	50 U	NA	NA	NA	NA	5.2 U	NA	6.8 UJ	6.4 UJ				
Xylene, total	88,511	27,000	10,000	--	150 U	150 U	6,700	150 U	150 U	150 U	150 U	150 U	NA	NA	NA	NA	5.2 U	NA	6.8 UJ	6.4 UJ
Semi-volatile Organic Compounds (µg/kg)																				
1,1-Biphenyl	36,056	300,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	358	31,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50,362	370,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	1,000,000	2,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	704	620	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	--	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	23,000,000	1,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	70,283	62,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	3,100,000	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	63,623	270,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	239	5,600	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	--	2,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	362,806	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	--	35,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)																				
4,4'-DDE	17,159	1,700	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	10,096	1,700	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	8.14	29	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	726	110	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin aldehyde	--	1,800	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
alpha-BHC	0.716	90	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
gamma-Chlordane	4,607	1,600	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (mg/kg)																				
Aluminum	1,000,000	7,600	--	29,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	1.08	3.1	--	2.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.746	0.39	--	2.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	250	1,600	--	320	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	--	--	--	45,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	1,000,000	210	--	74	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	24.7	140	--	33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	125	310	--	68	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	672	2,300	--	39,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	21.5	400	50	6.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	--	--	--	12,834	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	137	180	--	1,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	3,400	160	--	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	--	--	1,700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	47.6	39	--	0.077	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	--	--	1,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	62.4	7.8	--	130	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	14,000	2,300	--	71	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wet Chemistry (mg/kg)																				
Total organic carbon (TOC)	--	--	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)																				
Oil and Grease	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	63.1 U	59.4 U	63.7 U	98.8 J	116 J	95.1 J	65.1 U	
TPH-diesel range	--	--	100	--	25 U	25 U	25 U	25 U	NA	NA	NA	NA	NA	NA	NA					
TPH-gas range	--	--	100	--	10 U	10 U	42,000	10 U	10 U	10 U	10 U	10 U	NA	NA	NA	NA	NA	NA	NA	
TPH-oil range	--	--	100	--	50 U	50 U	2,400	50 U	50 U	50 U	50 U	50 U	NA	NA	NA	NA	NA	NA	NA	
Total Petroleum Hydrocarbons, C10-C28	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	126 U	120 U	127 U	113 UJ	116 U	4.7 J	17.4 J	
Total Petroleum Hydrocarbons, C6-C10	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	0.012 J	122 U	122 U	111 U	116 U	157 U	134 U	
Total recoverable TPH	--	--	100	--	520	390	36,000	230	80	430	590	380	87	NA	NA	NA	NA	NA	NA	

Notes:
NA - Not analyzed / Not Applicable
U - Analyte not detected
J - Result may be estimated
R - Unreliable result
UJ - Analyte not detected, result may be estimated
JN - Qualitative identification questionable due to poor resolution
-- Criteria not established

Exceeds Background, HHRA and PREQB Criteria
Exceeds Background and Site Specific SSL Criteria
Exceeds Background, HHRA, Site Specific SSL Criteria
Exceeds PREQB UST Corrective Action Criteria
Exceeds Background, HHRA, Site Specific SSL and PREQB Criteria
Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria

TABLE 4-2
Subsurface Soil Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Subsurface Soil Sample	Site Specific SSL - DAF 2.4	Vieques HHRA SO	PREQB UST Corrective Action Criteria	Vieques (West) Background Zone Qa SO	SB - 09					SB - 10				SB - 11		SB - 12			
					AOCE-SB-09					AOCE-SB-10				AOCE-SB-11		AOCE-SB-12			
					DSSB09-12	FD305-2802	DSSB09-22	DSSB09-28	DSSB09-42	DSSB10R-12	DSSB10-24	DSSB10R-24	DSSB10-30	DSSB11-12	DSSB11-28	DSSB12-12	DSSB12-26	DSSB12-28	DSSB12-42
Station ID																			
Sample ID																			
Sample Date																			
Sample Depth																			
Chemical Name																			
Volatle Organic Compounds (µg/kg)																			
1,2-Dichlorobenzene	5,255	110,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	1,406	1,400,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	17.5	640	5,000	--	4,150 J	2,560 J	491 U	25.8 J	2 J	5.4 U	NA	5.2 U	NA	4.7 U	4.6 U	5.4 U	5.2 U	1.7 J	580 U
Ethylbenzene	7,216	190,000	10,000	--	14,200	8,590 J	2,160	1,470 J	22.1 J	5.4 U	NA	5.2 U	NA	4.7 U	4.6 U	0.19 J	5.2 U	38.6 J	284 J
Isopropylbenzene	10,644	57,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	2.04	17,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylcyclohexane	71,583	260,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5,490	630,000	10,000	--	2,750 J	1,890 J	220 J	1,070 J	1.2 J	5.4 U	NA	5.2 U	NA	4.7 U	4.6 U	5.4 U	5.2 U	1.1 J	53.3 J
Xylene, total	88,511	27,000	10,000	--	90,600	55,500 J	17,000	11,100 J	119 J	5.4 U	NA	5.2 U	NA	4.7 U	4.6 U	5.4 U	5.2 U	18.7 J	4,010
Semi-volatile Organic Compounds (µg/kg)																			
1,1-Biphenyl	36,056	300,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	358	31,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	50,362	370,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	1,000,000	2,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	704	620	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	--	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	23,000,000	1,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	70,283	62,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	3,100,000	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	63,623	270,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	239	5,600	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	--	2,200,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	362,806	230,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	--	35,000	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)																			
4,4'-DDE	17,159	1,700	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	10,096	1,700	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	8.14	29	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	726	110	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin aldehyde	--	1,800	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
alpha-BHC	0.716	90	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
gamma-Chlordane	4,607	1,600	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (mg/kg)																			
Aluminum	1,000,000	7,600	--	29,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	1.08	3.1	--	2.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	0.746	0.39	--	2.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	250	1,600	--	320	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	--	--	--	45,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	1,000,000	210	--	74	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	24.7	140	--	33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	125	310	--	68	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	672	2,300	--	39,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	21.5	400	50	6.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	--	--	--	12,834	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	137	180	--	1,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	3,400	160	--	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	--	--	1,700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	47.6	39	--	0.077	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	--	--	1,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	62.4	7.8	--	130	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	14,000	2,300	--	71	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wet Chemistry (mg/kg)																			
Total organic carbon (TOC)	--	--	--	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)																			
Oil and Grease	--	--	100	--	19,300	17,100	7,100	4,940	2,310	57 U	66.4 J	52.3 U	114 J	53 U	57.1 U	106 J	105 J	57.4 U	56.6 U
TPH-diesel range	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPH-gas range	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPH-oil range	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C10-C28	--	--	100	--	3,410 J	3,780 J	2,770 J	1,930 J	438 J	112 U	120 U	104 U	114 U	106 U	114 U	111 U	18.9 J	805 J	1,110 J
Total Petroleum Hydrocarbons, C6-C10	--	--	100	--	2,150 J	981 J	370 J	154 J	0.86 J	538 J	118 U	84.4 U	234 U	103 U	222 UJ	220 UJ	42 J	149 J	
Total recoverable TPH	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
 NA - Not analyzed / Not Applicable
 U - Analyte not detected
 J - Result may be estimated
 R - Unreliable result
 UJ - Analyte not detected, result may be estimated
 JN - Qualitative identification questionable due to poor resolution
 -- Criteria not established

Exceeds Background, HHRA and PREQB Criteria
Exceeds Background and Site Specific SSL Criteria
Exceeds Background, HHRA, Site Specific SSL Criteria
Exceeds PREQB UST Corrective Action Criteria
Exceeds Background, HHRA, Site Specific SSL and PREQB Criteria
Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria

TABLE 4-2
Subsurface Soil Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Subsurface Soil Sample	Site Specific SSL - DAF 2.4	Vieques HHRA SO	PREQB UST Corrective Action Criteria	Vieques (West) Background Zone Qa SO	SB - 13				SB - 14			SB - 15	SB - 16
					WAE-SO13				WAE-SO14			WAE-SO15	WAE-SO16
					WAE-SB13-0406R	WAE-SB13P-0406R	WAE-SB13-3234	WAE-SB13-3436	WAE-SB14-0406	WAE-SB14-4244	WAE-SB14-4446	WAE-SB15-0406R	WAE-SB16-0406
					12/12/05	12/12/05	12/14/05	12/14/05	12/01/05	12/12/05	12/12/05	12/05/05	12/05/05
Sample ID	Sample Date	Sample Depth	Chemical Name	4 - 6'	4 - 6'	32 - 34'	34 - 36'	4 - 6'	42 - 44'	44 - 46'	4 - 6'	4 - 6'	
Volatle Organic Compounds (µg/kg)													
1,2-Dichlorobenzene	5,255	110,000	--	--	10 U	2 J	3 J	12	10 U	54	10 U	10 U	10 U
Acetone	1,406	1,400,000	--	--	5 J	11 U	12 U	21 U	10 U	10 U	10 U	10 U	10 U
Benzene	17.5	640	5,000	--	10 U	11 U	26	70	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	7,216	190,000	10,000	--	4 J	17	91	2,700	10 U	230	10 U	10 U	10 U
Isopropylbenzene	10,644	57,000	--	--	2 J	8 J	11	37	10 U	370	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	2.04	17,000	--	--	10 U	11 U	10 U	10 U	10 U	4 J	10 U	10 U	10 U
Methylcyclohexane	71,583	260,000	--	--	2 J	11 U	25	47	10 U	220	10 U	10 U	10 U
Toluene	5,490	630,000	10,000	--	10 U	11 U	18	37	10 U	10 U	10 U	10 U	10 U
Xylene, total	88,511	27,000	10,000	--	10 U	11 U	520	18,000	10 U	520	10 U	10 U	10 U
Semi-volatile Organic Compounds (µg/kg)													
1,1-Biphenyl	36,056	300,000	--	--	360 U	360 U	330 J	310 J	370 U	380 U	360 UJ	380 U	380 U
2-Methylnaphthalene	358	31,000	--	--	77 J	360 U	6,000	5,200	370 U	1,200	360 UJ	380 U	380 U
Acenaphthene	50,362	370,000	--	--	360 U	360 U	380 U	1,400 U	370 U	140 J	360 UJ	380 U	380 U
Anthracene	1,000,000	2,200,000	--	--	360 U	360 U	380 U	1,400 U	370 U	78 J	360 UJ	380 U	380 U
Benzo(a)anthracene	704	620	--	--	360 U	360 U	100 J	1,400 U	370 U	130 J	360 UJ	380 U	380 U
Benzo(g,h,i)perylene	--	230,000	--	--	84 J	360 U	380 U	1,400 U	370 U	380 U	360 UJ	380 U	380 U
Butylbenzylphthalate	23,000,000	1,200,000	--	--	360 U	360 U	210 J	1,400 U	370 U	380 U	360 UJ	380 U	380 U
Chrysene	70,283	62,000	--	--	360 U	360 U	130 J	1,400 U	370 U	130 J	360 UJ	380 U	380 U
Fluoranthene	3,100,000	230,000	--	--	360 U	360 U	130 J	1,400 U	370 U	160 J	360 UJ	380 U	380 U
Fluorene	63,623	270,000	--	--	360 U	360 U	380 U	1,400 U	370 U	190 J	360 UJ	380 U	380 U
Naphthalene	239	5,600	--	--	360 U	360 U	3,500	3,100	370 U	380 U	360 UJ	380 U	380 U
Phenanthrene	--	2,200,000	--	--	360 U	360 U	590	600 J	370 U	560	360 UJ	380 U	380 U
Pyrene	362,806	230,000	--	--	360 U	360 U	230 J	1,400 U	370 U	320 J	360 UJ	380 U	380 U
bis(2-Ethylhexyl)phthalate	--	35,000	--	--	360 U	99 J	630	700 J	370 U	660	120 J	380 U	380 U
Pesticide/Polychlorinated Biphenyls (µg/kg)													
4,4'-DDE	17,159	1,700	--	--	3.6 U	1.5 J	3.8 U	3.6 U	3.7 U	3.8 U	7.8	3.8 U	3.8 U
4,4'-DDT	10,096	1,700	--	--	3.6 U	3.6 U	3.8 U	3.6 U	3.7 U	3.8 U	9.2	3.8 U	3.8 U
Aldrin	8.14	29	--	--	1.9 U	1.9 U	2 U	1.1 J	1.9 U	1.9 U	1.9 U	1.9 U	2 U
Aroclor-1254	110	110	--	--	36 U	36 U	38 U	36 U	15 J	38 U	36 U	38 U	38 U
Endrin aldehyde	--	1,800	--	--	3.6 U	3.6 U	2.1 J	3.6 U	3.7 U	3.8 U	3.6 U	3.8 U	3.8 U
alpha-BHC	0.716	90	--	--	1.9 U	1.9 U	5.3 JN	4.1 J	1.9 U	1.9 U	1.9 U	1.9 U	2 U
gamma-Chlordane	4,607	1,600	--	--	1.9 U	5	2 U	1.8 U	1.9 U	1.9 U	8.3	1.9 U	2 U
Total Metals (mg/kg)													
Aluminum	1,000,000	7,600	--	29,000	7,070	6,670	10,200	3,780	9,730	23,800	23,100	10,600	10,100
Antimony	1.08	3.1	--	2.3	0.53 J	0.25 J	0.37 J	6.5 UJ	0.41 J	1.3 J	1.1 J	0.37 J	0.34 J
Arsenic	0.746	0.39	--	2.2	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	0.57 J	1.1 U	1.1 U	1.1 U
Barium	250	1,600	--	320	41.9	41.2	104	51.6	71.3	153	106	78.8	71.6
Calcium	--	--	--	45,000	1,610 J	1,540 J	2,880	1,720 J	3,440	8,990	8,620	2,290 J	2,740 J
Chromium	1,000,000	210	--	74	9.6 J	6.2 J	14.4	6.5	13.7	30	35.3	14.7	9.7
Cobalt	24.7	140	--	33	4.7 J	4.2 J	9.5	2.4 J	8.5	32.1	28.2	7.8	7.2
Copper	125	310	--	68	20.4	17	26.4	6	25.5	75.8	61	25.6	23.6
Iron	672	2,300	--	39,000	17,400 J	11,600 J	18,500	4,810	16,700	43,000	39,800	18,800	15,600
Lead	21.5	400	50	6.9	10.1 J	11.9 J	6 J	1.4 J	3.3 J	1.4 J	1.1 U	1.9 J	2.8 J
Magnesium	--	--	--	12,834	1,410 R	1,260 R	3,260	1,850 R	2,960	19,300	18,600	3,170	2,220 R
Manganese	137	180	--	1,200	287	225	486	124	476	1,000	776	348	423
Nickel	3,400	160	--	40	4.3 J	2.6 J	5.8 J	2.2 J	5.6 J	21.5 J	16.9 J	4.9 J	4.5 J
Potassium	--	--	--	1,700	930	830	525 J	481 J	1,500	55.6 J	63.4 J	1,160	1,320
Silver	47.6	39	--	0.077	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	0.29 J
Sodium	--	--	--	1,200	67.7 J	74.8 J	150 J	120 J	423 J	177 J	159 J	154 J	101 J
Vanadium	62.4	7.8	--	130	35.7	32.8	66	8.9	46.9	125	121	53.5	41.5
Zinc	14,000	2,300	--	71	31.4	27.6	58.8	12.9	42.6	68	61.8	26.9	25.6
Wet Chemistry (mg/kg)													
Total organic carbon (TOC)	--	--	--	--	2,890	3,480	3,170	7,400	1,500	5,070	1,740	1,940	1,390
Total Petroleum Hydrocarbons (mg/kg)													
Oil and Grease	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPH-diesel range	--	--	100	--	8 J	9.4 J	310	490 J	11 U	340	26 J	11 U	11 U
TPH-gas range	--	--	100	--	0.11 J	0.12 J	8.1	11	0.56 U	8.3	1.1	0.57 U	0.57 U
TPH-oil range	--	--	100	--	140 J	180 J	1,300 J	2,800 J	12 U	2,600 J	460 J	11 U	11 U
Total Petroleum Hydrocarbons, C10-C28	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	100	--	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
 NA - Not analyzed / Not Applicable
 U - Analyte not detected
 J - Result may be estimated
 R - Unreliable result
 UJ - Analyte not detected, result may be estimated
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Exceeds Background, HHRA and PREQB Criteria
Exceeds Background and Site Specific SSL Criteria
Exceeds Background, HHRA, Site Specific SSL Criteria
Exceeds PREQB UST Corrective Action Criteria
Exceeds Background, HHRA, Site Specific SSL and PREQB Criteria
Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria

TABLE 4-3
Groundwater Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Monitoring Well Station ID	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	Background																MW - 01	MW - 02	MW - 04			
				MW - 03						NDAEMW01	NDAEMW02	NDAEMW03	NDAEMW04	NDAEMW05	NDAEMW06	NDAEMW07	NDAEMW08	NDAEMW09	NDAEMW10						
				2016-MW3	2016-DUPE1-MW3	ND4029	ND4025FD1	GWMW03-R01	NDAEGW03-R01														WAE-GW03-05D	2016-MW1	2016-MW2
Sample ID				09/11/98	09/11/98	04/05/00	04/05/00	05/21/02	08/25/04	12/09/05	09/11/98	04/05/00	05/21/02	09/01/04	12/09/05	09/11/98	04/05/00	05/21/02	08/26/04	12/09/05	04/27/00	05/21/02	05/21/02	08/30/04	12/09/05
Sample Date																									
Chemical Name																									
Volatile Organic Compounds(µg/L)																									
1,2-Dichlorobenzene	37	600	--	NA	NA	1 U	1 U	1 U	0.5 U	NA	NA	NSFP	NSFP	4.6	NSFP	NA	1 U	1 U	0.5 U	NA	3	4.5	4.4	3.7	NA
1,2-Dichloroethane	0.12	5	--	NA	NA	1 U	1 U	1 U	0.5 U	NA	NA			0.5 U		NA	1 U	1 U	0.5 U	NA	1 U	4.6	4.9	0.59	NA
Acetone	550	--	--	NA	NA	5 R	5 R	5 U	5 U	NA	NA			5 U		NA	5 R	5 U	5 U	NA	12	5 U	5 U	5 U	NA
Benzene	0.35	5	5	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	17			4.1		5 U	1 U	1 U	0.5 U	NA	2	0.72 J	0.7 J	0.21 J	NA
Chlorobenzene	11	100	--	NA	NA	1 U	1 U	1 U	0.69	NA	NA			0.5 U		NA	1 U	1 U	0.5 U	NA	1.4	1.4	1.4	0.9	NA
Chloroform	0.17	80	--	NA	NA	1 U	1 U	1 U	1.4	NA	NA			0.5 U		NA	1 U	1 U	0.74	NA	1 U	1 U	1 U	0.5 U	NA
Cyclohexane	1,000	--	--	NA	NA	NA	NA	NA	1.3	NA	NA			0.5 U		NA	NA	NA	0.5 U	NA	NA	NA	NA	0.5 U	NA
Ethylbenzene	130	700	700	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	5 U			10.9		5 U	1 U	1 U	0.5 U	NA	1 U	1 U	1 U	0.5 U	NA
Isopropylbenzene	66	--	--	NA	NA	NA	NA	NA	0.5 U	NA	NA			6.3		NA	NA	NA	0.5 U	NA	NA	NA	NA	0.5 U	NA
Methyl-tert-butyl ether (MTBE)	11	--	--	NA	NA	NA	NA	NA	0.5 U	NA	NA			2.9		NA	NA	NA	0.5 U	NA	NA	NA	NA	234	NA
Methylcyclohexane	520	--	--	NA	NA	NA	NA	NA	0.58 U	NA	NA			2.60		NA	NA	NA	0.58 U	NA	NA	NA	NA	0.61	NA
Toluene	230	1,000	1,000	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	5 U			0.3 J		5 U	1 U	1 U	0.5 U	NA	1 U	1 U	1 U	0.5 U	NA
Xylene, total	--	10,000	10,000	15 U	15 U	1 U	1 U	1 U	2 U	NA	15 U			26.2		15 U	1 U	1 U	2 U	NA	0.9 J	1 U	1 U	2 U	NA
m- and p-Xylene	21	--	--	NA	NA	1 U	1 U	NA	NA	NA	NA			NA		NA	1 U	NA	NA	NA	0.9 J	NA	NA	NA	NA
o-Xylene	21	--	--	NA	NA	1 U	1 U	NA	NA	NA	NA			NA		NA	1 U	NA	NA	NA	1 U	NA	NA	NA	NA
Semi-volatile Organic Compounds (µg/L)																									
2-Methylnaphthalene	2.4	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA	NSFP	NSFP	12	NSFP	NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
Acenaphthene	37	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	5 U	0.54 J	0.55 J	5.1 U	NA
Acetophenone	61	--	--	NA	NA	NA	NA	NA	5.3 U	NA	NA			8.1		NA	NA	NA	5.3 U	NA	NA	NA	NA	5.1 U	NA
Butylbenzylphthalate	730	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
Caprolactam	1,800	--	--	NA	NA	NA	NA	NA	4.5 J	NA	NA			5.2 U		NA	NA	NA	5.3 U	NA	NA	NA	NA	5.1 U	NA
Di-n-butylphthalate	360	--	--	NA	NA	0.7 J	2 J	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
Diethylphthalate	2,900	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	0.6 J	5.4 U	5.4 U	5.1 U	NA
Fluorene	24	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
Naphthalene	0.62	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			9.5		NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
Phenanthrene	18	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	NA			5.2 U		NA	5 U	5.4 U	5.3 U	NA	5 U	5.4 U	5.4 U	5.1 U	NA
bis(2-Ethylhexyl)phthalate	4.8	6	--	NA	NA	2 J	5 J	5.6 U	10.5 U	NA	NA			10.3 U		NA	1 J	5.4 U	10.6 U	NA	5 U	5.4 U	5.4 U	10.2 U	NA
Pesticide/Polychlorinated Biphenyls(µg/L)																									
Dieldrin	0.0042	--	--	NA	NA	0.03 UJ	0.02 UJ	NA	NA	NA	NA	NSFP	NSFP	0.021 U	NSFP	NA	0.02 UJ	NA	0.0019 J	NA	0.02 UJ	NA	NA	0.02 U	NA
Total Metals (µg/L)																									
Aluminum	3,600	--	--	NA	NA	24,000	21,100	72.6 J	45.8 J	NA	NA	NSFP	NSFP	35 U	NSFP	NA	106,000	1,890 J	212	NA	66,000 J	38,600 J	35,400 J	195 J	NA
Amenable cyanide	--	--	--	NA	NA	NA	NA	2.3 U	NA	NA	NA			NA		NA	NA	2.3 U	NA	NA	NA	2.72 J	7.18 J	NA	NA
Antimony	1.5	6	--	NA	NA	1.4 U	1.4 U	2.8 U	2.5 U	NA	NA			2.5 U		NA	5.6 J	2.8 U	2.5 U	NA	2.2 J	2.8 U	2.8 U	2.5 U	NA
Arsenic	0.045	10	--	NA	NA	3.4 U	3.4 U	1.3 J	8.91 J	NA	NA			11.4		NA	3.4 U	1 J	15.2	NA	3.4 U	3.2 J	1.4 J	10.5	NA
Barium	730	2,000	--	NA	NA	248	234	118 J	127 J	NA	NA			205		NA	826	111 J	115 J	NA	584	624	623	405	NA
Beryllium	7.3	4	--	NA	NA	0.3 U	0.3 U	0.32 J	0.2 U	NA	NA			0.2 U		NA	0.55 J	0.39 J	0.2 U	NA	0.3 U	0.56 J	0.5 J	0.23 J	NA
Cadmium	1.8	5	--	NA	NA	0.2 U	0.2 U	0.42 U	0.51	NA	NA			0.356 U		NA	0.2 U	0.42 U	0.356 U	NA	0.2 U	0.42 U	0.42 U	0.356 U	NA
Calcium	--	--	--	NA	NA	69,900	69,200	60,700	62,200	NA	NA			96,500		NA	121,000	54,400	52,400	NA	115,000 J	127,000	127,000	117,000	NA
Chromium	11	100	--	NA	NA	50.7	44.3	2 J	1.3 U	NA	NA			1.3 U		NA	110	4.3 J	3.98 J	NA	141	59.2	54.9	28	NA
Cobalt	73	--	--	NA	NA	23.6 J	20.5 J	0.93 J	0.76 U	NA	NA			0.76 U		NA	118	2 J	0.76 U	NA	36.1 J	13.2 J	11.4 J	0.76 U	NA
Copper	150	1,300	--	NA	NA	85.3	70.5	7.2 J	3.31 J	NA	NA			2.05 J		NA	247	8.5 J	1.34 J	NA	144	74.1	68.1	1.17 U	NA
Cyanide	73	200	--	NA	NA	NA	NA	NA	9.9 U	NA	NA			9.9 U		NA	NA	NA	9.9 U	NA	NA	NA	NA	9.9 U	NA
Iron	1,100	--	--	NA	NA	39,300	34,000	29 UJ	48.6 J	NA	NA			3,190 J		NA	180,000	2,310 J	332 J	NA	66,000 J	32,100 J	28,900 J	2,420	NA
Lead	15	15	50	NA	NA	1.1 UJ	1.1 UJ	2 U	2.68 J	NA	NA			2.2 U		NA	3.6	2 U	4.29	NA	11.7	2.8 J	2.3 J	2.2 U	NA
Magnesium	--	--	--	NA	NA	45,900	44,100	35,000	38,100	NA	NA			55,700		NA	101,000	29,900	31,100	NA	61,800	65,700	66,300	61,800	NA
Manganese	88	--	--	NA	NA	1,500	1,340	40.9	33.8	NA	NA			1,990		NA	6,490	79.4	12 J	NA	3,890	6,410	6,340	5,810	NA
Mercury	1.1	2	--	NA	NA	0.18 U	0.18 U	0.04 U	0.132 J	NA	NA			0.026 J		NA	0.18 U	0.04 U	0.025 U	NA	0.18 U	0.04 U	0.04 U	0.025 U	NA
Nickel	73	--	--	NA	NA	21.7 J	18.9 J	3.2 U	2.16 J	NA	NA			1.7 U		NA	65.1	3.8 J	2.24 J	NA	87.7	37.4 J	34.6 J	25 J	NA
Potassium	--	--	--	NA	NA	6,000 J	5,720 J	3,520 J	1,930 J	NA	NA			2,400 J		NA	10,400 J	2,890 J	1,600 J	NA	12,000 J	8,360	8,130	1,570 J	NA
Selenium	18	50	--	NA	NA	2.7 J	2.1 U	4.1 J	2.6 U	NA	NA			2.6 U		NA	5.6	3.8 J	2.6 U	NA	2.1 U	5.5	4.8 J	2.6 U	NA
Silver	18	--	--	NA	NA	0.5 U	0.5 U	0.86 U	0.65 U	NA	NA			0.65 U		NA	0.5 U	0.86 U	0.65 U	NA	0.5 U	0.86 U	0.86 U	0.65 U	NA
Sodium	--	--	--	NA	NA	130,000	130,000	130,000																	

TABLE 4.3
Groundwater Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Monitoring Well Station ID	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	Background																						
				MW - 03						MW - 05			MW - 06			MW - 07			MW - 08							
				NDAEMW03	AOC-E-MW03	AOCE-MW-03	NDAEMW03	WAE-MW03	AOC-E-MW05	NDAEMW05	NDAEMW05	AOC-E-MW06	AOCE-MW-06	NDAEMW06	WAE-MW06	AOC-E-MW07	NDAEMW07	WAE-MW07	NDAEMW08	NDAEMW08	WAE-MW08					
2016-MW3 09/11/98	2016-DUPE1-MW3 09/11/98	NDA029 04/05/00	NDA025FD1 04/05/00	GWMW03-R01 05/21/02	NDAEGW03-R01 08/25/04	WAE-GW03-05D 12/09/05	NDA026 05/20/02	NDAEGW05-R03 08/30/04	NDAEFD01-R03 08/30/04	NDA028 12/09/05	GWMW06-R01 04/27/00	NDAEGW06-R03 08/25/04	WAE-GW06-05D 12/09/05	GWMW07-R01 05/24/02	NDAEGW07-R03 08/26/04	WAE-GW07-05D 12/08/05	WAE-GW07P-05D 12/08/05	NDAEGW08-R01 09/08/03	NDAEGW08-R03 08/26/04	WAE-GW08-05D 12/09/05						
Chemical Name																										
Volatile Organic Compounds(µg/L)																										
1,2-Dichlorobenzene	37	600	--	NA	NA	1 U	1 U	1 U	0.5 U	NA	4	NSFP	3.5	3.8	NSFP	1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
1,2-Dichloroethane	0.12	5	--	NA	NA	1 U	1 U	1 U	0.5 U	NA	32		7.2	6.4		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
Acetone	550	--	--	NA	NA	5 R	5 R	5 U	5 U	NA	5 U		5 U	5 U		10	5 U	5 U	NA	5 U	5 U	NA	5 U	5 U	NA	
Benzene	0.35	5	5	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	6		0.81 J	1.2 J		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
Chlorobenzene	11	100	--	NA	NA	1 U	1 U	1 U	0.5 U	NA	1 U		1.1	1		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
Chloroform	0.17	80	--	NA	NA	1 U	1 U	1 U	1.4	NA	1 U		0.5 U	0.5 U		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.49 J	0.3 J	NA	
Cyclohexane	1,000	--	--	NA	NA	NA	NA	NA	0.5 U	NA	NA		0.31 J	0.5 U		NA	NA	0.5 U	NA	NA	0.5 U	NA	0.5 U	0.5 U	NA	
Ethylbenzene	130	700	700	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	0.9 J		0.46 J	0.71 J		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
Isopropylbenzene	66	--	--	NA	NA	NA	NA	NA	0.5 U	NA	NA		0.17 J	0.22 J		NA	NA	0.5 U	NA	NA	0.5 U	NA	0.5 U	0.5 U	NA	
Methyl-tert-butyl ether (MTBE)	11	--	--	NA	NA	NA	NA	NA	0.5 U	NA	NA		1.180	1.220		NA	NA	0.5 U	NA	NA	0.5 U	NA	0.5 U	0.5 U	NA	
Methylcyclohexane	520	--	--	NA	NA	NA	NA	NA	0.58 U	NA	NA		0.75 J	0.58 UJ		NA	NA	0.58 U	NA	NA	0.58 U	NA	0.5 U	0.58 U	NA	
Toluene	230	1,000	1,000	5 U	5 U	1 U	1 U	1 U	0.5 U	NA	0.3 J		0.5 U	0.21 J		1 U	1 U	0.5 U	NA	1 U	0.5 U	NA	0.5 U	0.5 U	NA	
Xylene, total	--	10,000	10,000	15 U	15 U	1 U	1 U	1 U	2 U	NA	20		1 J	1.8 J		1 U	1 U	2 U	NA	1 U	2 U	NA	2 U	2 U	NA	
m- and p-Xylene	21	--	--	NA	NA	1 U	1 U	NA	NA	NA	17		NA	NA		1 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	
o-Xylene	21	--	--	NA	NA	1 U	1 U	NA	NA	NA	3		NA	NA		1 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Semi-volatile Organic Compounds (µg/L)																										
2-Methylnaphthalene	2.4	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	14		NSFP	5.1 U	5.2 U	NSFP	6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA
Acenaphthene	37	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	6 U		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
Acetophenone	61	--	--	NA	NA	NA	NA	NA	5.3 U	NA	NA		5.1 U	5.2 U		NA	NA	5.3 U	NA	NA	5 U	NA	5.2 U	5.2 U	NA	
Butylbenzylphthalate	730	--	--	NA	NA	5 U	5 U	5.6 U	5.2 U	NA	0.4 J		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
Caprolactam	1,800	--	--	NA	NA	NA	NA	4.5 J	NA	NA	NA		12.2 J	33 J		NA	NA	5.3 U	NA	NA	6.8	NA	5.2 R	5.2 U	NA	
Di-n-butylphthalate	360	--	--	NA	NA	0.7 J	2 J	5.6 U	5.3 U	NA	6 U		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	0.49 J	5.2 U	NA	
Diethylphthalate	2,900	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	6 U		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
Fluorene	24	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	0.5 J		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
Naphthalene	0.62	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	15		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
Phenanthrene	18	--	--	NA	NA	5 U	5 U	5.6 U	5.3 U	NA	0.6 J		5.1 U	5.2 U		6 U	5.4 U	5.3 U	NA	5.8 U	5 U	NA	5.2 U	5.2 U	NA	
bis(2-Ethylhexyl)phthalate	4.8	6	--	NA	NA	2 J	5 J	5.6 U	10.5 U	NA	6 U		10.2 U	10.3 U		6 U	5.4 U	10.5 U	NA	5.8 U	10 U	NA	10.3 U	10.3 U	NA	
Pesticide/Polychlorinated Biphenyls(µg/L)																										
Dieldrin	0.0042	--	--	NA	NA	0.03 UJ	0.02 UJ	NA	NA	NA	0.02 U		NSFP	NA	0.02 UJ	NSFP	0.11	NA	0.027	NA	NA	NA	NA	NA	NA	NA
Total Metals (µg/L)																										
Aluminum	3,600	--	--	NA	NA	24,000	21,100	72.6 J	45.8 J	NA	11,900		NSFP	71 J	216	NSFP	2,020 J	3,310 J	287	NA	851	151 J	NA	5,310	147 J	NA
Amenable cyanide	--	--	--	NA	NA	NA	NA	2.3 U	NA	NA	NA		NA	NA		NA	5.52 J	NA	NA	2.3 U	NA	NA	NA	NA	NA	NA
Antimony	1.5	6	--	NA	NA	1.4 U	1.4 U	2.8 U	2.5 U	NA	1.9 J		2.5 U	2.5 U		1.4 U	2.8 U	2.5 U	NA	2.8 U	2.5 U	NA	2.5 U	2.5 U	NA	
Arsenic	0.045	10	--	NA	NA	3.4 U	3.4 U	1.3 J	8.91 J	NA	3.5 J		13.6	12.7		3.4 U	2.1 J	13.7 J	NA	0.88 U	10.1 J	NA	2.04 UJ	15 J	NA	
Barium	730	2,000	--	NA	NA	248	234	118 J	127 J	NA	269		240	127 J		131 J	201	186 J	NA	134 J	134 J	NA	114 J	114 J	NA	
Beryllium	7.3	4	--	NA	NA	0.3 U	0.3 U	0.32 J	0.2 U	NA	0.3 U		0.2 U	0.2 U		0.3 U	0.42 J	0.2 U	NA	0.29 U	0.2 U	NA	0.0945 U	0.2 U	NA	
Cadmium	1.8	5	--	NA	NA	0.2 U	0.2 U	0.42 U	5.51	NA	0.2 U		0.356 U	0.356 U		0.2 U	0.48 J	7.2	NA	0.42 U	0.356 U	NA	0.356 U	0.356 U	NA	
Calcium	--	--	--	NA	NA	69,900	69,200	60,700	62,200	NA	103,000		80,100	81,200		50,400 J	70,100	62,000	NA	47,400	44,700	NA	46,500 J	48,200	NA	
Chromium	11	100	--	NA	NA	50.7	44.3	2 J	1.3 U	NA	38.1		5.29 J	4.77 J		10	14	4.17 J	NA	6 J	3.45 J	NA	11.8	4.22 J	NA	
Cobalt	73	--	--	NA	NA	23.6 J	20.5 J	0.93 J	0.76 U	NA	8.6 J		0.76 U	0.76 U		1.1 J	9.3 J	0.76 U	NA	0.89 U	0.76 U	NA	4.66 J	0.76 U	NA	
Copper	150	1,300	--	NA	NA	85.3	70.5	1.17 J	3.31 J	NA	31.2		1.17 J	1.17 J		5.5 J	5.5 J	1.45 J	NA	2.8 J	1.77 J	NA	15.4 J	1.21 J	NA	
Cyanide	73	200	--	NA	NA	NA	NA	9.9 U	9.9 U	NA	9.9 U		9.9 U	9.9 U		NA	NA	9.9 U	NA	9.9 U	NA	NA	6.57 J	9.9 U	NA	
Iron	1,100	--	--	NA	NA	39,300	34,000	29 UJ	48.6 J	NA	13,800		1,390 J	1,600 J		2,020	2,730 J	290 J	NA	990 J	130	NA	7,340	184 J	NA	
Lead	15	15	50	NA	NA	1.1 UJ	1.1 UJ	2 U	2.68 J	NA	1.8 J		2.2 U	2.2 U		1.5 J	2 U	4.12	NA	2 U	2.2 U	NA	1.76 UJ	5.45	NA	
Magnesium	--	--	--	NA	NA	45,900	44,100	35,000	38,100	NA	48,900		48,200	48,700		30,300	45,900	41,500	NA	27,700	30,200	NA	30,700 J	31,600	NA	
Manganese	88	--	--	NA	NA	1,500	1,340	40.9	33.8	NA	3,340		1,900	2,020		65.2	101	20	NA	111	5.92 J	NA	218 J	10.2 J	NA	
Mercury	1.1	2	--	NA	NA	0.18 U	0.18 U	0.04 U	0.132 J	NA	0.18 U		0.025 U	0.025 U		0.18 U	0.04 U	0.025 U	NA	0.04 U	0.025 U	NA	0.0162 U	0.025 U	NA	
Nickel	73	--	--	NA	NA	21.7 J	18.9 J	3.2 U	216 J	NA	24.4 J		5.04 J	3.78 J		6 J	9.8 J	1.92 J	NA	5.4 J	1.83 J	NA	7.02 J	2.21 J	NA	
Potassium	--	--	--	NA	NA	6,000 J	5,720 J	3,520 J	1,930 J	NA	5,860 J		5,860 J	1,940 J		3,300 J	3,480 J	1,760 J	NA	3,020 J	1,410 J	NA	4,790 J	1,650 J	NA	
Selenium	18	50	--	NA	NA	2.7 J	2.1 U	4.1 J	2.6 U	NA	2.1 U		2.1 U	4.4 J		2.1 U	4.4 J	2.6 U	NA	2.9 U	2.6 U	NA	2.1 U	2.6 U	NA	
Silver	18	--	--	NA	NA	0.5 U	0.5 U	0.86 U	0.65 U	NA	0.5 U		0.65 U	0.65 U		0.5 U	0.86 U	0.65 U	NA	0.86 U	0.65 U	NA	0.54 J	0.65 U	NA	
Sodium	--	--	--	NA	NA	130,000	130,000	130,000	139,000 J	NA	152,000		165,000	163,000		119,000 J	122,000	122,000	NA	105,000	111,000	NA	105,000 J	120,000	NA	
Thallium	0.24	2	--	NA	NA	2.7 U	2.7 U	4.6 J	0.23 U	NA	2.7 U		0.23 U	0.23 U		2										

TABLE 4-4
 Free Product - Analytical Data
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Station ID	NDAEMW01
Sample ID	NDAEGW01-FP1
Sample Date	09/01/04
Chemical Name	
Volatile Organic Compounds (UG/KG)	
1,1,1-Trichloroethane	198,000 U
1,1,2,2-Tetrachloroethane	198,000 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	198,000 U
1,1,2-Trichloroethane	198,000 UJ
1,1-Dichloroethane	198,000 U
1,1-Dichloroethene	198,000 U
1,2,4-Trichlorobenzene	198,000 U
1,2-Dibromo-3-chloropropane	198,000 U
1,2-Dibromoethane	198,000 U
1,2-Dichlorobenzene	198,000 U
1,2-Dichloroethane	198,000 UJ
1,2-Dichloropropane	198,000 U
1,3-Dichlorobenzene	198,000 U
1,4-Dichlorobenzene	198,000 U
2-Butanone	198,000 U
2-Hexanone	198,000 U
4-Methyl-2-pentanone	198,000 U
Acetone	198,000 U
Benzene	198,000 UJ
Bromodichloromethane	198,000 U
Bromoform	198,000 U
Bromomethane	198,000 U
Carbon disulfide	198,000 UJ
Carbon tetrachloride	198,000 U
Chlorobenzene	198,000 U
Chloroethane	198,000 U
Chloroform	198,000 U
Chloromethane	198,000 U
Cyclohexane	17,600 J
Dibromochloromethane	198,000 U
Dichlorodifluoromethane (Freon-12)	198,000 U
Ethylbenzene	86,000 J
Isopropylbenzene	85,700 J
Methyl acetate	198,000 U
Methyl-tert-butyl ether (MTBE)	198,000 U
Methylcyclohexane	119,000 J
Methylene chloride	198,000 U
Styrene	198,000 U
Tetrachloroethene	198,000 U
Toluene	198,000 U
Trichloroethene	198,000 U
Trichlorofluoromethane(Freon-11)	198,000 U
Vinyl chloride	198,000 U
Xylene, total	322,000
cis-1,2-Dichloroethene	198,000 U
cis-1,3-Dichloropropene	198,000 U
trans-1,2-Dichloroethene	198,000 U
trans-1,3-Dichloropropene	198,000 U
Semi-volatile Organic Compounds (UG/KG)	
1,1-Biphenyl	99,000 U
2,2'-Oxybis(1-chloropropane)	99,000 U
2,4,5-Trichlorophenol	297,000 U
2,4,6-Trichlorophenol	99,000 U
2,4-Dichlorophenol	99,000 U
2,4-Dimethylphenol	99,000 U
2,4-Dinitrophenol	297,000 R
2,4-Dinitrotoluene	99,000 U
2,6-Dinitrotoluene	99,000 U
2-Chloronaphthalene	99,000 U
2-Chlorophenol	99,000 U
2-Methylnaphthalene	341,000 J
2-Methylphenol	99,000 U
2-Nitroaniline	297,000 R
2-Nitrophenol	99,000 U
3,3'-Dichlorobenzidine	201,000 U
3-Nitroaniline	297,000 R
4,6-Dinitro-2-methylphenol	297,000 R
4-Bromophenyl-phenylether	99,000 U
4-Chloro-3-methylphenol	99,000 U
4-Chloroaniline	99,000 U
4-Chlorophenyl-phenylether	99,000 U
4-Methylphenol	99,000 U
4-Nitroaniline	297,000 R

Notes:

- U - Analyte not detected
- J - Result may be estimated
- R - Unreliable result
- UJ - Analyte not detected, result may be estimated

TABLE 4-4
Free Product - Analytical Data
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Station ID	NDAEMW01
Sample ID	NDAEGW01-FP1
Sample Date	09/01/04
Chemical Name	
4-Nitrophenol	297,000 R
Acenaphthene	99,000 U
Acenaphthylene	99,000 U
Acetophenone	99,000 U
Anthracene	99,000 U
Atrazine	99,000 U
Benzaldehyde	99,000 U
Benzo(a)anthracene	23,700 J
Benzo(a)pyrene	99,000 U
Benzo(b)fluoranthene	99,000 U
Benzo(g,h,i)perylene	18,900 J
Benzo(k)fluoranthene	99,000 U
Butylbenzylphthalate	17,500 J
Caprolactam	99,000 U
Carbazole	99,000 U
Chrysene	20,800 J
Di-n-butylphthalate	99,000 U
Di-n-octylphthalate	99,000 R
Dibenz(a,h)anthracene	99,000 U
Dibenzofuran	99,000 U
Diethylphthalate	99,000 U
Dimethyl phthalate	99,000 U
Fluoranthene	99,000 U
Fluorene	30,400 J
Hexachlorobenzene	99,000 U
Hexachlorobutadiene	99,000 U
Hexachlorocyclopentadiene	99,000 U
Hexachloroethane	99,000 U
Indeno(1,2,3-cd)pyrene	99,000 R
Isophorone	99,000 U
Naphthalene	118,000 J
Nitrobenzene	99,000 U
Pentachlorophenol	297,000 R
Phenanthrene	73,800 J
Phenol	99,000 U
Pyrene	50,300 J
bis(2-Chloroethoxy)methane	99,000 U
bis(2-Chloroethyl)ether	99,000 U
bis(2-Ethylhexyl)phthalate	92,100 J
n-Nitroso-di-n-propylamine	99,000 U
n-Nitrosodiphenylamine	99,000 U
Pesticide/Polychlorinated Biphenyls (UG/KG)	
4,4'-DDD	21,000 U
4,4'-DDE	21,000 U
4,4'-DDT	21,000 U
Aldrin	11,000 U
Aroclor-1016	210,000 U
Aroclor-1221	430,000 U
Aroclor-1232	210,000 U
Aroclor-1242	210,000 U
Aroclor-1248	210,000 U
Aroclor-1254	210,000 U
Aroclor-1260	210,000 U
Dieldrin	21,000 U
Endosulfan I	11,000 U
Endosulfan II	21,000 U
Endosulfan sulfate	21,000 U
Endrin	21,000 U
Endrin aldehyde	21,000 U
Endrin ketone	21,000 U
Heptachlor	11,000 U
Heptachlor epoxide	11,000 U
Methoxychlor	110,000 U
Toxaphene	1,100,000 U
alpha-BHC	11,000 U
alpha-Chlordane	11,000 U
beta-BHC	11,000 U
delta-BHC	11,000 U
gamma-BHC (Lindane)	11,000 U
gamma-Chlordane	11,000 U
Total Metals (MG/KG)	
Aluminum	29.8 J
Antimony	0.307 J
Arsenic	0.512 J

Notes:

- U - Analyte not detected
- J - Result may be estimated
- R - Unreliable result
- UJ - Analyte not detected, result may be estimated

TABLE 4-4

Free Product - Analytical Data
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Station ID	NDAEMW01
Sample ID	NDAEGW01-FP1
Sample Date	09/01/04
Chemical Name	
Barium	7.5 J
Beryllium	0.0156 U
Cadmium	0.0361 J
Calcium	133 J
Chromium	0.386 J
Cobalt	0.166 J
Copper	35.2 J
Cyanide	0.132 U
Iron	97.7 J
Lead	8.78
Magnesium	3.85 J
Manganese	2.81
Mercury	0.00396 J
Nickel	0.705 J
Potassium	3.1 J
Selenium	0.277 U
Silver	0.026 U
Sodium	13.7 J
Thallium	0.0454 U
Vanadium	16.3
Zinc	2.18 J
Total Petroleum Hydrocarbons (MG/KG)	
Aliphatics C10-12	15,800
Aliphatics C12-16	11,100
Aliphatics C16-21	20,500
Aliphatics C21-35	1,150,000
Aliphatics C6-8	2,980
Aliphatics C8-10	10,300
Aromatics C10-12	1,210
Aromatics C12-16	1,380
Aromatics C16-21	3,220
Aromatics C21-35	52,800
Aromatics C7-8	245
Aromatics C8-10	576
Total Petroleum Hydrocarbons, C10-C28	533,000
Total Petroleum Hydrocarbons, C12-C28	235,000
Total Petroleum Hydrocarbons, C6-C10	10,400
Total Petroleum Hydrocarbons, C6-C12	51,300

Notes:

U - Analyte not detected

J - Result may be estimated

R - Unreliable result

UJ - Analyte not detected, result may be estimated

TABLE 4-5
Updated Human Health and Ecological Screening Values
AOC E Remedial Investigation Report
Vieques, Puerto Rico

	Human Health Screening Value		Ecological Screening Value		Reference
	Previous Value ¹	New Value ²	Previous Value ¹	New Value ²	
Soil					
VOCs					
Toluene	66,000 µg/kg	630,000 µg/kg			Updated toxicity values in Integrated Risk Information System (IRIS)
Xylenes	2,700 µg/kg	27,000 µg/kg			Decimal place error in Master QAPP; 27,000 µg/kg is adjusted PRG from Region IX Table (EPA, 2004)
SVOCs					
2-Methylnaphthalene	160,000 µg/kg	31,000 µg/kg			Updated toxicity values in Integrated Risk Information System (IRIS)
Benzo(g,h,i)perylene	2,300,000 µg/kg	230,000 µg/kg			Decimal place error in Master QAPP; 230,000 µg/kg is the adjusted PRG (pyrene as surrogate) from Region IX Table (EPA, 2004)
Pentachlorophenol			3,000 ug/kg	5,000 ug/kg	EPA. 2007. <i>Ecological Soil Screening Levels for Pentachlorophenol</i> . OSWER Directive 9285.7-58. April
Phenanthrene	230,000 µg/kg	2,200,000 µg/kg			Pyrene used as surrogate in Master QAPP; anthracene is a more appropriate surrogate. 2,200,000µg/kg is the adjusted PRG from Region IX Table (EPA, 2004)
Metals					
Barium	540 mg/kg	1,600 mg/kg			Updated toxicity values in Integrated Risk Information System (IRIS)
Copper			50 mg/kg	70 mg/kg	EPA. 2007. <i>Ecological Soil Screening Levels for Copper</i> . OSWER Directive 9285.7-68. February.
Iron	2,400 mg/kg	2,300 mg/kg			Incorrect value in Master QAPP; 2,300 mg/kg is adjusted PRG from Region IX Table (EPA, 2004)
Manganese			100 mg/kg	220 mg/kg	EPA. 2007. <i>Ecological Soil Screening Levels for Manganese</i> . OSWER Directive 9285.7-71. April.
Nickel			30 mg/kg	38 mg/kg	EPA. 2007. <i>Ecological Soil Screening Levels for Nickel</i> . OSWER Directive 9285.7-76. March.
Selenium			1.0 mg/kg	0.52 mg/kg	EPA. 2007. <i>Ecological Soil Screening Levels for Selenium</i> . OSWER Directive 9285.7-72. July.
Silver			2.0 mg/kg	560 mg/kg	EPA. 2006. <i>Ecological Soil Screening Levels for Silver</i> . OSWER Directive 9285.7-77. September.
Zinc	2,400 mg/kg	2,300 mg/kg	50 mg/kg	120 mg/kg	Incorrect value in Master QAPP; 2,300 mg/kg is adjusted PRG from Region IX Table (EPA, 2004) EPA. 2007. <i>Ecological Soil Screening Levels for Zinc</i> . OSWER Directive 9285.7-73. June.
Groundwater and Surface Water					
VOCs					
Toluene	72 µg/L	230 µg/L			Updated toxicity values in Integrated Risk Information System (IRIS)
SVOCs					
Acetophenone	42 µg/L	61 µg/L			Updated toxicity values in Integrated Risk Information System (IRIS)
2-Methylnaphthalene	12 µg/L	2.4 µg/L			Updated toxicity values in Integrated Risk Information System (IRIS)
Metals					
Barium	260 µg/L	730 µg/L			Updated toxicity values in Integrated Risk Information System (IRIS)

Notes:

¹ From the *Final Master Quality Assurance Project Plan, Environmental Restoration Program, Vieques, Puerto Rico* (CH2M HILL, 2007)

² Value used for screening in RI Report

TABLE 4-6
 Site Specific Soil Screening Level Algorithm
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Governing Equation:

$$SSL(mg / kg) = C_w \left[K_d + \frac{(\theta_w + \theta_a H')}{\rho_b} \right] DAF$$

Symbol Definitions:

<i>SSL</i>	<i>soil screening level (mg/kg)</i>
<i>C_w</i>	<i>target soil leachate concentration (mg/L); hierarchy is Federal MCL, Federal MCLG, and EPA Region IX Tap Water PRG</i>
<i>K_d</i>	<i>soil-water partition coefficient (L/kg)</i>
<i>θ_w</i>	<i>water-filled porosity (L_{water}/L_{soil})</i>
<i>θ_a</i>	<i>air-filled soil porosity (L_{air}/L_{soil}); [n - θ_w]</i>
<i>ρ_b</i>	<i>dry soil bulk density (kg/L)</i>
<i>n</i>	<i>soil porosity (L_{pore}/L_{soil})</i>
<i>ρ_s</i>	<i>soil particle density (kg/L)</i>
<i>H'</i>	<i>dimensionless Henry's Law Constant, from Oak Ridge National Laboratory Risk Assessment Information System (on-line)</i>

Numeric Soil Descriptors:

Variable	Value	Definition
<i>f_{oc}</i>	0.008	<i>fraction organic carbon in soil (g/g) (site specific data), K_d = k_{oc} x f_{oc}; k_{oc} (organic carbon/water partitioning coefficient) values from Oak Ridge National Laboratory Risk Assessment Information System (on-line)</i>
<i>θ_w</i>	0.14	<i>water-filled porosity (L_{water}/L_{soil})</i>
<i>ρ_b</i>	1.50	<i>dry soil bulk density (kg/L)</i>
<i>ρ_s</i>	2.65	<i>soil particle density (kg/L)</i>
<i>n</i>	0.45	<i>soil porosity (L_{pore}/L_{soil}); [1- ρ_b/ ρ_s]</i>
<i>θ_a</i>	0.30	<i>air-filled soil porosity (L_{air}/L_{soil})</i>
<i>Soil pH</i>	8	<i>From site specific values (Used for K_d calculations)</i>
<i>Soil type</i>	Loamy	<i>Sandy, loamy or clayey (Used for K_d aluminum and lead)</i>

Notes:

EPA (1996). Superfund Soil Screening Guidance: User's Guide. Pub No. 9355.4-23 (second edition), page 29.

TABLE 4-7
 Dilution Attenuation Factor Parameters
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Governing Equation:

$$DAF = 1 + \frac{Kd}{IL}$$

$$I = 0.0009(P^2) \left(\frac{\text{in}}{2.54\text{cm}} \right) \left(\frac{\text{ft}}{12\text{in}} \right) \left(\frac{\text{yr}}{365\text{d}} \right)$$

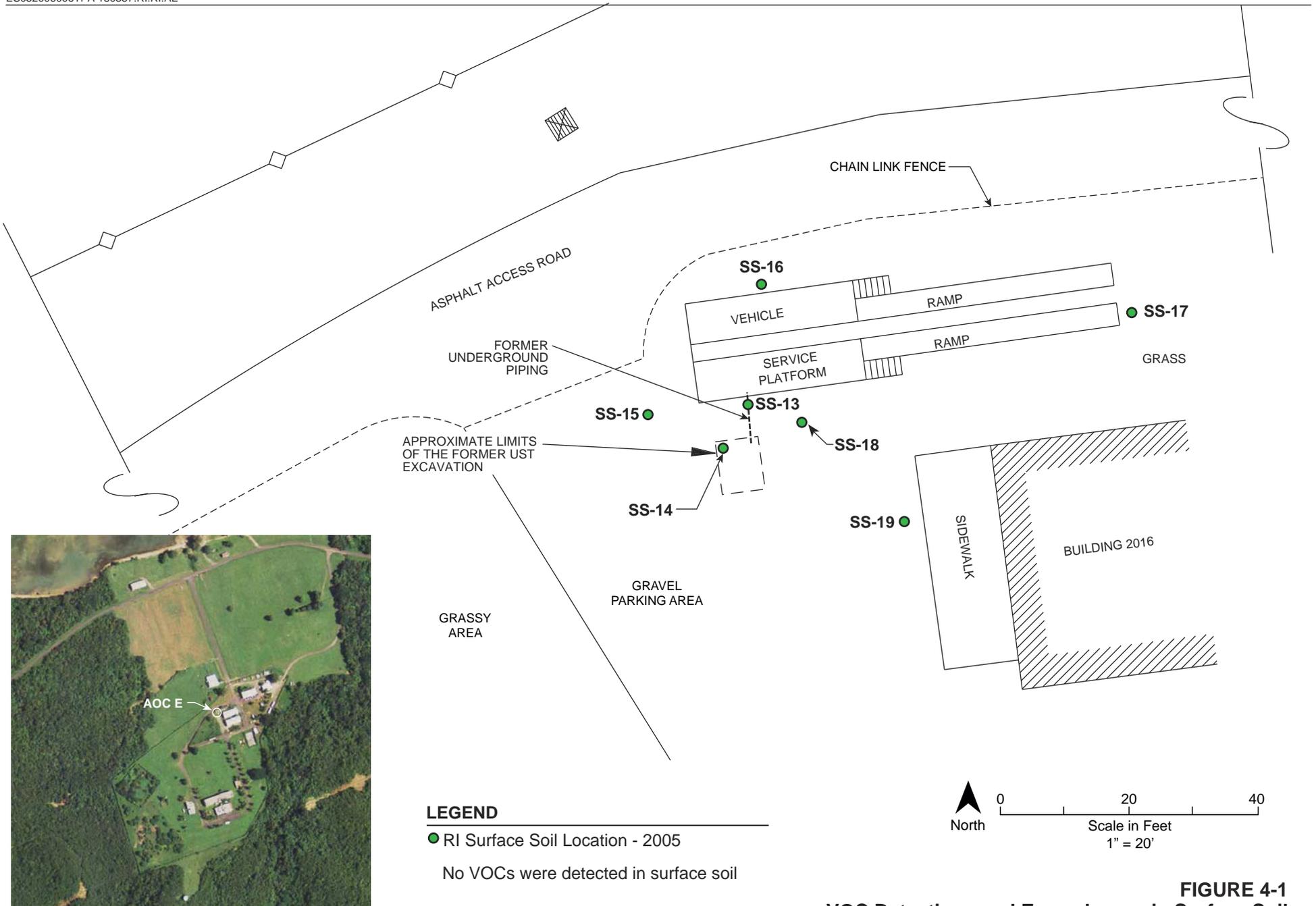
Symbol Definitions:

DAF	soil leachate dilution factor (unitless)
K	hydraulic conductivity of the groundwater bearing unit (feet/day)
i	hydraulic gradient (unitless)
d	saturated thickness of the groundwater bearing unit (ft)
I	infiltration rate (feet/day)
L	length of the affected soil area parallel to the direction of groundwater flow (feet)
P	precipitation (cm/year)

Numeric Soil Descriptors:

Parameter	Value	Estimation Method
Hydraulic Conductivity (K)	0.105 ft/d	Geometric mean of hydraulic conductivity measurements made from site specific slug tests.
Hydraulic Gradient (i)	0.012	Geometric mean of seven groundwater monitoring events.
Saturated Thickness (d)	20 ft	Professional judgment
Infiltration Rate (I)	4.2 in/yr 0.012 in/d 0.001 ft/d	The estimate of infiltration (I) uses an algorithm developed in Soil Attenuation Model for Derivation of Risk-Based Soil Remediation Standards (J. A. Connor, R. L. Bowers, S. M. Paquette, C. J., Groundwater Services, Inc., July 1997).
Site Length (L)	19 ft	
Precipitation (P)	109 cm/yr	

Note: A site specific soil leachate dilution attenuation factor (DAF) was developed for AOC-E using the process described in Soil Screening Guidance: User's Guide (USEPA 1996) as follows:



2004 Aerial Photograph

FIGURE 4-1
VOC Detections and Exceedances in Surface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Site Specific SSL - DAF 2.4	Vieques HHRA SO	PREQB UST Corrective Action Criteria
Volatile Organic Compounds			
1,2-Dichlorobenzene	5,255	110,000	
Acetone	1,406	1,400,000	
Benzene	17.5	640	5,000
Ethylbenzene	7,216	190,000	10,000
Isopropylbenzene	10,644	57,000	
Methyl-tert-butyl ether (MTBE)	2.04	17,000	
Methylcyclohexane	71,583	260,000	
Toluene	5,490	630,000	10,000
Xylene, total	88,511	27,000	10,000

SB-13	4-6'	32-34'	34-36'
Depth	4-6'	32-34'	34-36'
1,2-Dichlorobenzene	ND	3 J	12
Acetone	5 J	ND	ND
Benzene	ND	26	70
Ethylbenzene	17 J	91	2,700
Isopropylbenzene	8 J	11	37
Methylcyclohexane	2 J	25	47
Toluene	ND	18	37
Xylene, total	ND	520	18,000

SB-09	12-14'	22-24'	28-30'	42-44'
Depth	12-14'	22-24'	28-30'	42-44'
Benzene	4,150 J	ND	25.8 J	2 J
Ethylbenzene	14,200	2,160 J	1,470 J	22.1 J
Toluene	2,750 J	220 J	1,070 J	1.2 J
Xylene, total	90,600	17,000	11,100 J	119 J

SB-14	4-6'	42-44'	44-46'
Depth	4-6'	42-44'	44-46'
1,2-Dichlorobenzene	ND	54	ND
Ethylbenzene	ND	230	ND
Isopropylbenzene	ND	370	ND
Methyl-tert-butyl ether (MTBE)	ND	ND	4 J
Methylcyclohexane	ND	220	ND
Xylene, total	ND	520	ND

SB-08	32-34'	46-48'
Depth	32-34'	46-48'
Benzene	0.31 J	ND
Ethylbenzene	0.25 J	ND

SB-01	4-6'	45-47'
Depth	4-6'	45-47'
Ethylbenzene	ND	240
Xylene, total	ND	6,700

SB-12	12-14'	26-28'	28-30'	42-44'
Depth	12-14'	26-28'	28-30'	42-44'
Benzene	ND	ND	1.7 J	ND
Ethylbenzene	0.19 J	ND	38.6 J	284 J
Toluene	ND	ND	1.1 J	53.3 J
Xylene, total	ND	ND	18.7 J	4,010



2004 Aerial Photograph

LEGEND

- Site Characterization Subsurface Soil Sample Location - 1998
- RI Subsurface Soil Sample Location - 2002
- RI Subsurface Soil Sample Location - 2005

Exceeds Site Specific SSL Criteria
Exceeds HHRA and Site Specific SSL Criteria
Exceeds PREQB UST Corrective Action Criteria
Exceeds HHRA, Site Specific SSL and PREQB Criteria
Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria

J Estimated Result
 ND Not Detected

All constituent concentrations in µg/kg
 Subsurface soil samples SB-1 through SB-12 were only analyzed for BTEX in the VOC compound list.

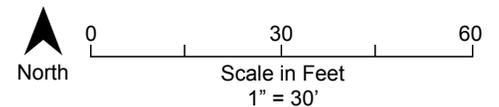
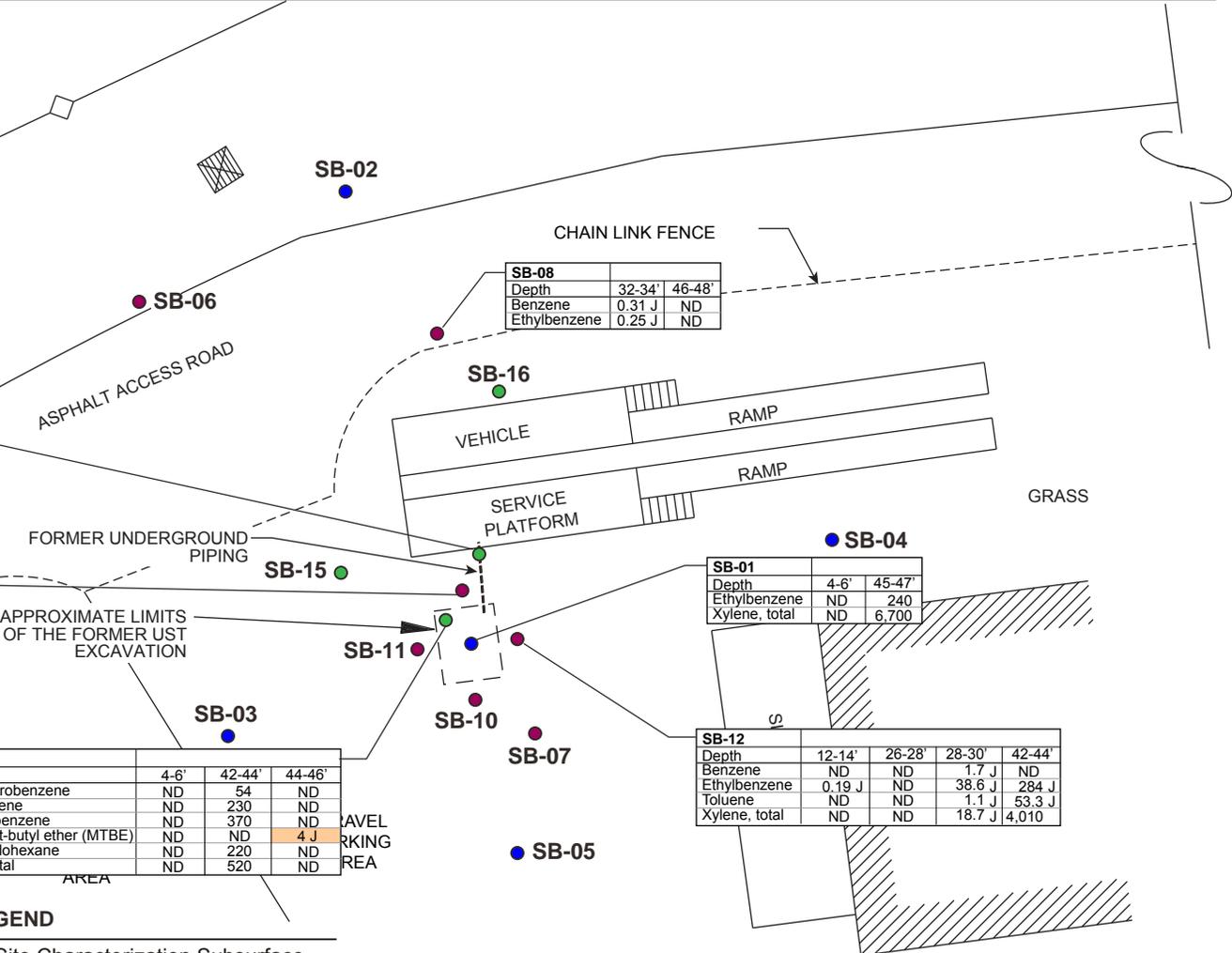
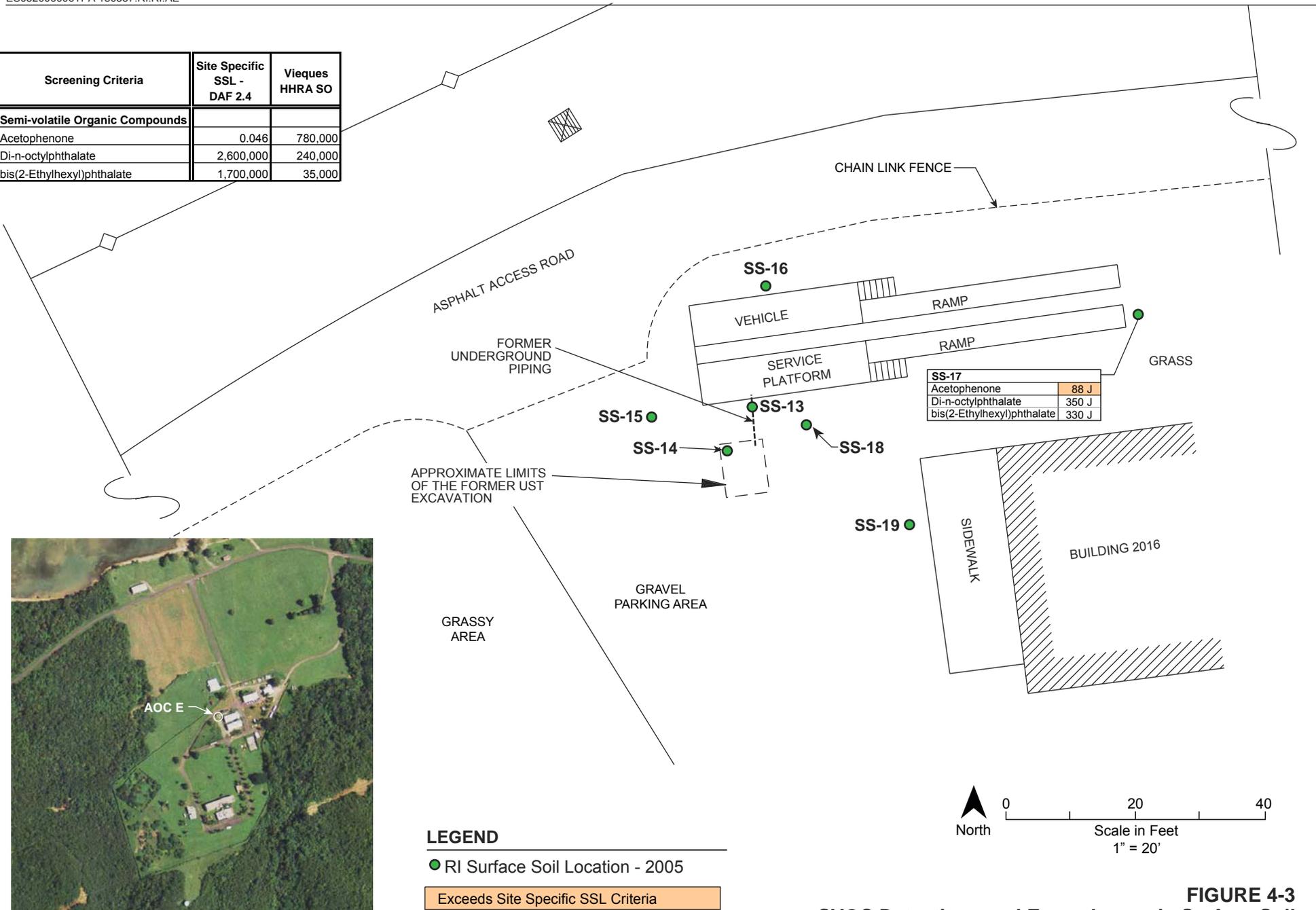


FIGURE 4-2
VOC Detections and Exceedances
in Subsurface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Site Specific SSL - DAF 2.4	Vieques HHRA SO
Semi-volatile Organic Compounds		
Acetophenone	0.046	780,000
Di-n-octylphthalate	2,600,000	240,000
bis(2-Ethylhexyl)phthalate	1,700,000	35,000



2004 Aerial Photograph

LEGEND

● RI Surface Soil Location - 2005

Exceeds Site Specific SSL Criteria

J Estimated Result

All constituent concentrations in $\mu\text{g}/\text{kg}$

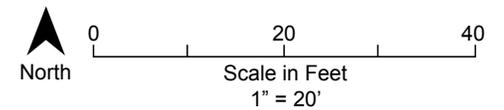
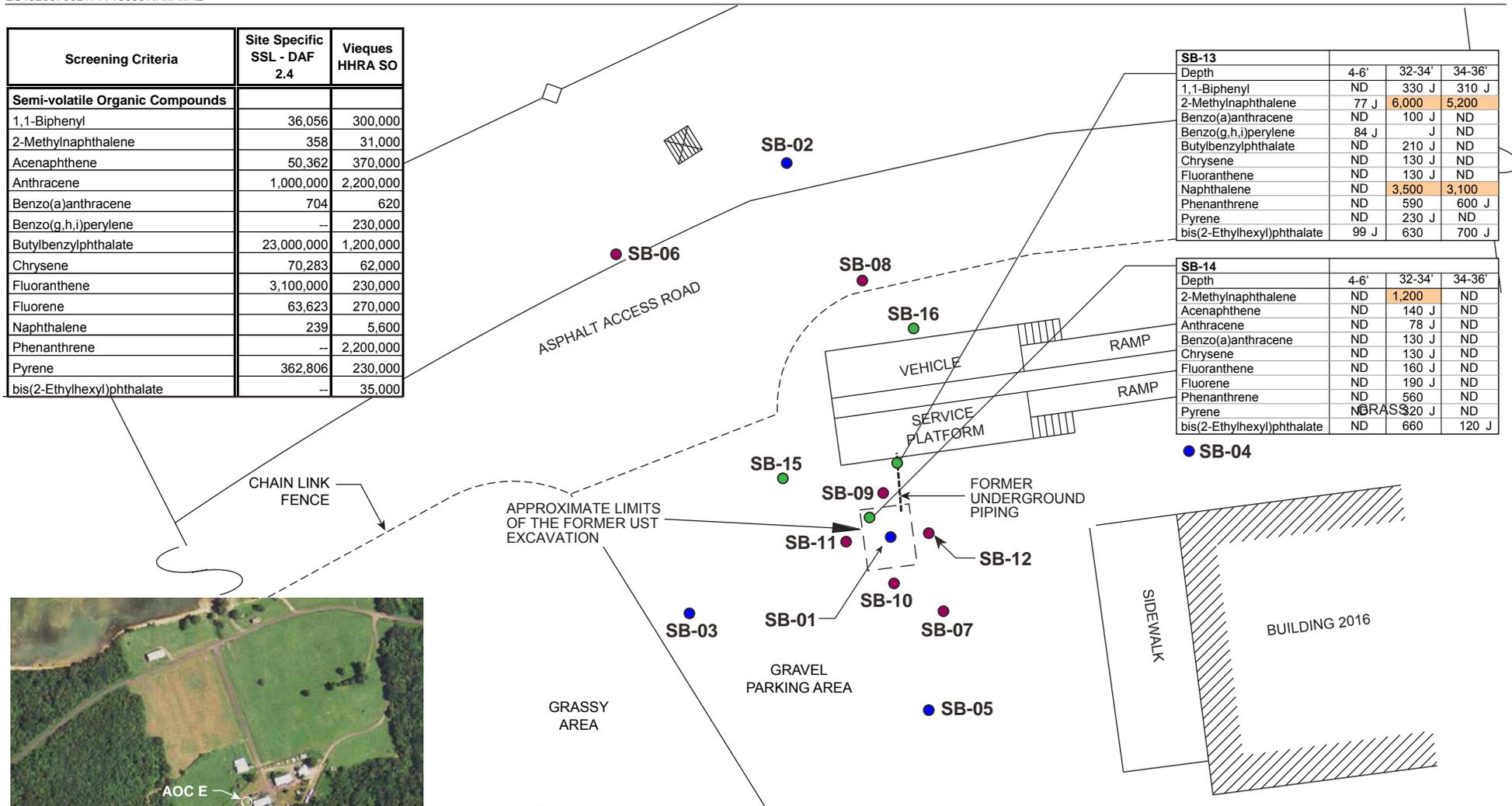


FIGURE 4-3
SVOC Detections and Exceedances in Surface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Site Specific SSL - DAF 2.4	Vieques HHRA SO
Semi-volatile Organic Compounds		
1,1-Biphenyl	36,056	300,000
2-Methylnaphthalene	358	31,000
Acenaphthene	50,362	370,000
Anthracene	1,000,000	2,200,000
Benzo(a)anthracene	704	620
Benzo(g,h,i)perylene	--	230,000
Butylbenzylphthalate	23,000,000	1,200,000
Chrysene	70,283	62,000
Fluoranthene	3,100,000	230,000
Fluorene	63,623	270,000
Naphthalene	239	5,600
Phenanthrene	--	2,200,000
Pyrene	362,806	230,000
bis(2-Ethylhexyl)phthalate	--	35,000

SB-13			
Depth	4-6'	32-34'	34-36'
1,1-Biphenyl	ND	330 J	310 J
2-Methylnaphthalene	77 J	6,000	5,200
Benzo(a)anthracene	ND	100 J	ND
Benzo(g,h,i)perylene	84 J	J	ND
Butylbenzylphthalate	ND	210 J	ND
Chrysene	ND	130 J	ND
Fluoranthene	ND	130 J	ND
Naphthalene	ND	3,500	3,100
Phenanthrene	ND	590	600 J
Pyrene	ND	230 J	ND
bis(2-Ethylhexyl)phthalate	99 J	630	700 J

SB-14			
Depth	4-6'	32-34'	34-36'
2-Methylnaphthalene	ND	1,200	ND
Acenaphthene	ND	140 J	ND
Anthracene	ND	78 J	ND
Benzo(a)anthracene	ND	130 J	ND
Chrysene	ND	130 J	ND
Fluoranthene	ND	160 J	ND
Fluorene	ND	190 J	ND
Phenanthrene	ND	560	ND
Pyrene	ND	320 J	ND
bis(2-Ethylhexyl)phthalate	ND	660	120 J



2004 Aerial Photograph

LEGEND

- Site Characterization Subsurface Soil Sample Location - 1998
- RI Subsurface Soil Sample Location - 2002
- RI Subsurface Soil Sample Location - 2005
- Exceeds Site Specific SSL Criteria

J Estimated Result
 ND Not Detected
 All constituent concentrations in µg/kg
 Subsurface soil samples SB-01 through SB-12 were not analyzed for SVOCs

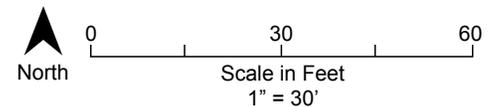


FIGURE 4-4
SVOC Detections and Exceedances
in Subsurface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	PREQB UST Corrective Action Criteria
Total Petroleum Hydrocarbons	
TPH-diesel range	100
TPH-oil range	100

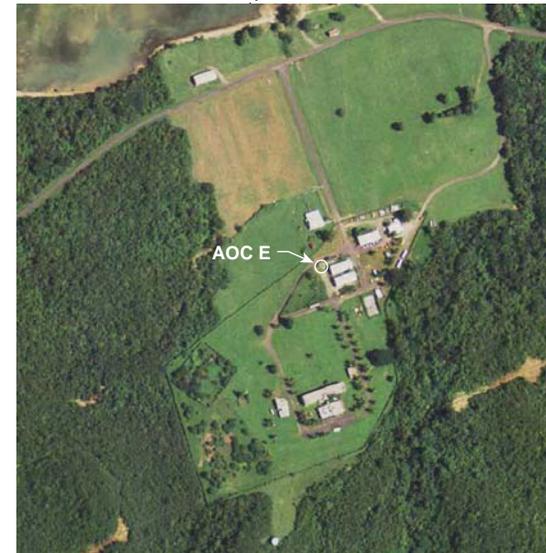
SS-16	
TPH-diesel range	11 J
TPH-oil range	270

SS-14	
TPH-oil range	51 J

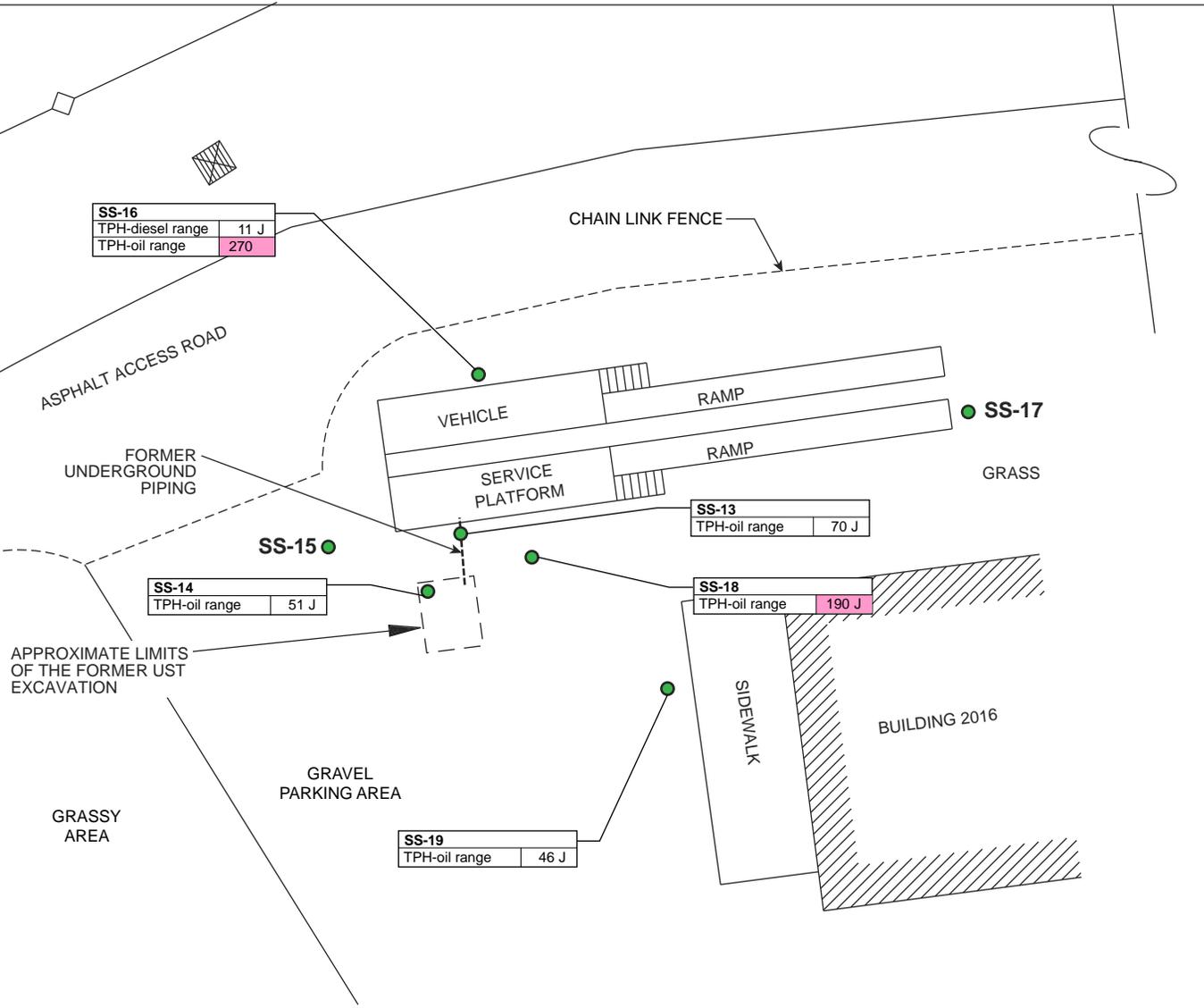
SS-13	
TPH-oil range	70 J

SS-18	
TPH-oil range	190 J

SS-19	
TPH-oil range	46 J



2004 Aerial Photograph



LEGEND

● RI Surface Soil Sample Location - 2005

Exceeds PREQB UST Corrective Action Criteria

J Estimated Result

All constituent concentrations in mg/kg

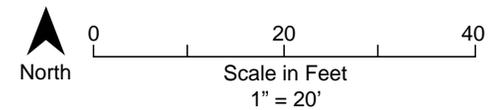
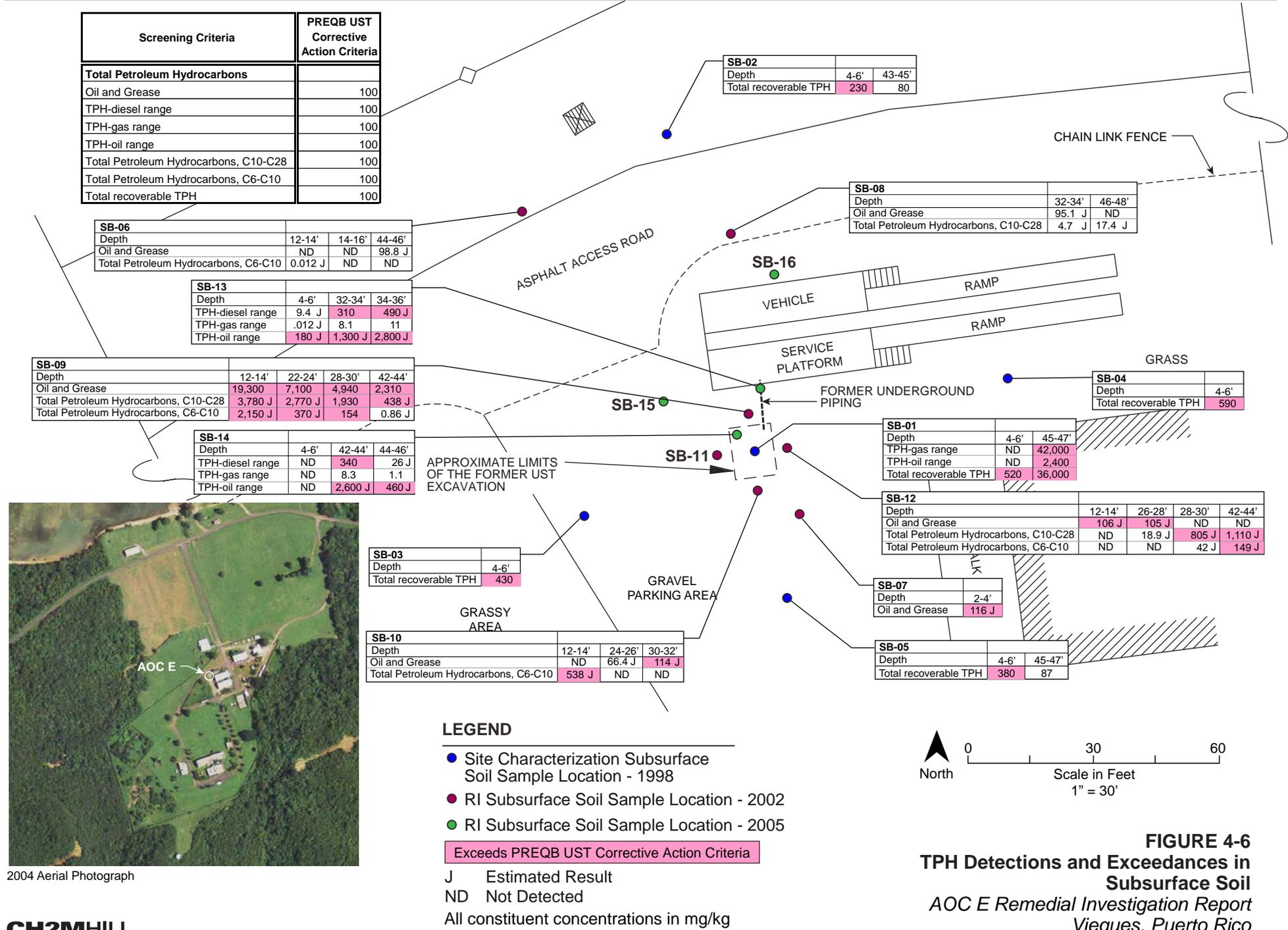
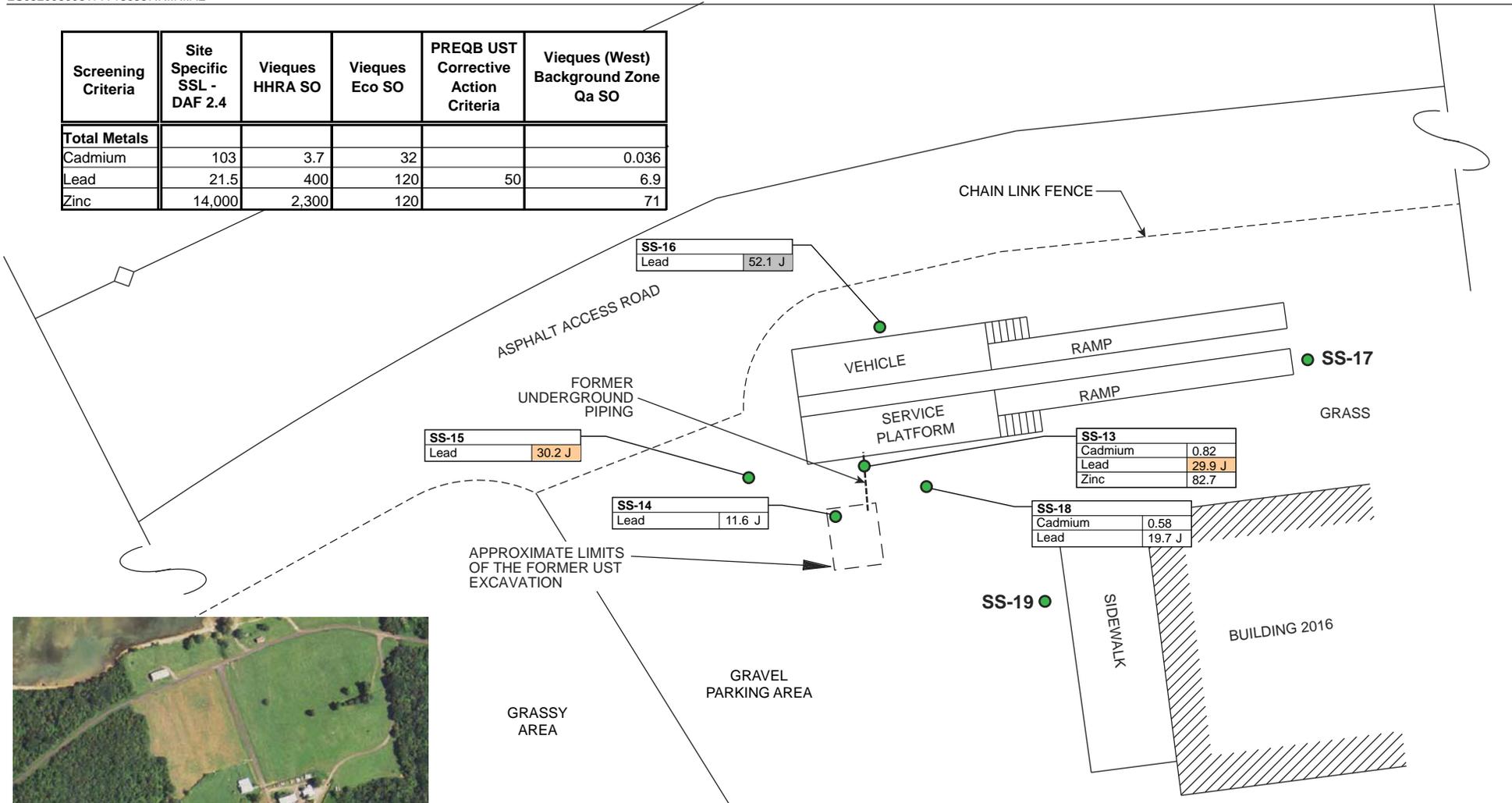


FIGURE 4-5
TPH Detections and Exceedances in Surface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico



2004 Aerial Photograph

Screening Criteria	Site Specific SSL - DAF 2.4	Vieques HHRA SO	Vieques Eco SO	PREQB UST Corrective Action Criteria	Vieques (West) Background Zone Qa SO
Total Metals					
Cadmium	103	3.7	32		0.036
Lead	21.5	400	120	50	6.9
Zinc	14,000	2,300	120		71



2004 Aerial Photograph

APPROXIMATE LIMITS OF THE FORMER UST EXCAVATION

LEGEND

- RI Surface Soil Sample Location - 2005
- Exceeds Background and Site Specific SSL Criteria
- Exceeds PREQB UST Corrective Action Criteria and Site Specific SSL Criteria
- Exceeds Background Criteria

J Estimated Result
All constituent concentrations in mg/kg

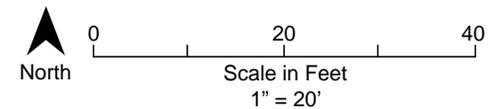
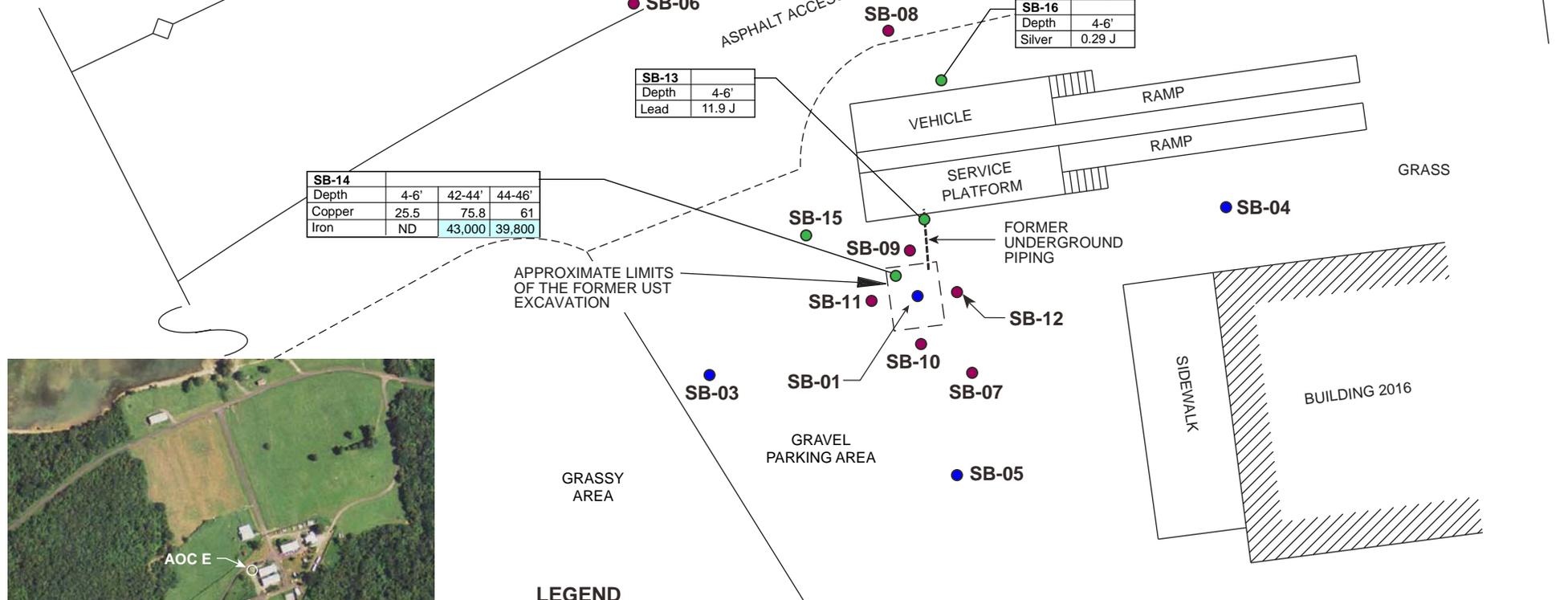


FIGURE 4-7
Inorganic Exceedances in Surface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Site Specific SSL - DAF 2.4	Vieques HHRA SO	PREQB UST Corrective Action Criteria	Vieques (West) Background Zone Qa 50
Total Metals				
Copper	125	310		68
Iron	672	2,300		39,000
Lead	21.5	400	50	
Silver	47.6	39		0.077



2004 Aerial Photograph

SB-14			
Depth	4-6'	42-44'	44-46'
Copper	25.5	75.8	61
Iron	ND	43,000	39,800

SB-13	
Depth	4-6'
Lead	11.9 J

SB-16	
Depth	4-6'
Silver	0.29 J

LEGEND

- Site Characterization Subsurface Soil Sample Location - 1998
- RI Subsurface Soil Sample Location - 2002
- RI Subsurface Soil Sample Location - 2005

Exceeds Background, HHRA, Site Specific SSL Criteria
Exceeds Background Criteria

J Estimated Result
 ND Not Detected
 All constituent concentrations in mg/kg

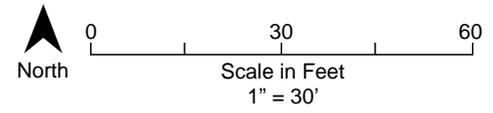


FIGURE 4-8
Inorganic Exceedances in Subsurface Soil
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria
Volatile Organic Compounds			
1,2-Dichlorobenzene	37	600	
1,2-Dichloroethane	0.12	5	
Acetone	550	--	
Benzene	0.35	5	5
Chlorobenzene	11	100	
Chloroform	0.17	80	
Cyclohexane	1,000	--	
Ethylbenzene	130	700	700
Isopropylbenzene	66	--	
Methyl-tert-butyl ether (MTBE)	11	--	
Methylcyclohexane	520	--	
Toluene	230	1,000	1,000
Xylene, total	--	10,000	10,000
m- and p-Xylene	21	--	
o-Xylene	21	--	

MW-04	2000	2002	2004	2005
1,2-Dichlorobenzene	3	4.5	3.9	NA
1,2-Dichloroethane	1 U	4.9	0.59	NA
Acetone	12	5 U	5 U	NA
Benzene	2	0.72 J	0.21 J	NA
Chlorobenzene	1 U	1.4	0.9	NA
Methyl-tert-butyl ether (MTBE)	NA	NA	234	NA
Methylcyclohexane	NA	NA	0.61	NA
Xylene, total	0.9 J	1 U	2 U	NA
m- and p-Xylene	0.9 J	NA	NA	NA

MW-01	1998	2000	2002	2004	2005
1,2-Dichlorobenzene	NA	NS-FP	NS-FP	4.6	NS-FP
Benzene	17	NS-FP	NS-FP	4.1	NS-FP
Chlorobenzene	NA	NS-FP	NS-FP	0.69	NS-FP
Cyclohexane	NA	NS-FP	NS-FP	1.3	NS-FP
Ethylbenzene	5 U	NS-FP	NS-FP	10.9	NS-FP
Isopropylbenzene	NA	NS-FP	NS-FP	6.3	NS-FP
Methyl-tert-butyl ether (MTBE)	NA	NS-FP	NS-FP	260	NS-FP
Methylcyclohexane	NA	NS-FP	NS-FP	2.9	NS-FP
Toluene	5 U	NS-FP	NS-FP	0.3 J	NS-FP
Xylene, total	15 U	NS-FP	NS-FP	26.2	NS-FP

MW-02	1998	2000	2002	2004	2005
Chloroform	NA	1 U	1 U	0.74	NA

MW-07	2002	2004	2005
Chloroform	0.39 J	0.3 J	NA

MW-08	2003	2004	2005
Chloroform	0.49 J	1.2	NA

MW-06	2000	2002	2004	2005
Acetone	10	5 U	5 U	NA

MW-05	2000	2002	2004	2005
1,2-Dichlorobenzene	4	NS-FP	3.8	NS-FP
1,2-Dichloroethane	32	NS-FP	7.2	NS-FP
Benzene	6	NS-FP	1.2 J	NS-FP
Chlorobenzene	1 U	NS-FP	1.1	NS-FP
Cyclohexane	NA	NS-FP	0.31 J	NS-FP
Ethylbenzene	0.9 J	NS-FP	0.71 J	NS-FP
Isopropylbenzene	NA	NS-FP	0.22 J	NS-FP
Methyl-tert-butyl ether (MTBE)	NA	NS-FP	1,220	NS-FP
Methylcyclohexane	NA	NS-FP	0.75 J	NS-FP
Toluene	0.3 J	NS-FP	0.21 J	NS-FP
Xylene, total	20	NS-FP	1.8 J	NS-FP
m- and p-Xylene	17	NS-FP	NA	NS-FP
o-Xylene	3	NS-FP	NA	NS-FP

MW-03	1998	2000	2002	2004	2005
Chloroform	NA	1 U	1 U	1.4	NA



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed During the Site Characterization
- Monitoring Well Installed During the PA/SI
- Monitoring Well Installed During the RI

Exceeds HHRA Criteria
Exceeds HHRA and MCL Criteria
Exceeds HHRA, MCL and PREQB UST Corrective Action Criteria

- J Estimated result
- U Analyte not detected
- NA Not analyzed / Not applicable
- NS-FP Not sampled due to free product
- All constituent concentrations in µg/L

ASPHALT ACCESS ROAD

FORMER UNDERGROUND PIPING
APPROXIMATE LIMITS OF THE FORMER UST EXCAVATION

VEHICLE RAMP
SERVICE PLATFORM RAMP

CHAIN LINK FENCE

GRASS

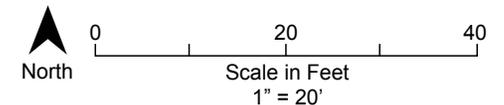


FIGURE 4-9
VOC Detections and Exceedances
in Groundwater
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	Vieques HHRA GW	MCL - GW
Semi-volatile Organic Compounds		
2-Methylnaphthalene	2.4	--
Acenaphthene	37	--
Acetophenone	61	--
Anthracene	180	--
Butylbenzylphthalate	730	--
Caprolactam	1,800	--
Di-n-butylphthalate	360	--
Dibenz(a,h)anthracene	0.0092	--
Diethylphthalate	2,900	--
Fluorene	24	--
Indeno(1,2,3-cd)pyrene	0.092	--
Naphthalene	0.62	--
Phenanthrene	18	--
Pyrene	18	--
benzo(b,k)fluoranthene	--	--
bis(2-Ethylhexyl)phthalate	4.8	6

MW-04	2000	2002	2004	2005
Acenaphthene	5 U	0.55 J	5.1 U	NA
Diethylphthalate	0.6 J	5.4 U	5.1 U	NA

APPROXIMATE LIMITS OF THE FORMER UST EXCAVATION

MW-01	1998	2000	2002	2004	2005
2-Methylnaphthalene	NA	NS-FP	NS-FP	12	NS-FP
Acetophenone	NA	NS-FP	NS-FP	8.1	NS-FP
Naphthalene	NA	NS-FP	NS-FP	9.5	NS-FP

MW-02	1998	2000	2002	2004	2005
bis(2-Ethylhexyl)phthalate	NA	1 J	5.4 U	10.6 U	NA

MW-07	2002	2004	2005
Caprolactam	NA	6.8	NA

MW-08	2003	2004	2005
Di-n-butylphthalate	0.49 J	5.2 U	NA

MW-05	2000	2002	2004	2005
2-Methylnaphthalene	14	NS-FP	5.2 U	NS-FP
Butylbenzylphthalate	0.4 J	NS-FP	5.2 U	NS-FP
Caprolactam	NA	NS-FP	33 J	NS-FP
Fluorene	0.5 J	NS-FP	5.2 U	NS-FP
Naphthalene	15	NS-FP	5.2 U	NS-FP
Phenanthrene	0.6 J	NS-FP	5.2 U	NS-FP

MW-03	1998	2000	2002	2004	2005
Caprolactam	NA	NA	NA	4.5 J	NA
Di-n-butylphthalate	NA	2 J	5.6 U	5.3 U	NA
bis(2-Ethylhexyl)phthalate	NA	5 J	5.6 U	10.5 U	NA



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed During the Site Characterization
- Monitoring Well Installed During the PA/SI
- Monitoring Well Installed During the RI

Exceeds HHRA Criteria

- J Estimated result
- U Analyte not detected
- NA Not analyzed / Not applicable
- NS-FP Not sampled due to free product
- All constituent concentrations in µg/L

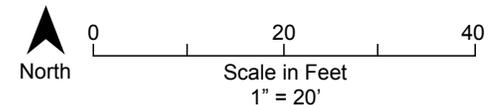
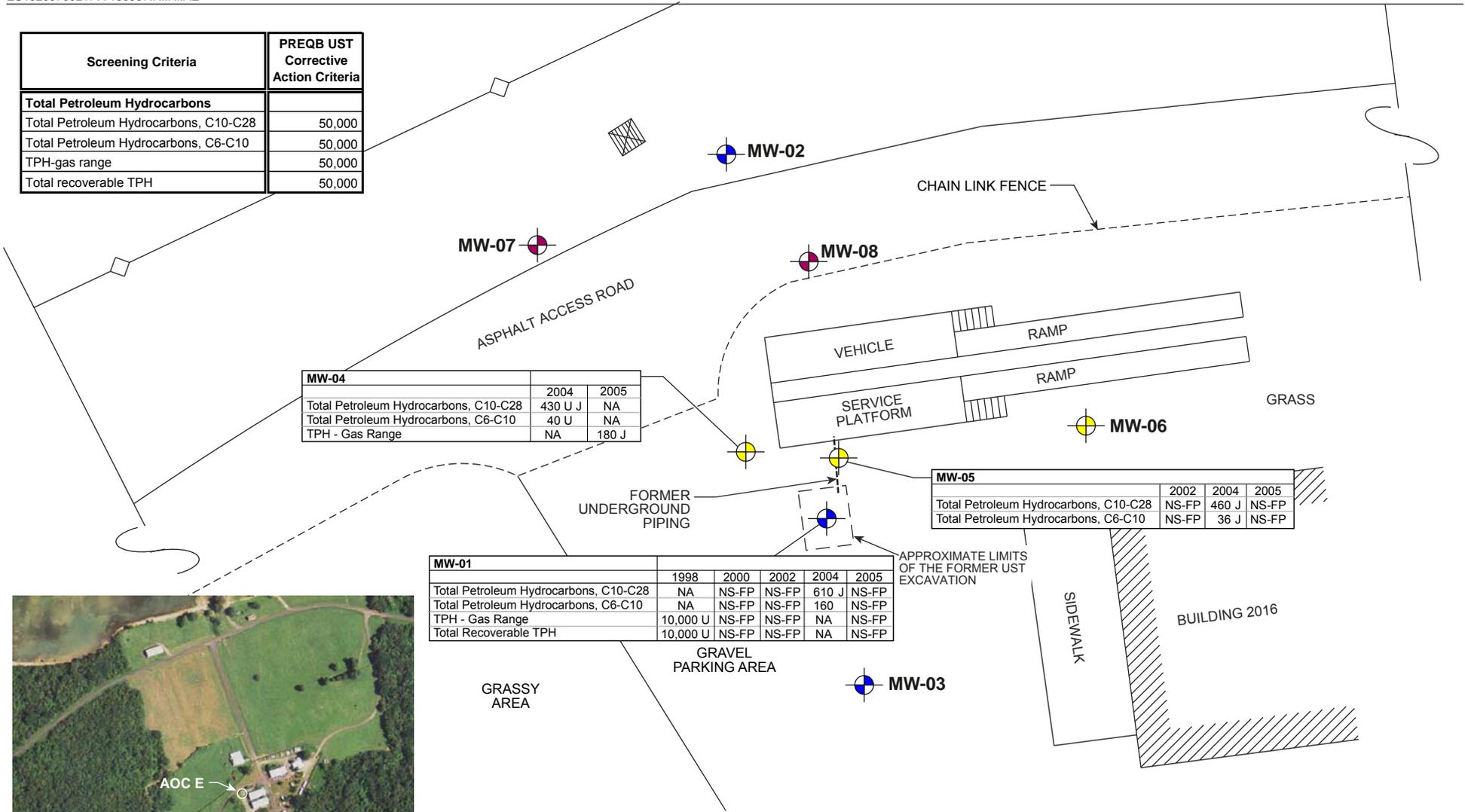


FIGURE 4-10
SVOC Detections and Exceedances
in Groundwater
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening Criteria	PREQB UST Corrective Action Criteria
Total Petroleum Hydrocarbons	
Total Petroleum Hydrocarbons, C10-C28	50,000
Total Petroleum Hydrocarbons, C6-C10	50,000
TPH-gas range	50,000
Total recoverable TPH	50,000



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed During the Site Characterization
- Monitoring Well Installed During the PA/SI
- Monitoring Well Installed During the RI
- J Estimated result
- U Analyte not detected
- UJ Analyte not detected, result may be estimated
- NA Not analyzed / Not applicable
- NS-FP Not sampled due to free product
- All constituent concentrations in µg/L

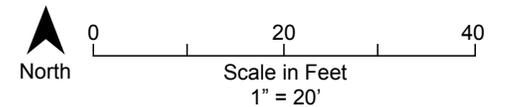


FIGURE 4-11
TPH Detections and Exceedances in
Groundwater
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Screening	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	MW - 03 Background 04/05/00	MW - 03 Background 05/21/02	MW - 03 Background 08/25/04
Dissolved Metals						
Antimony	1.5	6		1.4 U	2.8 U	2.5 U
Arsenic	0.045	10		3.4 U	1.9 J	11.3 J
Manganese	88	--		394	37.9	26.8
Nickel	73	--		1.6 J	3.2 U	212 J
Thallium	0.24	2		2.7 U	5 J	0.23 UJ
Vanadium	3.6	--		15.8 J	11.1 J	12.5 J

MW-07	2002	2004
Dissolved Metals		
Antimony	2.8 U	3.25 J
Arsenic	0.88 U	12.5 J
Vanadium	10.9 J	17.8 J

MW-02	2000	2002	2004
Dissolved Metals			
Arsenic	3.4 U	1.9 J	16.5
Nickel	0.8 U	3.2 U	343 J
Thallium	2.7 U	5.8 J	0.23 U
Vanadium	10.8 J	12.9 J	13.7 J

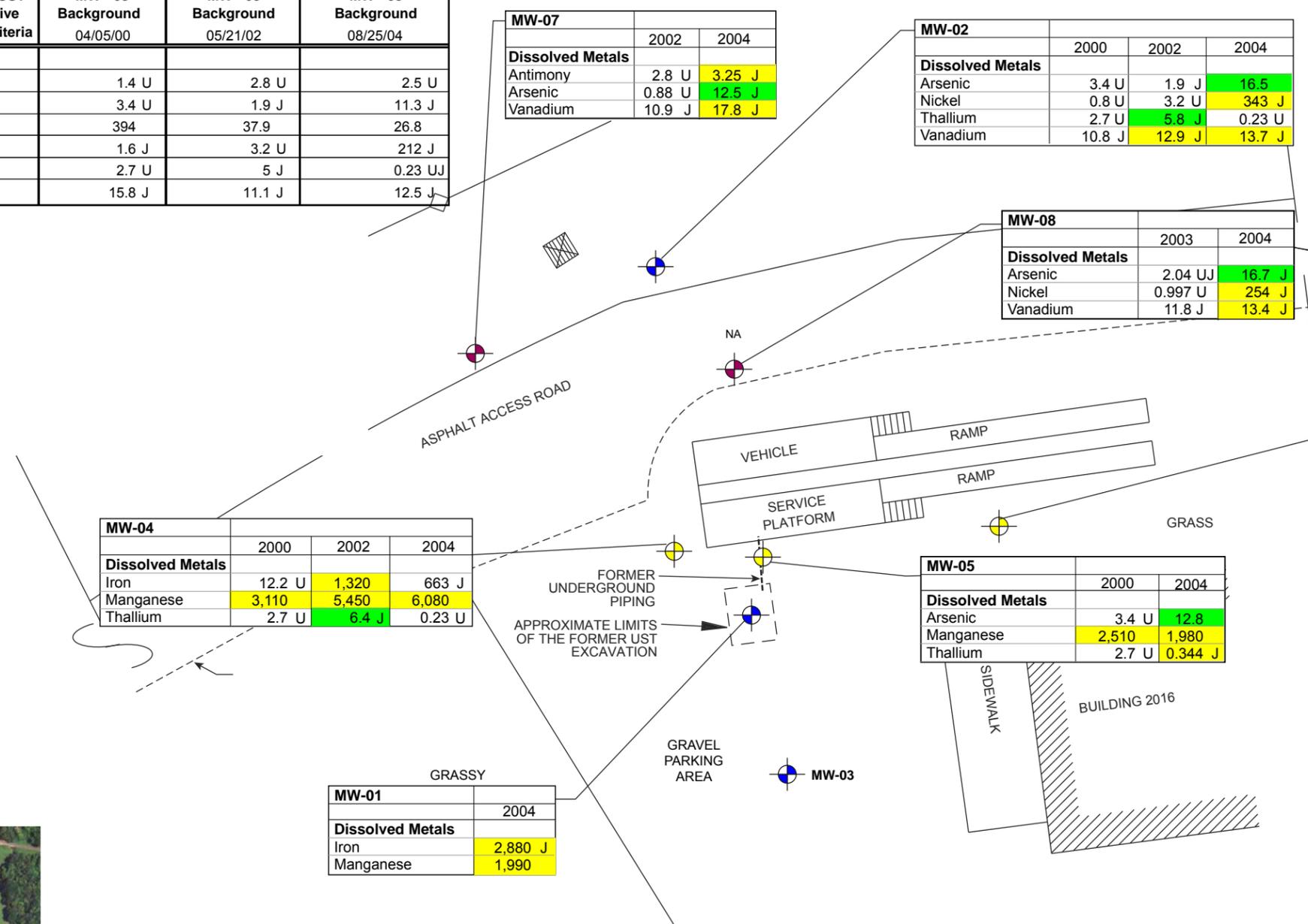
MW-08	2003	2004
Dissolved Metals		
Arsenic	2.04 UJ	16.7 J
Nickel	0.997 U	254 J
Vanadium	11.8 J	13.4 J

MW-06	2000	2002	2004
Dissolved Metals			
Arsenic	3.4 U	0.88 U	16.2 J
Nickel	6.1 J	3.2 U	276 J
Vanadium	15.4 J	15.1 J	14.8 J

MW-04	2000	2002	2004
Dissolved Metals			
Iron	12.2 U	1,320	663 J
Manganese	3,110	5,450	6,080
Thallium	2.7 U	6.4 J	0.23 U

MW-05	2000	2004
Dissolved Metals		
Arsenic	3.4 U	12.8
Manganese	2,510	1,980
Thallium	2.7 U	0.344 J

MW-01	2004
Dissolved Metals	
Iron	2,880 J
Manganese	1,990



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed During the Site Characterization
- Monitoring Well Installed During the PA/SI
- Monitoring Well Installed During the RI

- Exceeds Background andr HHRA Criteria
- Exceeds Background, HHRA and MCL Criteria

- J Estimated result
 - U Analyte not detected
 - NA Not analyzed / Not applicable
- All constituent concentrations in µg/kg

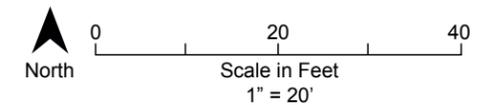


FIGURE 4-12
Dissolved Inorganic Exceedances in Groundwater
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Screening Criteria	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	Background		
				AOC-E-MW03	AOCE-MW-03	NDAEMW03
				NDA029	GWMW03-R01	NDAEGW03-R01
				04/05/00	05/21/02	08/25/04
Chemical Name						
Total Metals (µg/L)						
Aluminum	3,600	--	--	24,000	72.6 J	45.8 J
Antimony	1.5	6	--	1.4 U	2.8 U	2.5 U
Arsenic	0.045	10	--	3.4 U	1.3 J	8.91 J
Barium	730	2,000	--	248	118 J	127 J
Cadmium	1.8	5	--	0.2 U	0.42 U	5.51
Chromium	11	100	--	50.7	2 J	1.3 U
Cobalt	73	--	--	23.6 J	0.93 J	0.76 U
Copper	150	1,300	--	85.3	7.2 J	3.31 J
Iron	1,100	--	--	39,300	29 UJ	48.6 J
Manganese	88	--	--	1,500	40.9	33.8
Nickel	73	--	--	21.7 J	3.2 U	216 J
Thallium	0.24	2	--	2.7 U	4.6 J	0.23 UJ
Vanadium	3.6	--	--	120	11.7 J	12.6 J

MW-07	2002	2004
Total Metals (µg/L)		
Arsenic	0.88 U	10.1 J
Manganese	111	5.92 J
Vanadium	14.2 J	17.1 J

MW-02	2000	2002	2004
Total Metals (µg/L)			
Aluminum	106,000 J	1,890 J	212
Antimony	5.6 U	2.7 U	2.5 U
Arsenic	3.4	1 J	15.2
Barium	826 U	111 J	115 J
Chromium	110	4.3 J	3.98 J
Cobalt	118	2 J	0.76 U
Copper	247	8.5 J	1.34 J
Iron	180,000	2,310 J	332 J
Manganese	6,490	79.4	12 J
Vanadium	489	20.3 J	13.9 J

MW-08	2003	2004
Total Metals (µg/L)		
Arsenic	2.4 UJ	15 J
Vanadium	31.4 J	13.9 J

MW-06	2000	2002	2004
Total Metals (µg/L)			
Arsenic	3.4 U	2.1 J	13.7 J
Cadmium	0.2	0.48 J	7.2
Chromium	10	14	4.17 J
Iron	2,020	2,730 J	290 J
Manganese	65.2	101	20
Thallium	2.7 U	6.6 J	0.23 U
Vanadium	22 J	22.3 J	15.2 J

MW-04	2000	2002	2004
Total Metals (µg/L)			
Aluminum	66,000 J	38,600 J	195 J
Antimony	2.2 J	2.8 U	2.5 U
Arsenic	3.4 U	3.2 J	10.5
Chromium	141	59.2	28
Iron	66,000	32,100 J	2,420
Manganese	3,890	6,410	5,810
Nickel	87.7	37.4 J	25 J
Thallium	2.7 U	5.2 J	0.23 U
Vanadium	175	90.3	1.1 U

MW-05	2000	2004
Total Metals (µg/L)		
Antimony	1.9 J	2.5 U
Arsenic	3.5 J	13.6
Iron	13,800	1,600 J
Manganese	3,340	2,020

MW-01	2004
Total Metals (µg/L)	
Arsenic	11.4
Iron	3,190 J
Manganese	1,990

LEGEND

- Monitoring Well Installed During the Site Characterization
- Monitoring Well Installed During the PA/SI
- Monitoring Well Installed During the RI

- Exceeds Background andr HHRA Criteria
- Exceeds Background, HHRA and MCL Criteria

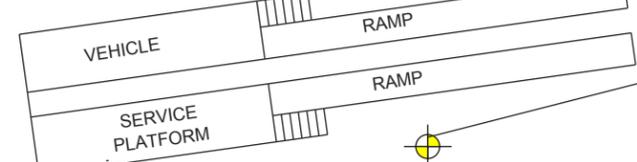
- J Estimated result
 - U Analyte not detected
 - UJ Analyte not detected, result may be estimated
 - Criteria not established
- All constituent concentrations in µg/kg



2004 Aerial Photograph

ASPHALT ACCESS ROAD

NA



FORMER UNDERGROUND PIPING
APPROXIMATE LIMITS OF THE FORMER UST EXCAVATION

GRAVEL PARKING AREA

EWALK

BUILDING 2016

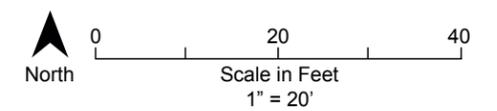
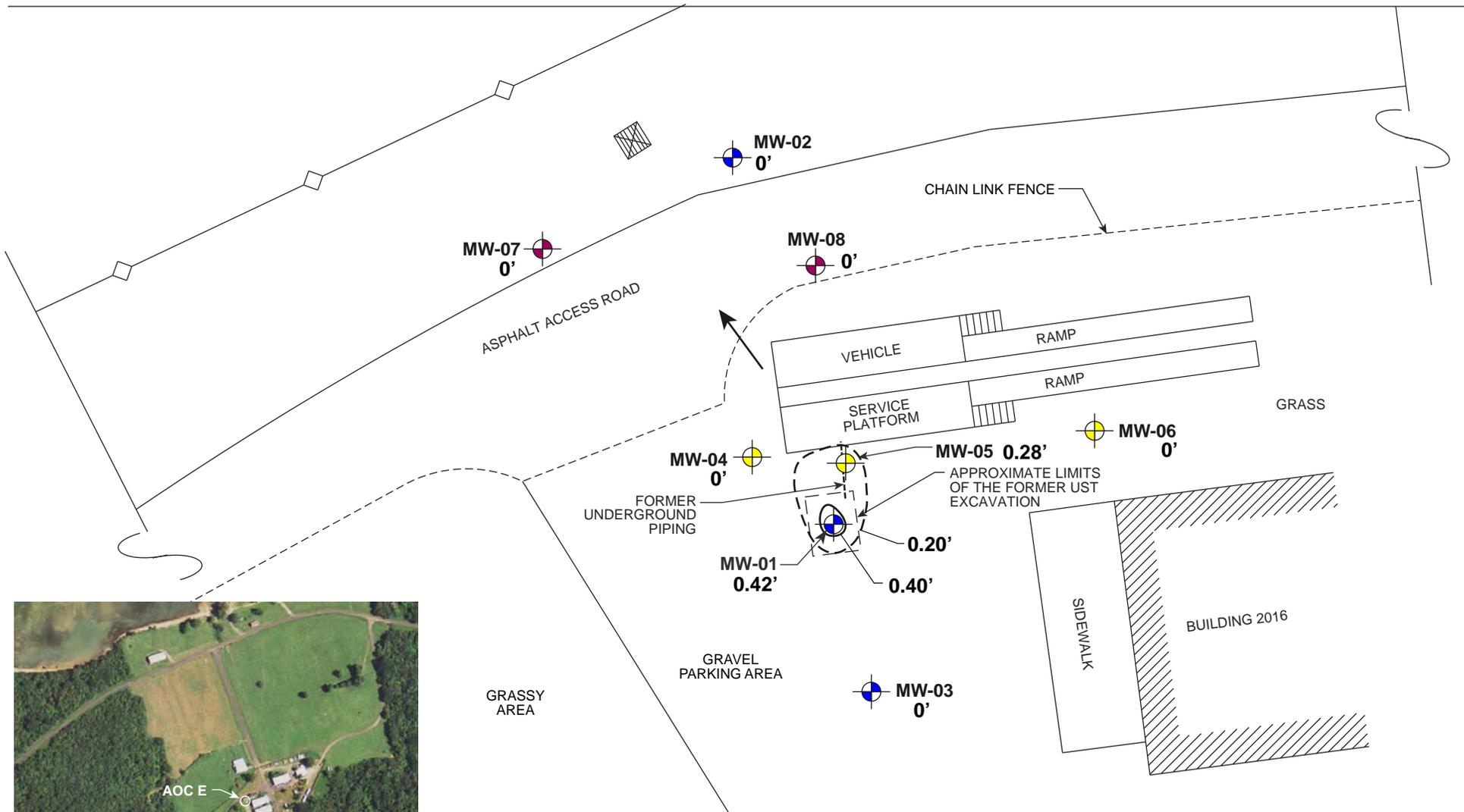


FIGURE 4-13
Total Inorganic Exceedances in Groundwater
AOC E Remedial Investigation Report
Vieques, Puerto Rico



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed during the 1998 Site Characterization
 - Monitoring Well Installed during the 2000 PA/SI
 - Monitoring Well Installed during the 2002 RI
 - Estimated LNAPL Thickness Isopleth
 - Estimated Direction of Groundwater Flow
- Product Thickness Measured on May 31, 2002
0.42' Product Thickness Measured in Feet

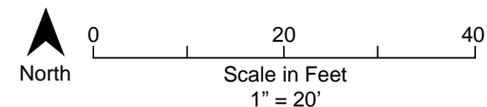
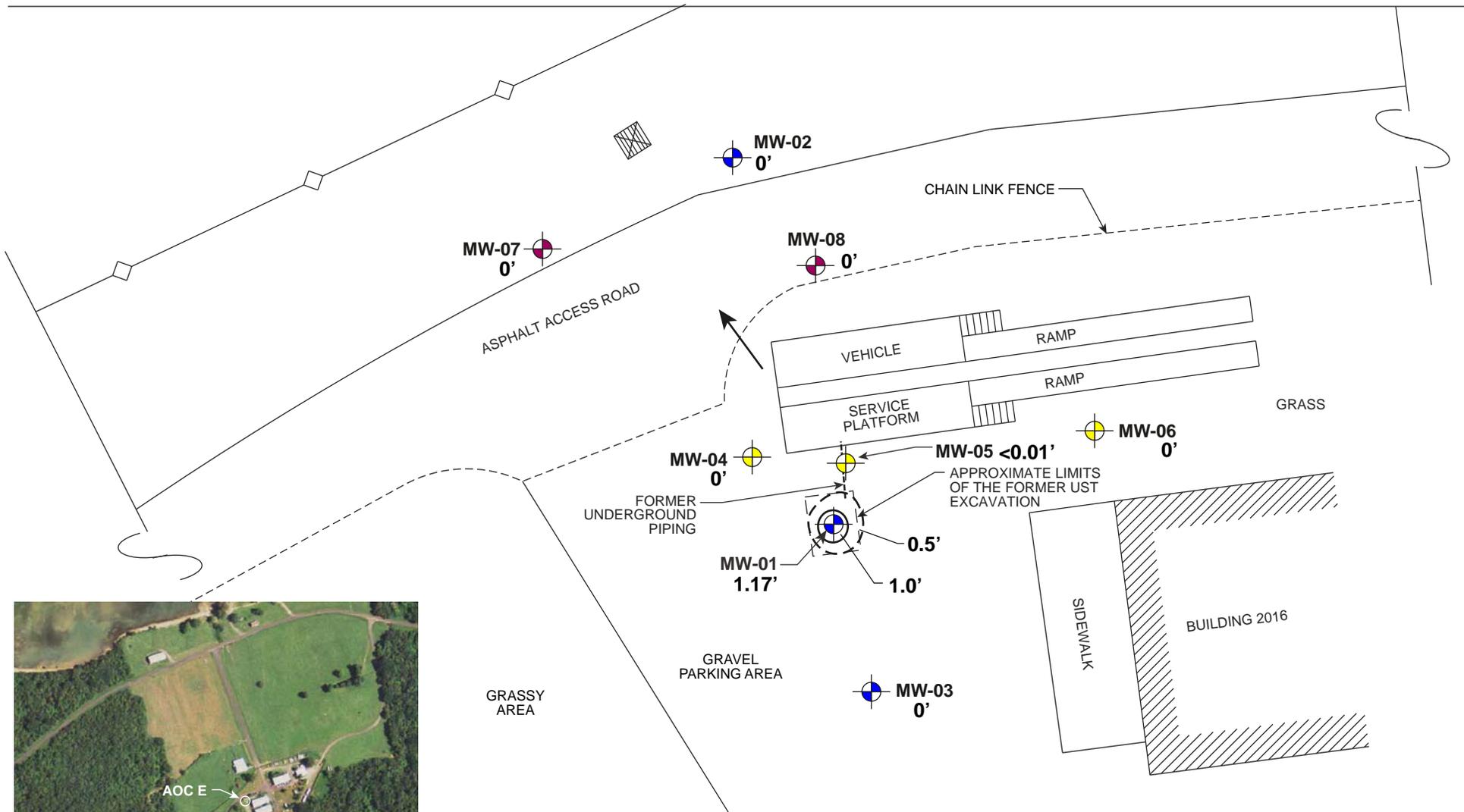


FIGURE 4-14
Extent of LNAPL Prior to MPE Pilot Study
AOC E Remedial Investigation Report
Viques, Puerto Rico



2004 Aerial Photograph

LEGEND

- Monitoring Well Installed during the 1998 Site Characterization
 - Monitoring Well Installed during the 2000 PA/SI
 - Monitoring Well Installed during the 2002 RI
 - Estimated LNAPL Thickness Isopleth
 - Estimated Direction of Groundwater Flow
- Product Thickness Measured on November 30, 2005
1.17' Product Thickness Measured in Feet

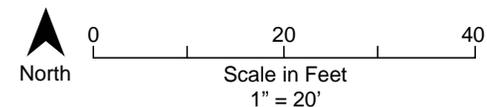


FIGURE 4-15
Extent of LNAPL Post MPE Pilot Study
AOC E Remedial Investigation Report
Viques, Puerto Rico

Contaminant Fate and Transport

This section discusses conceptually the fate and transport of representative contaminants/potential contaminants in soil and groundwater identified in Section 4. This section also presents a Conceptual Site Model (CSM) for AOC E that forms the basis of the contaminant fate and transport evaluation.

5.1 Conceptual Site Model

Key components of the CSM are:

1. **Source of contamination:** The source of contamination at AOC E is the former 500-gallon used oil UST and associated piping between the vehicle maintenance platform and the UST.
2. **Release(s):** The probable release mechanisms were leaks from the tank and piping, as well as possible spills and leaks from the maintenance operations at the site.
3. **Migration Routes:** Based on the extent of contamination identified during the RI, the primary route of contaminant migration is likely vertical leaching from subsurface soil to groundwater and subsequent transport with groundwater flow. However, the saturated zone at the site is a relatively “tight” clay saprolite, which likely restricts groundwater flow and contaminant transport. This supposition is supported by the relatively localized area of free product and groundwater contamination identified at the site. Overland transport of surface contaminants via wind or runoff is not likely an important contaminant migration route because the surficial soil around the tank and piping were excavated during the removal activities and the site topography is flat.
4. **Contaminated Media:** Sampling and analysis conducted at AOC E indicate that petroleum-related organic compounds exist primarily in subsurface soil and groundwater at the site. Free-product has also been detected on the water table. Contamination is generally localized around the immediate area of the former tank and associated piping. Leaching has likely resulted in residual soil contamination from the bottom of the UST/piping excavations to the water table. In addition, groundwater fluctuations between about 15 and 20 ft have been observed at the site. This fluctuation has likely resulted in a “smear zone” of contamination throughout the vertical extent of groundwater fluctuation within the area where LNAPL on the water table is located.
5. **Exposure:** Because contaminated soil was excavated during the UST and associated piping removal, there is little potential for current human and ecological exposures to contaminated soil. Further, there are no current exposure pathways to groundwater at the site because groundwater is not currently used as a potable or other source. Additionally, limited habitat is present at the site due to its developed, maintained nature.

Figure 5-1 graphically depicts the key components of the CSM described above. Based on this conceptual understanding, the fate and transport of the following representative contaminants and potential contaminants at the site are discussed in the remainder of this section.

5.1.1 Volatile Organic Compounds

As noted in Section 4, the VOCs detected at AOC E fall into two categories: solvents and fuel-related constituents. Representative contaminants in each category are as follows:

- Solvents such as 1,2-DCA, 1,2-DCB, chlorobenzene, and MTBE (1,2-DCB and chlorobenzene can also be associated with petroleum products and MTBE is a fuel additive, but they are included with the solvents because they are more similar chemically to a solvent)
- Fuel-related constituents: BTEX

5.1.2 Semivolatile Organic Compounds

SVOCs are all typically associated with fuel and/or oil, and fall into one of three categories:

- Fuel-related PAHs such as 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorene, naphthalene, phenanthrene, and pyrene
- Heterocyclic aromatic hydrocarbons (HAHs): caprolactam and acetophenone
- Hydraulic oil-related phthalates: bis(2-ethylhexyl)phthalate and butylbenzyl-phthalate

5.1.3 Inorganics

As noted in Section 4, the majority of inorganic concentrations detected in surface soil, subsurface soil, and groundwater at AOC E are likely attributable to background. There were six inorganics detected in surface and/or subsurface soil above background UTLs: copper, lead, iron, zinc, silver, and cadmium. Of these inorganics, the concentrations of only three are above screening values: lead, iron, and zinc. As described in Section 4, although various inorganics were detected in groundwater at concentrations greater than the background values in the single background well, none of the inorganic concentrations detected in groundwater is likely attributable to historic site-related releases. However, as a conservative measure, arsenic and manganese are included as potential contaminants, primarily because arsenic is the only dissolved inorganic (not including thallium, whose concentrations are suspect) detected above its MCL and because manganese was detected at higher concentrations in the wells in the vicinity of the former UST and piping than in the other site wells. Based on the above information, the following are considered representative potential contaminants for the purposes of the fate and transport discussion:

- Lead, iron, zinc, arsenic, and manganese

5.2 Fate and Transport Mechanisms

There are four probable fate and transport mechanisms for contaminants at AOC E:

- Volatilization: This mechanism can be an important factor for VOCs, less so for SVOCs, and is not a viable transport mechanism for inorganics.
- Leaching by infiltrating water: Due to the nature of releases (into unsaturated subsurface soil), this mechanism accounts for the presence of site-related contaminants in deeper soils and groundwater at AOC E. Leaching generally occurs through complex, successive sorption to/desorption from soil particles and varies depending on such factors as the contaminant type (e.g., inorganics versus VOCs), soil type (e.g., clay versus sand), organic matter content, and the chemistry of the infiltrating water.
- Transport in groundwater: Once contaminants reach groundwater via leaching, they can be transported downgradient via groundwater flow (advection) or from areas of higher concentration to lower concentration (dispersive mass flux or “dispersion”). While these mechanisms surely exist at AOC E, the rate of migration appears to be very low because of the general absence of contaminants in groundwater monitoring wells downgradient of the former tank and pipeline. Contaminants can also migrate as free-phase product on the water table.
- Transformation and degradation of contaminants in soil and groundwater: Within environmental media, contaminants may be subject to biotic (biological-based) and abiotic (non-biological-based) reactions that transform and degrade them into other constituents.

Each of the above mechanisms is discussed below with respect to representative contaminants.

5.2.1 Volatilization

Volatilization occurs when a constituent transfers to the gas phase (i.e., evaporates). A conventional measure of volatility is Henry’s Law Constant (K_h). Values of K_h for representative volatile and semivolatile contaminants at AOC E are provided in Table 5-1. Inorganics are not volatile under normal temperature and pressure conditions and thus are not included in Table 5-1.

Compounds with higher K_h values volatilize more readily than those with lower K_h values. As shown in Table 5-1, the solvent-related VOCs detected at AOC E tend to be more volatile than the fuel-related VOCs, which, in turn, are more volatile than the SVOCs.

Although many of the contaminants at AOC E have high K_h values (VOCs [and SVOCs to a lesser degree]), volatilization is not likely an important fate and transport mechanism at the site because, in general, contaminants with these high K_h values were only detected at substantial concentrations in groundwater and subsurface soil depth intervals greater than 12 ft bls where volatilization is less likely to occur. Volatilization from soil tends to occur more readily from shallow soil than from deeper soil or groundwater for several reasons. In unsaturated shallow soil, the soil gas pressure generally approximates the ambient air pressure. With depth, the soil gas pressure tends to increase and it becomes more difficult for the gas to escape and equalize with the ambient air pressure. In groundwater, volatilization can occur only at the air/water interface between the saturated and unsaturated zones, and movement of aqueous-phase contaminants from bulk groundwater to the interface is largely diffusion-limited.

5.2.2 Leaching

As noted previously, leaching is one of the primary transport mechanisms at AOC E. The contaminants detected in groundwater are the result of leaching from the subsurface soil around the former tank and piping, through the unsaturated zone, and into groundwater. The degree of leaching of a particular contaminant is primarily a function of the amount of organic matter in the subsurface, the contaminant's water solubility, the amount of the contaminant present, the physical and chemical properties of the matrix through which the contaminant is leaching, and the chemistry of the water infiltrating the soil matrix.

Sorption occurs when a constituent adheres to and becomes associated with solid particles in the formation (sorbed phase). The subsurface materials likely to sorb chemicals typically are clays and organic matter. In addition, some inorganics such as arsenic, can sorb to iron oxyhydroxide or oxide coatings on soil grains. The soil borings collected at AOC E indicate the unconsolidated material consists of approximately 10 to 15 ft of clay underlain by silty sand to a depth of approximately 25 to 30 ft bls, at which point a predominantly clay saprolite with weathered rock fragments is encountered.

The conventional measure of sorption is the distribution coefficient (K_d). The K_d for organic chemicals is the product of the soil organic carbon partition coefficient (K_{oc}) of the chemical and the fraction of organic carbon (f_{oc}) in the soil. In general, higher K_{oc} values indicate a greater degree of sorption and lower chemical mobility. The K_d for inorganic chemicals is a complex function of pH, organic content, oxide coatings, and other factors; therefore, K_d is not easily estimated by methods other than site-specific testing. For VOCs and SVOCs detected in AOC E media, the ranges of K_{oc} values are shown in Table 5-1. Other factors being equal (e.g., f_{oc}), the values indicate that SVOCs have a higher affinity for sorbing onto organic matter than do VOCs.

Solubility is a measure of the degree to which a constituent will dissolve in water, which is the transporting medium for the leaching process. It is noted here that leaching of LNAPLs or dense non-aqueous phase liquids (DNAPLs) can occur in the absence of infiltrating water. LNAPL has been detected at AOC E in wells around the former UST and associated piping. Therefore, leaching at this location may be ongoing, even in the absence of rainfall.

Solubilities of site contaminants in pure water (pH =7) are shown on Table 5-1. VOCs tend to have higher solubilities than SVOCs, but both VOCs and SVOCs have a broad range of solubilities. VOCs toward the lower end of the solubility range are the dichlorobenzenes and cyclohexanes, while VOCs with relatively high solubilities include acetone and chloroform. SVOCs toward the lower end of the solubility range include most of the PAHs. More than half of the PAHs have solubilities of 10^1 or less. The SVOCs detected at the highest concentrations in groundwater at AOC E (naphthalene and 2-methylnaphthalene) have relatively high solubilities in the 10^2 range, while many constituents detected in free product and soils but not in groundwater, such as fluoranthene and chrysene, have lower aqueous solubilities in the 10^{-1} to 10^{-3} range. This indicates that aqueous solubility is a major factor contributing to the likelihood of contaminants at AOC E to leach into groundwater from contaminated soil and from free product on the water table.

Other factors, such as organic matter content and the physical and chemical properties of the matrix, also control leaching. The solubilities of inorganics are not included in Table 5-1 because they are highly dependent on their oxidation state, which, in turn, is dependent on

the reduction-oxidation (redox) conditions and/or pH of the subsurface environment in addition to the chemical characteristics of the infiltrating water. Under most environmental conditions, constituents such as lead and zinc are expected to be relatively immobile in soil.

Only three metals were detected in AOC E soil at concentrations greater than background and screening values: iron, lead, and zinc. Iron tends to be less mobile at high pH conditions (Gerritse *et. al.*, 1982). Samples have not been collected for pH in soil at AOC E; however, at a nearby site, AOC I, samples were collected and the pH of the soil was generally alkaline. Assuming similar conditions at AOC E, iron will likely be adsorbed onto soil particles and remain relatively immobile. The same is true for lead (ATSDR, 1997) and zinc (<http://www.lenntech.com/elements-and-water/zinc-and-water.htm>). Lead and zinc were not detected in groundwater at elevated concentrations. Dissolved iron was detected in two wells (MW-01 and MW-04, both of which are located in the vicinity of the former UST and associated piping) at concentrations exceeding background and screening values. While it is possible this iron was directly released from the UST/piping, naturally occurring iron may be mobilized under certain geochemical conditions, including lower pH and lower ORP and DO. Groundwater samples collected from MW-01 and MW-04 had slightly acidic pHs during the rounds in which iron was detected at concentrations exceeding screening values. The pH may also be more acidic in soils collected close to the soil/water table interface, which could mobilize naturally occurring iron.

As noted previously, leaching is controlled by many chemical-specific and site-specific factors, so the information presented above regarding constituent leaching should be considered qualitative generalizations, not quantitative predictors of contaminant fate, especially considering the complex nature of the media at AOC E.

5.2.3 Groundwater Transport

Once in groundwater, contaminants typically will not move as rapidly as groundwater because of adsorption of the contaminant to the solid media. This process, known as retardation, is chemical-specific. Retardation of any particular chemical is influenced by the interactions between the many chemical species present and the solid surfaces of the porous media. The degree of retardation depends upon any factor strongly affecting chemistry (e.g., temperature, pH, redox potential, salinity, organic content, and concentrations of other chemical species). Consequently, rates of retardation are not easily estimated.

Contaminants in groundwater are moved through advection and dispersion. Advection is the transport of dissolved contaminants by the bulk motion of flowing groundwater. It is the primary transport mechanism for dissolved contamination along the hydraulic gradient. Advective contaminant transport is a function of the groundwater flow, as modified by the retardation factor of the specific contaminant. Dispersion is the spreading of dissolved contaminants from the path they would be expected to follow during advection. It results from the spatial variation in aquifer permeability, fluid mixing, and molecular diffusion. Dispersion primarily controls the concentration of the contaminant at any point in the flow system.

At AOC E, groundwater data suggest that there has been very little transport of contaminants downgradient of the former tank area. The clay soils located around the water table may be contributing to retarding the advective flow of the constituents.

5.2.4 Transformation and Degradation

Transformation and degradation are also likely to be significant factors in the fate and transport of contaminants at AOC E.

Transformation

Transformation of metals occurs when the valence state and/or species is changed due to changes in redox potential and/or pH. Transformation may have a significant effect on the mobility of metals.

Essentially all lead and zinc released to soil from anthropogenic sources is transformed by biotic and abiotic processes to adsorbed forms in soil. This transformation primarily comprises formation of lead and zinc complexes on clay minerals, organic matter, and hydrous iron oxides (ATSDR, 1997; A. Manceau et al., 2000). Therefore, if lead or zinc was released by historic activities at AOC E, they would likely be primarily bound in the soil. The groundwater data for the site tend to support this as the lead and zinc concentrations in groundwater are comparable to background.

Naturally occurring iron, arsenic, and manganese are typically found as a part of ferric iron oxyhydroxide and manganese oxide minerals in systems with high redox potentials, but can be released to groundwater in systems with lower redox potential. Dissolved iron was detected at a concentration greater than background and the adjusted tap water PRG in only one well (MW-01) during the most recent sampling event (2004). The concentration in this well was 2,880 µg/L. Arsenic was detected at concentrations greater than screening values in a number of wells during the most recent event, but was detected at much lower concentrations in most wells during previous rounds. At AOC E, ORP and DO data generally indicate slightly reducing to highly oxidizing conditions that are not consistent with geochemical conditions favorable for dissolution of naturally occurring arsenic, iron, and manganese from soils. Groundwater pHs are, however, slightly acidic, which is favorable for mobility of these metals. With the exception of iron, these metals were not detected at elevated concentrations in soils (relative to background) at the site and, therefore, cannot be clearly attributed to the tank release; therefore, they could be related to normal site geochemistry.

Degradation of Organic Compounds

Degradation is the transformation of a chemical either biologically (biodegradation) or abiotically through such processes as hydrolysis and photolysis. Biodegradation occurs when microorganisms transform a chemical as part of their metabolic processes. Hydrolysis is the reaction of a chemical with water and photolysis is the result of exposing the chemical to light. Degradation of organic compounds detected at concentrations greater than background and one or more screening values are described below.

1,1-DCA

1,2-DCA was detected in AOC E groundwater in locations in the vicinity of the former tank. 1,2-DCA is capable of degrading via a series of bacterial hydrolytic dehalogenation reactions facilitated by the aerobic species *Xanthobacter autotrophicus*, which uses the end product, glycolate, as an energy source. The degradation pathway for 1,2-DCA is shown below:

1,2-DCA → 2-chloroethanol → chloroacetaldehyde → chloroacetic acid → glycolate

Groundwater conditions are generally oxidizing at AOC E, which is favorable for this type of degradation.

MTBE

While a number of microorganisms are known to metabolize MTBE under aerobic conditions, not much is known about the mechanism of degradation. Based on the model proposed by Smith (2003), MTBE is converted through a series of complex reactions to *tert*-butyl formate, which is then hydrolyzed to *tert*-butyl alcohol and formate. Organisms known to complete this reaction include *Nocardia* sp. and various strains of *Mycobacterium*.

Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) and Chlorobenzenes

Benzene, toluene, ethylbenzene, xylenes, and chlorobenzenes are present in groundwater and soils at AOC E. Benzene is the only one of the BTEX compounds detected at a concentration greater than the tap water PRG in groundwater, but all of the BTEX components, with the exception of toluene, exceed screening values in soil. BTEX constituents generally degrade under aerobic conditions to catechol (benzene only), methylcatechols (toluene and xylenes), or ethylcatechols (ethylbenzene only), which can be further degraded into organic fatty acids. The oxidizing conditions at AOC E are favorable for this degradation pathway. Chlorobenzenes are also degraded by a very similar process, which results in catechols and ultimately fatty acids.

PAHs Including Naphthalene and 2-Methylnaphthalene

PAHs are generally degraded by microbes that produce enzymes that allow for oxygenation of these compounds. The aromatic compounds detected at concentrations exceeding screening values at AOC E, naphthalene and 2-methylnaphthalene, degrade readily under aerobic conditions via a number of complex reactions facilitated by various bacteria, which result in degradation of these compounds to salicytic compounds and catechols. These chemicals can be further degraded into organic fatty acids. These reactions are usually initiated in both naphthalene and 2-methylnaphthalene by varieties of the *Pseudomonas* bacteria, which can produce an enzyme called "naphthalene dioxygenase." These compounds have not been shown to degrade under anaerobic conditions.

Phthalates

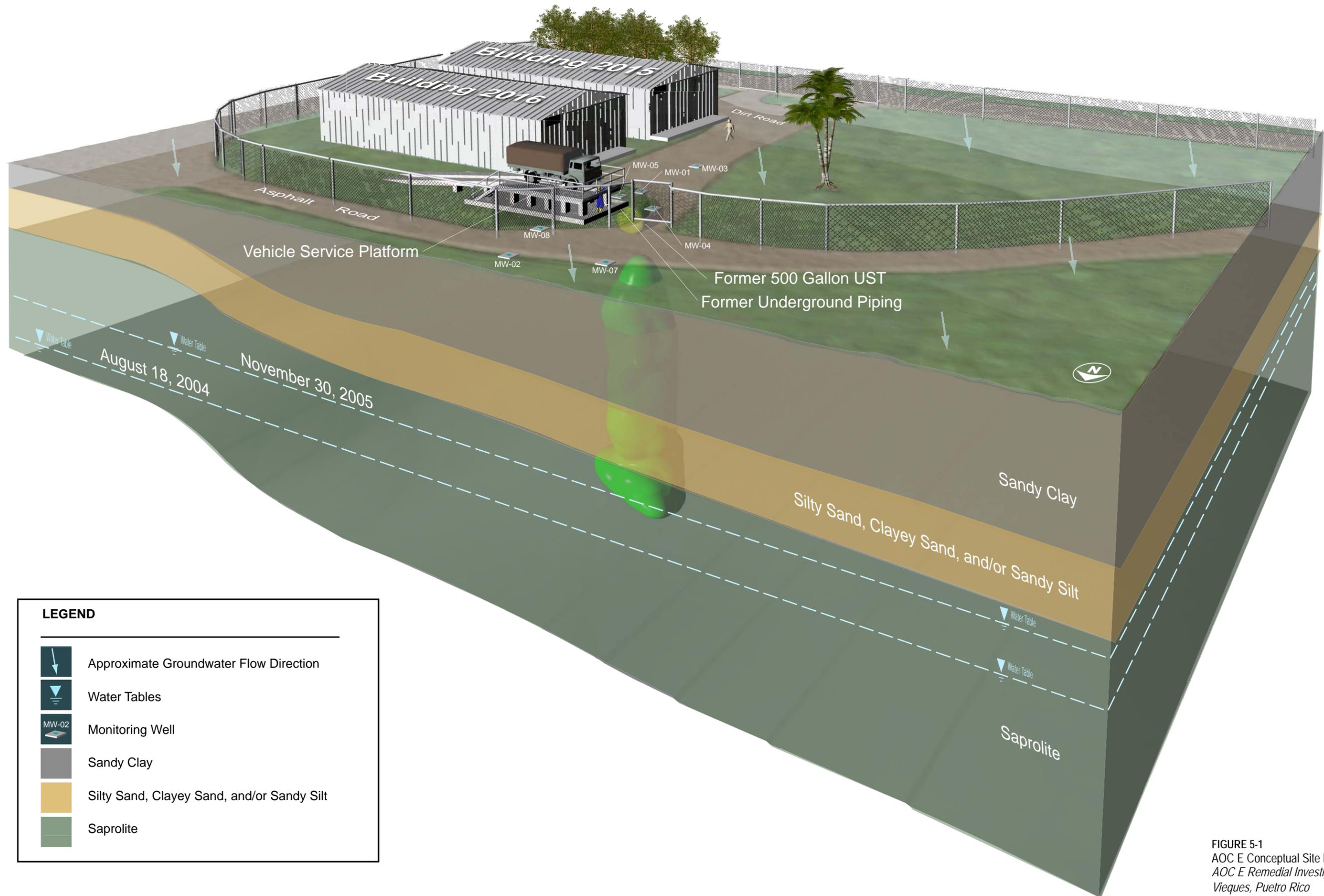
Phthalates have been shown to be resistant to bacterial degradation in nature. However, only one detection of bis(2-ethylhexyl)phthalate, during the 2000 sampling event, exceeds a screening value. Further, this detection is likely attributable to laboratory contamination.

Petroleum Hydrocarbons

TPH can be degraded by numerous organisms under aerobic conditions. These organisms consume the TPH as a food source and respire oxygen.

TABLE 5-1
 Physical Properties of VOCs and
 SVOCs Detected at AOC E
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Contaminant Type	Representative Contaminants	Henry's Law Constant (atm-m ³ /mole)	Solubility (µg/L)	K _{oc}
VOCs				
Solvents	1,1-dichloroethene, 1,2-dichlorobenzene, acetone, chloroform, cyclohexane, methylcyclohexane, isopropylbenzene, MTBE	10 ⁻³ to 10 ⁻¹	10 ⁴ to 10 ⁸	10 ⁻¹ to 10 ³
Fuel Constituents	benzene, ethylbenzene, toluene, xylene	10 ⁻³	10 ⁵ to 10 ⁶	10 ¹ to 10 ²
SVOCs				
Fuel-related PAHs ¹	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorene, naphthalene, phenanthrene, pyrene	10 ⁻⁴ to 10 ⁻⁷	10 ⁻¹ to 10 ⁴	10 ³ to 10 ⁷
HAHs ²	caprolactam, acetophenone	10 ⁻⁵ to 10 ⁻⁸	10 ³	10 ³
Hydraulic Oil Phthalate	bis(2-ethylhexyl)phthalate, butylbenzyl-phthalate	10 ⁻⁵	10 ²	10 ⁴
<p>Notes</p> <p>¹PAH = polycyclic aromatic hydrocarbon</p> <p>²HAH = heterocyclic aromatic hydrocarbon</p> <p>Sources of Henry's Law Constants:</p> <p>Lide (ed.), 2007</p> <p>Montgomery. 2007</p> <p>TOXNET Hazardous Substances Data Bank</p> <p>Source of Solubilities:</p> <p>Montgomery. 2007</p> <p>Sources of K_{oc} Values:</p> <p>EPA Region IX PRG (EPA, 2004a)</p> <p>EPA Soil Screening Guidance (EPA, 1996)</p> <p>Risk Assistant (Environment Agency, 2003)</p> <p>Gustafson, J., J. Griffith Tell, and D. Orem. 1997.</p>				



LEGEND

-  Approximate Groundwater Flow Direction
-  Water Tables
-  Monitoring Well
-  Sandy Clay
-  Silty Sand, Clayey Sand, and/or Sandy Silt
-  Saprolite

FIGURE 5-1
 AOC E Conceptual Site Model
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Human Health Risk Assessment Summary

A baseline HHRA was conducted for AOC E. The HHRA evaluated potential future health risks (the site is unused) from exposure to site media potentially affected by former operations at the site. The HHRA was conducted in accordance with the protocol in the Final Master QAPP for sites in the Environmental Restoration Program (ERP) (CH2M HILL, 2007), which is consistent with EPA Region II policy and EPA guidance documents, primarily: *Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Parts A, D, and E* (EPA, 1989, 2001, and 2004); *Exposure Factors Handbook* (EPA, 1997), and *Human Health Evaluation Manual, Standard Default Exposure Factors* (EPA, 1991). The complete HHRA is presented in Appendix N of this RI Report. This section summarizes the key components and findings of the HHRA.

6.1 Chemicals of Potential Concern

The soil dataset used in the HHRA consists of soil samples collected during field investigations in May 2002 (RI) and November/ December 2005 (RI). The dataset consists of soil samples collected within the 0- to 6-ft interval, including seven surface soil samples (0 to 2 ft) and five subsurface soil samples (one collected from 2 to 4 ft bls and four collected from 4 to 6 ft bls).

The groundwater dataset used in the HHRA consists of groundwater samples collected during May 2002 and August/September 2004. Groundwater samples were collected from five monitoring wells in 2002 (MW-02 through MW-4, MW-6 and MW-7) and eight monitoring wells in 2004 (MW01 through MW08).

Chemicals of potential concern (COPCs) were identified for soil and groundwater using the screening process presented in the Final Master QAPP HHRA protocol (CH2M HILL, 2007). The screening process resulted in no COPCs being identified for maintenance workers, industrial workers (soil only), or construction workers. However, the following COPCs were identified for the indicated receptors and data groupings:

- **Recreational User/ Resident (Soil; 0 to 2 ft)** – aluminum, arsenic, iron, manganese, and vanadium
- **Resident (Soil; 0 to 6 ft)** – aluminum, arsenic, iron, manganese, and vanadium
- **Resident/Industrial Worker (Groundwater)** – Aluminum, arsenic, cadmium, chromium, iron, manganese, nickel, thallium, vanadium, 1,2-dichloroethane (1,2-DCA), benzene, chloroform, MTBE, xylenes, 2-methylnaphthalene, naphthalene, and dieldrin

6.2 Exposure Evaluation

Potential current and future receptors were evaluated in the HHRA. The only current potential receptor type at AOC E is a maintenance worker, who may conduct grounds

maintenance. As noted in Section 6.1 and in the conceptual model for potential human receptors (Figure 6-1), future receptors evaluated in the HHRA consisted of maintenance workers, industrial workers, construction workers, recreational users (adult, youth, and child) and residents (adult and child).

The potential exposure pathways quantified for future recreators (adult, youth, and child) were:

- Ingestion, dermal contact, and inhalation of surface soil (0 to 2 ft bls)

The potential exposure pathways quantified for hypothetical future residents (child and adult) were:

- Ingestion, dermal contact, and inhalation of surface soil (0 to 2 ft bls) and total soil (0 to 6 ft bls)
- Ingestion and dermal contact with groundwater from hypothetical potable use
- Inhalation of bathroom air (as a result of adult showering and child bathing) from hypothetical tap water use

The potential exposure pathways quantified for future industrial workers were:

- Ingestion and dermal contact with groundwater from hypothetical potable use

6.3 Risk Estimates

EPA's target range for excess lifetime cancer risk (ELCR) associated with CERCLA is 1-in-10,000 (1×10^{-4}) to 1-in-1,000,000 (1×10^{-6}). Similarly, the target non-cancer hazard index (HI) is 1.0 or less. Risk estimates were calculated for receptors and exposure pathways using conservative assumptions for exposure factors and exposure point concentrations. Results of the risk estimates are summarized as follows:

- **Future Recreational Adult/Youth/Child**
 - ELCR $< 1 \times 10^{-6}$ and all target organ-specific HIs < 1
- **Future Residential Adult/Child**
 - Three target organ-specific HIs > 1.0 for an adult (primarily due to aluminum, arsenic, manganese, and thallium in groundwater)
 - Seven target organ-specific HIs > 1.0 for a child (primarily due to aluminum, arsenic, cadmium, manganese, thallium, vanadium, 1,2-DCA, MTBE, xylenes, 2-methylnaphthalene, and naphthalene in groundwater)
 - 3×10^{-4} ELCR (primarily due to 1,2-DCA, dieldrin, and arsenic in groundwater)
- **Future Industrial Worker**

- 6×10^{-5} ELCR (primarily due to dieldrin and arsenic in groundwater) and all target organ-specific HIs < 1

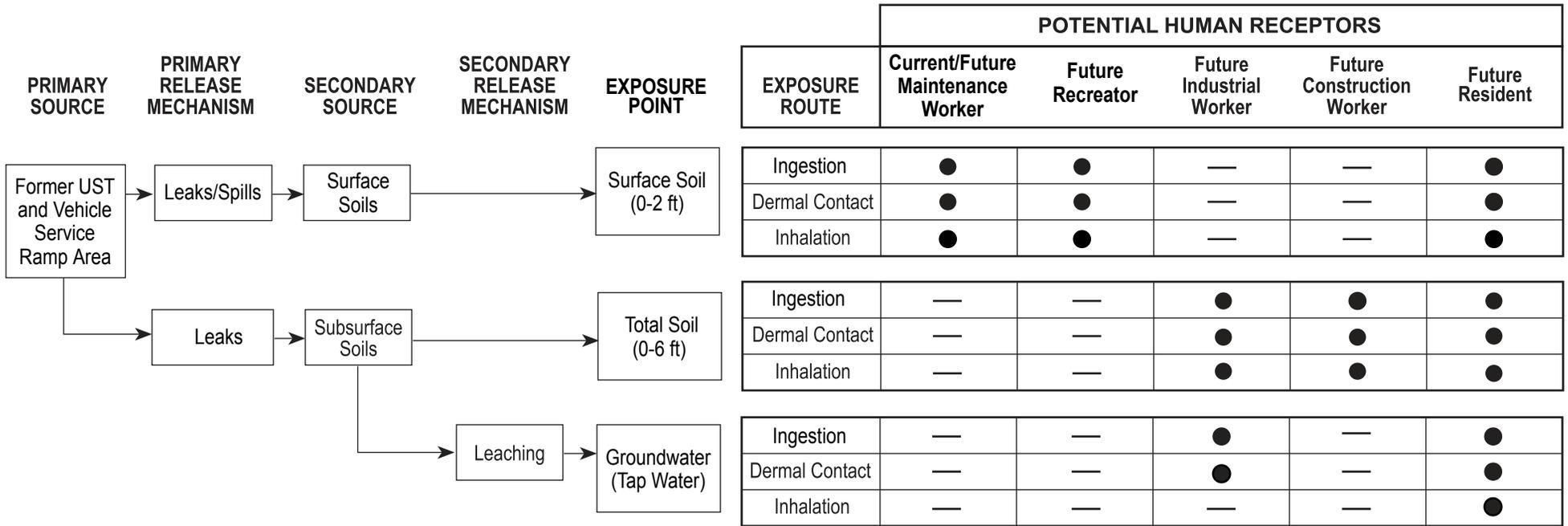
6.4 Chemicals of Concern

Chemicals of concern (COCs) were identified where the ELCR or HI exceeded threshold values (a total ELCR greater than 1×10^{-4} or a target organ-specific HI greater than 1.0). When an ELCR of 1×10^{-4} was exceeded for a receptor, the site-related COPCs posing an individual ELCR greater than 1×10^{-6} in the environmental medium responsible for the unacceptable risks were identified as COCs. When a target organ-specific HI exceeded 1.0 for a receptor, the site-related COPCs posing an individual hazard quotient (HQ) greater than 0.10 for that target organ in the environmental medium responsible for the unacceptable risk were identified as COCs.

The only environmental medium at AOC E exceeding the threshold values for a receptor group was groundwater (assuming hypothetical potable use by residents). It should be noted that although background was not used to eliminate inorganic constituents prior to evaluation in the quantitative risk assessment, background concentrations were considered when identifying COCs following the quantitative risk assessment. Inorganics identified as COPCs that are wholly or primarily attributable to background levels were not identified as COCs. In addition, COPCs attributable to laboratory contamination (i.e., chloroform) or normal pesticide application (i.e., dieldrin) were also not identified as COCs.

Although several inorganics were identified as COPCs and were therefore carried through the quantitative risk assessment, after considering background levels, no inorganic COPCs were identified as COCs in soil for any receptor. Therefore, for hypothetical future residents, the following COCs were identified for groundwater:

- 1,2-DCA, MTBE, xylenes, 2-methylnaphthalene, and naphthalene.



LEGEND

- Potentially Complete Exposure Pathway
- Exposure Pathways for Quantitative Evaluation
- Incomplete Pathways

FIGURE 6-1
Human Health Conceptual Model
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Ecological Risk Assessment Summary

A screening ecological risk assessment (SERA), constituting Steps 1 and 2 of the ERA process, and the first step (Step 3A) of a baseline ecological risk assessment (BERA), were conducted for AOC E. The ERA was conducted to evaluate the potential for adverse effects to the environment at AOC E. The complete ERA is presented in Appendix O of this RI Report. This section summarizes the key components and findings of the ERA.

7.1 ERA Process and Objectives

The ERA was conducted in accordance with the protocol in the Final Master QAPP for sites in the ERP (CH2M HILL, 2007), which is consistent with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999), the Navy guidance for implementing this ERA policy (NAVFAC, 2003), and the EPA *Ecological Risk Assessment Guidance for Superfund* (EPA, 1997b). These guidance documents describe a process consisting of eight steps, of which Steps 1, 2, and 3A were conducted for this ERA. Steps 1 and 2 of the ERA process comprise the SERA, which is conducted using intentionally conservative assumptions. If the results of the SERA indicate that unacceptable risks are possible, the site normally continues on to Step 3A, the first step in the BERA.

The objectives of a SERA are to:

- Determine if potential risks to ecological receptors warrant either: (1) additional assessment beyond the conservative screening steps of the ERA process (unacceptable ecological risks are possible); or (2) the removal of the site from further ecological consideration (no unacceptable ecological risks likely).
- Focus subsequent steps of the ERA process on the specific chemicals, pathways, and receptors of potential concern if unacceptable ecological risks are possible.
- Identify any data gaps or areas of unacceptable uncertainty that may require the collection of additional data to support ERA evaluations beyond the screening level.

The general objectives of a Step 3 ERA are to:

- Refine the risk estimates from the SERA to determine if risks to ecological receptors from site-related chemicals are likely to be unacceptable based upon realistic exposure scenarios.
- Focus subsequent data collection activities if potentially unacceptable risks are indicated, uncertainties are unacceptably high, and/or data gaps are identified.

7.2 Environmental Setting

AOC E is a former used oil UST located near the northwestern corner of Building 2016 (the former vehicle maintenance and transportation shop) within the 21.7-acre main operational area of the Former NASD. Surface water bodies are not present at AOC E or the immediate surrounding area. Terrestrial habitat is limited to groundcover vegetation that surrounds the existing vehicle maintenance platform and concrete ramp. The vegetated area is small (approximately 40 by 100 ft), and is closely bound by paved roads to the north and east, Building 2016 to the south, and a dirt driveway immediately west. Similar groundcover vegetation occurs west of the maintenance platform and dirt driveway, within the fence that surrounds AOC E, as well as beyond the fence line in all directions. These areas are beyond the potential surface soil influence of activities at the former UST.

A site-specific survey of the ecology at AOC E has not been conducted; however, information is available from an ecological survey of nearby AOCs (e.g., AOC H, AOC L), as well as from CH2M HILL ecologists who have visited the site several times. The AOC E area is mostly devoid of natural resource systems due to historical and ongoing maintenance activities that involved building/road construction and periodic maintenance of vegetation (e.g., mowing). AOC E is a significant distance from any of the established conservation zones and wildlife landing and nesting areas. A variety of bird species, insects, and small invertebrates do periodically utilize the area around AOC E, but the area is largely unsuitable for long-term occupation.

The small site is dominated by paved areas with partial grass cover and herbaceous species due to ongoing grounds maintenance activities (mowing) within the public works area. The herbaceous plant community is dominated by several species, including *Bothriochloa ischaemum*, *Digitaria ciliaris*, *Cynodon dactylon*, and *Commelina erecta*.

Wildlife observed at this site is typical for developed grassed areas on Vieques, though the small size of the site offers very limited habitat for any species. The only small mammal observed was the Indian mongoose (*Herpestes auropunctatus*), and horses (*Equus caballus*) were frequent grazers outside the fence surrounding AOC E. Occasional common passerine birds such as northern mockingbird (*Mimus polyglottos*), gray kingbird (*Tyrannus dominicensis*), common ground dove (*Columbina passerine*), black faced grassquit (*Tiaris bicolor*), and bananaquit (*Coereba flaveola*) have been observed at or near AOC E.

No endangered or threatened species were observed within the AOC E area, nor are any expected to use the site as habitat.

7.3 Analytical Data Used in the ERA

Surface soil was sampled at seven locations (SS-13 through SS-19, as shown in Figure 3-1). The surface soil samples were obtained from 0 to 24 inches bls. These samples were analyzed for VOCs, SVOCs, pesticides, PCBs, inorganics, cyanide, TPH-GRO, TPH-DRO, TPH-ORO, and total organic carbon (TOC). As discussed in Section 4.2.1, pesticides are not quantitatively evaluated in surface soil as part of the ERA.

7.4 Results

Five inorganics (aluminum, chromium, iron, manganese, and vanadium) were identified as chemicals of potential concern (COPCs) in surface soils based upon comparisons to soil screening values. However, the maximum concentrations of all five of these inorganics did not exceed the background UTL in any sample. Thus, the concentrations of these inorganics are consistent with background conditions and these chemicals were not retained as chemicals of concern (COCs).

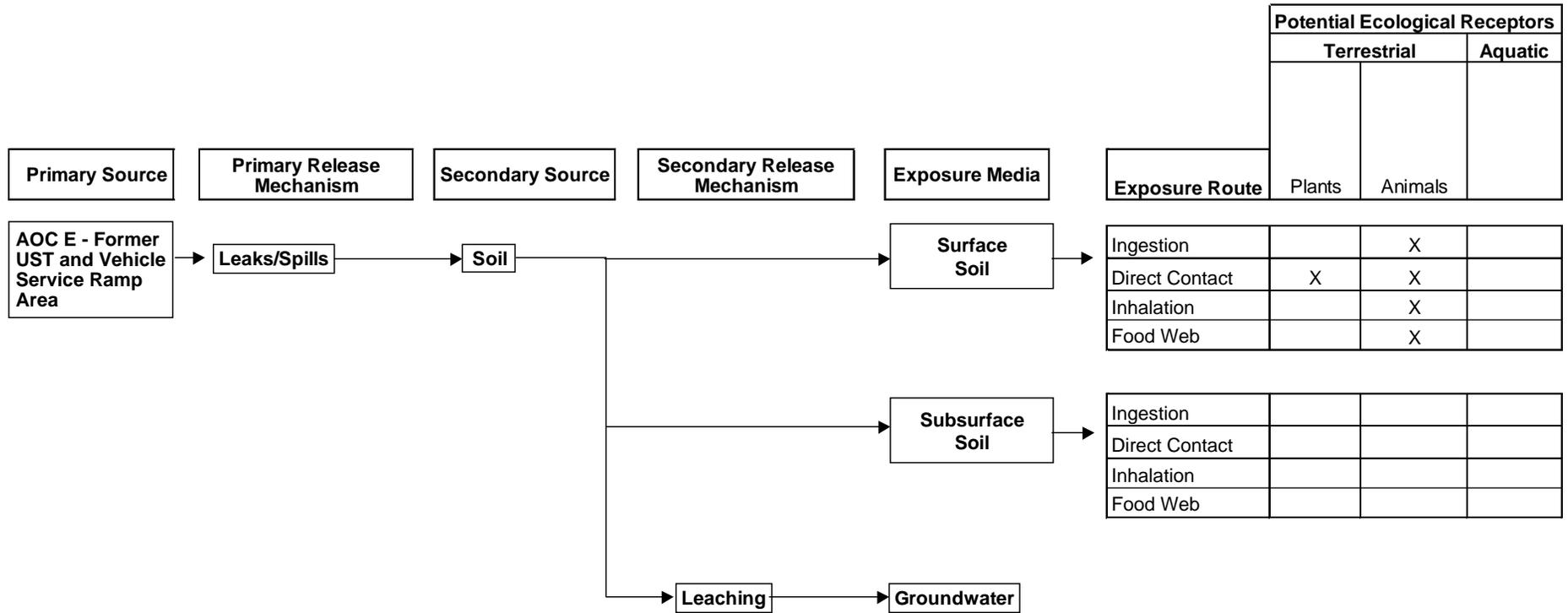
Two SVOCs (acetophenone and di-n-octylphthalate) and two TPHs (diesel range and oil range) were detected but could not be evaluated quantitatively because screening values are not available. Acetophenone was detected in only one of seven surface soil samples, at a concentration of 88 µg/kg, which is low in comparison to screening values for other SVOCs. Similarly, di-n-octylphthalate was detected in only one of seven surface soil samples, at a concentration of 350 µg/kg, which is well below screening values for other phthalates. Thus, neither of these SVOCs was identified as a COC.

There are no available soil screening values for TPH. However, PAHs (which are typically the most toxic fraction of the TPH) were not detected in the surface soil samples. Thus, TPH was not retained as a COC.

No COPCs were identified for terrestrial food web exposure pathways.

7.5 ERA Summary and Conclusions

In summary, none of the COPCs carried forward from Step 2 were retained as COCs following the Step 3A refinement. Thus, no unacceptable risks were identified for ecological receptors at AOC E and no further evaluation is warranted with respect to ecological receptors.



Notes:

X - Potentially complete exposure pathways identified

Figure 7-1
Ecological Conceptual Model
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Summary, Conclusions, and Recommendations

This section presents the summary and conclusions of the RI conducted at AOC E and the recommendations for the path forward at the site.

8.1 Summary

AOC E is the site of a former 500-gallon UST associated with a former vehicle maintenance operation within the main operational area (i.e., Public Works) of the Former NASD. The UST was in service between about 1970 and 1996, during which time it was used to store used oil generated from vehicle maintenance activities that took place at the vehicle maintenance and transportation shop (Building 2016). Specifically, oil removed from vehicles on the vehicle maintenance platform was drained to the UST via an underground pipe between the platform and the UST. In 1996, the UST was removed and replaced with a 500-gallon AST that, in turn, was removed in 2001.

AOC E occupies less than about a tenth of an acre in the northwest portion of the active Public Works facility. The topography at AOC E is flat; stormwater at the site has been observed to pond rather than run off. To the north of the site, a stormwater ditch channels stormwater runoff toward the north from the Public Works access roads. There are no surface water bodies at or immediately adjacent to AOC E; the Vieques Passage is located approximately 850 ft north of the site.

AOC E is the former location of a 550-gallon fiberglass used oil UST installed in 1970 during construction of the main operational area, and was used to store used oil generated from vehicle maintenance activities in Building 2016 of the former NASD on West Vieques. The site is currently fenced and no human receptors are present except periodically (approximately once per year) when maintenance workers cut vegetation at the site with a bush hog. At other times of the year, the site is vacant. In addition, there is no continuous or daily human occupancy of the buildings located immediately adjacent to AOC E (i.e., buildings 2015 and 2016). Because of the developed and periodically maintained characteristic of AOC E, ecological habitat in the area is minimal. Vegetative cover is primarily grass, weeds, and scrub brush. No endangered or threatened species were observed at AOC E, nor are any expected to use the site as habitat. No cultural resources are located at AOC E.

The soil at the site comprises sandy clay of the Qa geologic unit with interspersed silty/clayey sand from ground surface to a depth of approximately 35 ft in the vicinity of the former UST. Beneath these deposits lies a clay-rich saprolite developed in place from the underlying granodiorite bedrock.

Groundwater levels at the site have been observed to fluctuate by about 15 ft, occurring part of the time in the saprolite and less often in the lowest portion of the unconsolidated deposits directly above the saprolite. The direction of groundwater flow is north-northwest toward the Vieques Passage. Slug-test data for several site monitoring wells suggest a

relatively low groundwater velocity (about 1 ft/year). While slug test data in saprolite are prone to a high degree of uncertainty, the general absence of contamination in wells as little as about 50 ft downgradient of the former UST tend to support this velocity estimation.

Based on the distribution of contamination detected at AOC E, releases at the site occurred wholly or primarily as leaks from the former UST and associated piping. The data were collected through a series of investigations during which surface soil, subsurface soil, free product, and groundwater samples were collected in and around the area of the former UST and associated piping. Evaluation of the data collected during these investigations indicates the following constituents likely associated with releases from the former UST and associated piping are present in the soil and/or groundwater at the site:

- **Volatile Organic Compounds**

- Degreasing solvents such as 1,2-DCA, 1,2-DCB, and chlorobenzene (trace amounts of chlorinated solvents can be found in used engine oil and 1,2-DCB and chlorobenzene can also be associated with petroleum products)
- Fuel-related constituents such as BTEX and MTBE

- **Semivolatile Organic Compounds**

- Fuel-related PAHs such as 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, chrysene, fluorene, naphthalene, phenanthrene, and pyrene
- HAHs caprolactam and acetophenone
- Hydraulic-oil related phthalates bis(2-ethylhexyl)phthalate and butylbenzylphthalate

- **Total Petroleum Hydrocarbons**

- **Inorganics**

- Lead (while most inorganics analyzed for were detected in AOC E media, all but lead are likely to be wholly or primarily attributable to background)

Tables 8-1 through 8-3 provide statistical summaries of the constituents detected in surface soil, subsurface soil, and groundwater, respectively. The data were evaluated not only to determine the nature and extent of contamination present as a result of past releases, but were also compared to human health-based, ecological-based, and Puerto Rico UST-based screening values to gain an understanding of the magnitude of the releases. Groundwater data from all on-site wells (including those containing free product) were included in the evaluation; the comparison shows that there were relatively few detections of constituents in soil or groundwater above screening values, especially organics, with the exception of petroleum hydrocarbons in soil. Further, elevated concentrations in both soil and groundwater (with respect to screening values) are confined primarily to the area immediately under and around the former UST and associated piping. Free product has been observed in three monitoring wells (MW-01, MW-04, and MW-05) in the vicinity of the former UST and associated piping. However, as shown in Table 2-2, free product has been observed in only well MW-01 since 2006. As stated in Section 8.3, Recommendations, free

product thickness measurements will be made during the groundwater sampling event conducted during the feasibility study.

Based on the historical activities and extent of contamination identified during the RI and related investigations, the release mechanism at the site is believed to have been subsurface leaks from the former UST and associated piping. Therefore, the primary route of contaminant migration is likely vertical leaching through soil to groundwater and subsequent transport with groundwater flow through interstitial spaces in the saprolite (and to a lesser extent, the unconsolidated material overlying the saprolite). Because the saprolite consists of relatively “tight” clay, the rate of groundwater transport is likely very low. This supposition is supported by the general absence of contamination downgradient of the former UST area and relatively low estimated groundwater flow velocity. Because of the nature of the released materials (i.e., used engine oils), residual contamination is likely present in the soil between the base of the former UST/associated piping excavation and the saturated zone. Additionally, because of the past (and potentially current) presence of floating product on the water table, the fluctuation of the groundwater surface has likely created a “smear zone” of contamination along the vertical extent of fluctuation.

The fate and transport of contaminants present in environmental media is dependent on many factors, such as the contaminant type, soil type, organic matter content, presence and abundance of microorganisms, climatic conditions, chemistry of infiltrating water, and rate of groundwater migration. Degradation of organic contaminants detected in the environmental media at AOC E can occur through biotic (biological-based [biodegradation]) or abiotic (non-biological-based) processes. The majority of organic contaminants detected at AOC E biodegrade primarily under aerobic conditions (e.g., 1,2-DCA, BTEX, MTBE, and TPH). Several of the contaminants have been shown to biodegrade under both aerobic and anaerobic conditions (e.g., naphthalene and 2-methylnaphthalene). The rate at which biodegradation of these contaminants will occur is based on site-specific conditions, including the oxidation-reduction setting, presence and abundance of the proper microorganisms, and the concentrations of contaminants present.

Based on the nature, extent, and concentrations of constituents detected in environmental media at AOC E, potential ecological and human health risks were assessed. As noted previously, the developed and maintained area at and around the site provides minimal habitat. In fact, no preferred habitats were observed at AOC E, nor were any threatened or endangered species identified. Further, concentrations of constituents detected in surface soil were comparable to background concentrations. Therefore, no unacceptable risks were identified for potential ecological receptors at AOC E.

For potential human receptors, it is noted that there is no continuous human presence at or use of the site. However, exposures to various environmental media at the site were evaluated for hypothetical recreational users, maintenance workers, construction workers, industrial workers, and residents. Based on these evaluations, no unacceptable risk (over that attributable to background) was identified for exposure to soil by hypothetical human receptors. The only unacceptable risks were identified for potable use of groundwater by hypothetical future residents. The risk assessment identified 1,2-DCA, MTBE, xylenes, 2-methylnaphthalene, and naphthalene as the groundwater COCs. Inorganics were eliminated as COCs because their presence is wholly or primarily attributable to background.

8.2 Conclusions

Based on the above information, it is concluded that releases of used oil occurred during vehicle maintenance activities, likely in the form of leaks from the former UST and associated piping. These releases resulted in contamination of soil and groundwater. However, the extent of contamination is generally limited to the immediate vicinity of the former UST and associated piping, with vertical leaching to groundwater representing the primary transport pathway. The extent of contamination is limited to a relatively small area by the nature of the releases (subsurface), the size of the release area (the size and extent of the UST and associated piping), and the relatively “tight” material through which contamination must travel. Further, the contaminant levels present in soil are relatively low (with respect to human health-based and ecological-based screening values). In fact, potable groundwater use by residents is the only unacceptable risk identified for the site. In addition, only benzene was detected in groundwater above its MCL. However, residual petroleum contamination in soil may be acting as a continuing source of groundwater contamination, and free product has been detected in the wells in the immediate vicinity of the former UST and associated piping.

8.3 Recommendations

As summarized above, although contaminants are present in both soil and groundwater at the site, only the groundwater contamination poses an unacceptable risk (under the potable use scenario) to hypothetical future residents. However, soil contamination between the bottom of the former UST/associated piping may act as a continuing source of groundwater contamination, including free product. For the above reasons, it is recommended that a feasibility study (FS) be performed to evaluate whether there are technically and economically viable remedial alternatives to address the contamination.

It is noted that the most recent groundwater constituent concentration data are from 2005. Because it has been approximately 2 years since groundwater data were collected, it is recommended that as part of the FS, another round of groundwater samples be collected from all site wells and analyzed for the following parameters:

- VOCs
- SVOCs
- Total and dissolved inorganics
- TPH-GRO, TPH-DRO, and TPH-ORO
- Nitrate, nitrite, sulfide, sulfate, TOC, alkalinity, chloride, methane, ethane, ethene, ferrous iron, and functional gene testing for VOC and SVOC degrading microbes, as appropriate

At the same time as the groundwater samples are collected, free product thicknesses will also be determined. The free product thickness and additional round of VOC and SVOC data will provide current condition (as well as temporal) information that will assist in assessing viable groundwater remedial alternatives. Although the inorganic concentrations in groundwater are likely attributable to background based on the existing data, an additional round of inorganic data will help confirm this supposition. The additional geochemical and microbial parameters will be used to determine the potential

for natural attenuation of the organic compounds and the potential for mobilization of inorganics. If free product is observed in any of the wells and there is sufficient quantity to permit collection, a sample of the free product will be collected from one well and analyzed for the following parameters:

- Viscosity
- Interfacial tension
- Density
- Hydrocarbon “fingerprint”

In addition to collecting additional groundwater data, there are several soil parameters that would be beneficial to assessing viable soil remedial alternatives. For example, assessing the viability of potential soil remedial alternatives, such as soil vapor extraction, can be enhanced with information such as soil permeability. Additionally, assessing the potential for residual soil contamination to act as a continuing source of contamination (and potentially free product) to groundwater can be enhanced with information such as leaching potential. Therefore, it is recommended that as part of the FS, the following additional soil data be collected:

- Continuous soil cores (one from beneath the former UST and one from beneath the former piping) to the top of the saturated zone, with soil samples collected approximately every 5 ft (to assess vertical stratification) and analyzed for:
 - VOCs
 - SVOCs
 - Inorganics
 - TPH-GRO, TPH-DRO, and TPH-ORO
 - TOC
 - Grain size
 - Bulk density (if undisturbed soil sample can be collected)
 - Porosity (if undisturbed soil sample can be collected)
 - Soil permeability
 - Synthetic Precipitation Leaching Procedure (SPLP)

A MPE pilot study was conducted during the RI in which free product, groundwater, and soil vapor were extracted. The MPE study memorandum (Appendix H, Table 2) identifies a calculated estimated mass of NAPL to be 409 pounds and an estimated maximum recoverable NAPL mass of 205 pounds. However, the pilot study was not designed to facilitate calculating a petroleum mass removed. The process produced two waste streams (i.e., air and water), both of which were sent through a filter prior to discharge, which makes calculating a mass of removal (based on the data collected) impractical. While the results of this pilot study indicate this technology is potentially viable, free product returned to the test wells following completion of the test. This may have been due to the relatively short period of time in which the pilot study was performed (i.e., approximately 2 months). In addition, it is possible that the target zone of treatment was not sufficient to address the vertical extent of residual soil contamination. Therefore, if the Navy determines that an additional pilot study would provide information beneficial to the evaluation of alternative(s) in the FS, the FS will be temporarily deferred and a pilot study work plan submitted for agency review.

TABLE 8-1
 Surface Soil Summary Statistics
 AOC E Remedial Investigation Report
 Vieques, Puerto Rico

Chemical Name	Vieques Human Health Screening Value	Vieques Ecological Screening Value	PREQB UST Corrective Action Criteria	Number of Analyses	Number of Detects ²	Range of Concentrations ²	Number of Detects Above Human Health Screening Value ²	Number of Detects Above Ecological Screening Value ²	Number of Detects Above PREQB UST Corrective Action Criteria ²
Chemical Name									
Volatile Organic Compounds (µg/kg)									
No Detections									
Semi-volatile Organic Compounds (µg/kg)									
Acetophenone	780,000	--	--	7	1	88	0	NA	NA
Di-n-octylphthalate	240,000	--	--	7	1	350	0	NA	NA
bis(2-Ethylhexyl)phthalate	35,000	10,000	--	7	1	330	0	0	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)									
4,4'-DDD	2,400	10	--	7	1	2.1	0	0	NA
4,4'-DDE	1,700	10	--	7	1	8.4	0	0	NA
4,4'-DDT	1,700	10	--	7	1	3.6	0	0	NA
Aroclor-1260	110	40,000	--	7	1	12	0	0	NA
Total Metals (mg/kg)									
Aluminum	7,600	--	--	7	0	NA	0	NA	NA
Antimony	3.1	78	--	7	0	NA	0	0	NA
Arsenic	0.39	18	--	7	0	NA	0	0	NA
Barium	1,600	330	--	7	0	NA	0	0	NA
Cadmium	3.7	32	--	7	2	0.58-0.82	0	0	NA
Calcium	--	--	--	7	0	NA	NA	NA	NA
Chromium	210	0.4	--	7	0	NA	0	0	NA
Cobalt	140	13	--	7	0	NA	0	0	NA
Copper	310	70	--	7	0	NA	0	0	NA
Iron	2,300	--	--	7	0	NA	0	NA	NA
Lead	400 ¹	120	50	7	5	11.6-52.1	0	0	1
Magnesium	--	--	--	7	0	NA	NA	NA	NA
Manganese	180	220	--	7	0	NA	0	0	NA
Mercury	2.3	0.1	--	7	0	NA	0	0	NA
Nickel	160	38	--	7	0	NA	0	0	NA
Potassium	--	--	--	7	0	NA	NA	NA	NA
Sodium	--	--	--	7	0	NA	NA	NA	NA
Vanadium	7.8	2	--	7	0	NA	0	0	NA
Zinc	2,300	120	--	7	1	82.7	0	0	NA
Total Petroleum Hydrocarbons (mg/kg)									
TPH-diesel range	--	--	100	7	0	NA	0	0	0
TPH-oil range	--	--	100	7	2	190-270	NA	NA	2

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ Lead Action Level

² For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE 8-2

Subsurface Soil Detection Summary
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques Human Health Screening Value	PREQB UST Corrective Action Criteria	Number of Analyses	Number of Detects ²	Range of Concentrations ²	Number of Detects Above Human Health Screening Value ^c	Number of Detects Above PREQB UST Corrective Action Criteria ^c
Volatile Organic Compounds (µg/kg)							
1,2-Dichlorobenzene	110,000		8	4	2-54	0	NA
Acetone	1,400,000		8	1	5	0	NA
Benzene	640	5,000	31	7	0.31-4,150	1	0
Ethylbenzene	190,000	10,000	31	13	0.25-14,200	0	1
Isopropylbenzene	57,000		8	4	8-370	0	NA
Methyl-tert-butyl ether (MTBE)	17,000		8	1	4	0	NA
Methylcyclohexane	260,000		8	3	2-220	0	NA
Toluene	630,000	10,000	31	8	1.1-2,750	0	0
Xylene, total	27,000	10,000	31	10	18.7-90,600	1	4
Semi-volatile Organic Compounds (µg/kg)							
1,1-Biphenyl	300,000		8	2	310-330	0	NA
2-Methylnaphthalene	31,000		8	4	77-6,000	0	NA
Acenaphthene	370,000		8	1	140	0	NA
Anthracene	2,200,000		8	1	78	0	NA
Benzo(a)anthracene	620		8	2	100-130	0	NA
Benzo(g,h,i)perylene	230,000		8	1	130-160	0	NA
Butylbenzylphthalate	1,200,000		8	1	210	0	NA
Chrysene	62,000		8	2	130	0	NA
Fluoranthene	230,000		8	2	130-160	0	NA
Fluorene	270,000		8	1	190	0	NA
Naphthalene	5,600		8	2	3,100-3,500	0	NA
Phenanthrene	2,200,000		8	3	370-590	0	NA
Pyrene	230,000		8	2	230-320	0	NA
bis(2-Ethylhexyl)phthalate	35,000		8	5	99-700	0	NA
Pesticide/Polychlorinated Biphenyls (µg/kg)							
4,4'-DDE	1,700		8	2	1.5-7.8	0	NA
4,4'-DDT	1,700		8	1	9.2	0	NA
Aldrin	29		8	1	1.1	0	NA
Aroclor-1254	110		8	1	15	0	NA
Endrin aldehyde	1,800		8	1	2.1	0	NA
alpha-BHC	90		8	2	4.1-5.3	0	NA
gamma-Chlordane	1,600		8	2	5-8.3	0	NA
Total Metals (mg/kg)							
Aluminum	7,600		8	0	NA	NA	NA
Antimony	3.1		8	0	NA	NA	NA
Arsenic	0.39		8	0	NA	NA	NA
Barium	1,600		8	0	NA	NA	NA
Calcium	--		8	0	NA	NA	NA
Chromium	210		8	0	NA	NA	NA
Cobalt	140		8	0	NA	NA	NA
Copper	310		8	1	75.8	0	NA
Iron	2,300		8	2	39,800-43,000	1	NA
Lead ¹	400	50	8	1	11.9	0	0
Magnesium	--		8	2	18,600-19,300	NA	NA
Manganese	180		8	0	NA	NA	NA
Nickel	160		8	0	NA	NA	NA
Potassium	--		8	0	NA	NA	NA
Silver	39		8	1	0.29	0	NA
Sodium	--		8	0	NA	NA	NA
Vanadium	7.8		8	0	NA	NA	NA
Zinc	2,300		8	0	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)							
Oil and Grease	--	100	19	11	63.1-19,300	NA	8
TPH-diesel range	--	100	16	5	9.4-490	NA	3
TPH-gas range	--	100	16	6	0.12-42,000	NA	1
TPH-oil range	--	100	16	6	180-2,600	NA	6
Total Petroleum Hydrocarbons, C10-C28	--	100	19	9	4.7-3,780	NA	6
Total Petroleum Hydrocarbons, C6-C10	--	100	19	8	0.012-2,150	NA	5
Total recoverable TPH	--	100	8	8	80-36,000	NA	6

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ Lead Action Level

² For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE 8-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	1998					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹
Volatile Organic Compounds (µg/L)									
1,2-Dichlorobenzene	37	600		0	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.12	5		0	NA	NA	NA	NA	NA
Acetone	550	--		0	NA	NA	NA	NA	NA
Benzene	0.35	5	5	2	1	17	1	1	1
Chlorobenzene	11	100		0	NA	NA	NA	NA	NA
Chloroform	0.17	80		0	NA	NA	NA	NA	NA
Cyclohexane	1,000	--		0	NA	NA	NA	NA	NA
Ethylbenzene	130	700	700	2	0	NA	NA	NA	NA
Isopropylbenzene	66	--		0	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	11	--		0	NA	NA	NA	NA	NA
Methylcyclohexane	520	--		0	NA	NA	NA	NA	NA
Toluene	230	1,000	1,000	2	0	NA	NA	NA	NA
Xylene, total	--	10,000	10,000	2	0	NA	NA	NA	NA
m- and p-Xylene	21	--		0	NA	NA	NA	NA	NA
o-Xylene	21	--		0	NA	NA	NA	NA	NA
Semi-volatile Organic Compounds(µg/L)									
2-Methylnaphthalene	2.4	--		0	NA	NA	NA	NA	NA
Acenaphthene	37	--		0	NA	NA	NA	NA	NA
Acetophenone	61	--		0	NA	NA	NA	NA	NA
Butylbenzylphthalate	730	--		0	NA	NA	NA	NA	NA
Caprolactam	1,800	--		0	NA	NA	NA	NA	NA
Di-n-butylphthalate	360	--		0	NA	NA	NA	NA	NA
Diethylphthalate	2,900	--		0	NA	NA	NA	NA	NA
Fluorene	24	--		0	NA	NA	NA	NA	NA
Naphthalene	0.62	--		0	NA	NA	NA	NA	NA
Phenanthrene	18	--		0	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	4.8	6		0	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/L)									
Dieldrin	0.0042	--		0	NA	NA	NA	NA	NA
Total Metals (µg/L)									
Aluminum	3,600	--		0	NA	NA	NA	NA	NA
Arsenic	0.045	10		0	NA	NA	NA	NA	NA
Barium	730	2,000		0	NA	NA	NA	NA	NA
Beryllium	7.3	4		0	NA	NA	NA	NA	NA
Cadmium	1.8	5		0	NA	NA	NA	NA	NA
Calcium	--	--		0	NA	NA	NA	NA	NA
Chromium	11	100		0	NA	NA	NA	NA	NA
Cobalt	73	--		0	NA	NA	NA	NA	NA
Copper	150	1,300		0	NA	NA	NA	NA	NA
Cyanide	73	200		0	NA	NA	NA	NA	NA
Iron	1,100	--		0	NA	NA	NA	NA	NA
Lead	15	15	50	0	NA	NA	NA	NA	NA
Magnesium	--	--		0	NA	NA	NA	NA	NA
Manganese	88	--		0	NA	NA	NA	NA	NA
Mercury	1.1	2		0	NA	NA	NA	NA	NA
Nickel	73	--		0	NA	NA	NA	NA	NA
Potassium	--	--		0	NA	NA	NA	NA	NA
Selenium	18	50		0	NA	NA	NA	NA	NA
Silver	18	--		0	NA	NA	NA	NA	NA
Sodium	--	--		0	NA	NA	NA	NA	NA
Thallium	0.24	2		0	NA	NA	NA	NA	NA
Vanadium	3.6	--		0	NA	NA	NA	NA	NA
Zinc	1,100	--		0	NA	NA	NA	NA	NA
Dissolved Metals (µg/L)									
Aluminum	3,600	--		0	NA	NA	NA	NA	NA
Antimony	1.5	6		0	NA	NA	NA	NA	NA
Arsenic	0.045	10		0	NA	NA	NA	NA	NA
Barium	730	2,000		0	NA	NA	NA	NA	NA
Beryllium	7.3	4		0	NA	NA	NA	NA	NA
Cadmium	1.8	5		0	NA	NA	NA	NA	NA
Calcium	--	--		0	NA	NA	NA	NA	NA
Chromium	11	100		0	NA	NA	NA	NA	NA
Cobalt	73	--		0	NA	NA	NA	NA	NA
Copper	150	1,300		0	NA	NA	NA	NA	NA
Iron	1,100	--		0	NA	NA	NA	NA	NA
Lead	15	15	50	0	NA	NA	NA	NA	NA
Magnesium	--	--		0	NA	NA	NA	NA	NA
Manganese	88	--		0	NA	NA	NA	NA	NA
Nickel	73	--		0	NA	NA	NA	NA	NA
Potassium	--	--		0	NA	NA	NA	NA	NA
Selenium	18	50		0	NA	NA	NA	NA	NA
Silver	18	--		0	NA	NA	NA	NA	NA
Sodium	--	--		0	NA	NA	NA	NA	NA
Thallium	0.24	2		0	NA	NA	NA	NA	NA
Vanadium	3.6	--		0	NA	NA	NA	NA	NA
Zinc	1,100	--		0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (µg/L)									
TPH-gas range	--	--	50,000	2	0	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	0	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	50,000	2	0	NA	NA	NA	NA

Notes:

-- Criteria not established

NA - Not Analyzed / Not Applicable

¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE 8-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	2000						2002					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹	Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹
Volatile Organic Compounds (µg/L)															
1,2-Dichlorobenzene	37	600		4	2	3 - 4	0	0	NA	4	1	4.5	0	0	NA
1,2-Dichloroethane	0.12	5		4	1	32	1	1	NA	4	1	4.9	1	0	NA
Acetone	550	--		4	3	10 - 12	0	NA	NA	4	0	NA	NA	NA	NA
Benzene	0.35	5	5	4	2	2 - 6	2	1	1	4	1	0.72	1	0	0
Chlorobenzene	11	100		4	0	NA	NA	NA	NA	4	1	1.4	0	0	NA
Chloroform	0.17	80		4	0	NA	NA	NA	NA	4	1	0.39	1	0	NA
Cyclohexane	1,000	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Ethylbenzene	130	700	700	4	1	0.9	0	0	0	4	0	NA	NA	NA	NA
Isopropylbenzene	66	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	11	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Methylcyclohexane	520	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Toluene	230	1,000	1,000	4	1	0.3	0	0	0	4	0	NA	NA	NA	NA
Xylene, total	--	10,000	10,000	4	2	0.9 - 20	NA	0	0	4	0	NA	NA	NA	NA
m- and p-Xylene	21	--		4	2	0.9 - 17	0	NA	NA	0	NA	NA	NA	NA	NA
o-Xylene	21	--		4	1	3	0	NA	NA	0	NA	NA	NA	NA	NA
Semi-volatile Organic Compounds(µg/L)															
2-Methylnaphthalene	2.4	--		4	1	14	1	NA	NA	4	0	NA	NA	NA	NA
Acenaphthene	37	--		4	0	NA	NA	NA	NA	4	1	0.55	0	NA	NA
Acetophenone	61	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Butylbenzylphthalate	730	--		4	1	0.4	0	NA	NA	4	0	NA	NA	NA	NA
Caprolactam	1,800	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Di-n-butylphthalate	360	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Diethylphthalate	2,900	--		4	1	0.6	0	NA	NA	4	0	NA	NA	NA	NA
Fluorene	24	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Naphthalene	0.62	--		4	1	15	1	NA	NA	4	0	NA	NA	NA	NA
Phenanthrene	18	--		4	1	0.6	0	NA	NA	4	0	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	4.8	6		4	1	1	0	0	NA	4	0	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/L)															
Dieldrin	0.0042	--		4	1	0.11	0	NA	NA	0	NA	NA	NA	NA	NA
Total Metals (µg/L)															
Aluminum	3,600	--		4	4	2,020 - 106,000	2	NA	NA	4	4	851 - 38,600	1	NA	NA
Amenable cyanide	--	--		0	NA	NA	NA	NA	NA	4	2	5.52 - 7.18	NA	NA	NA
Antimony	1.5	6		4	3	1.9 - 5.6	3	0	NA	4	0	NA	NA	NA	NA
Arsenic	0.045	10		4	1	3.5	1	0	NA	4	2	2.1 - 3.2	2	0	NA
Barium	730	2,000		4	3	269 - 826	1	0	NA	4	3	127 - 624	0	0	NA
Beryllium	7.3	4		4	1	0.55	0	0	NA	4	3	0.39 - 0.42	0	0	NA
Cadmium	1.8	5		4	0	NA	NA	NA	NA	4	1	0.48	0	0	NA
Calcium	--	--		4	3	103,000 - 121,000	NA	NA	NA	4	2	70,100 - 127,000	NA	NA	NA
Chromium	11	100		4	2	110 - 141	2	2	NA	4	4	4.3 - 59.2	2	0	NA
Cobalt	73	--		4	2	36.1 - 118	1	NA	NA	4	3	2 - 13.2	0	NA	NA
Copper	150	1,300		4	2	144 - 247	1	0	NA	4	2	8.5 - 74.1	0	0	NA
Cyanide	73	200		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Iron	1,100	--		4	2	66,000 - 180,000	2	NA	NA	4	4	990 - 32,100	3	NA	NA
Lead	15	15	50	4	4	1.5 - 11.7	0	0	0	4	1	2.8	0	0	0
Magnesium	--	--		4	3	48,900 - 101,000	NA	NA	NA	4	2	45,900 - 66,300	NA	NA	NA
Manganese	88	--		4	3	3,340 - 6,490	3	NA	NA	4	4	79.4 - 6,410	3	NA	NA
Mercury	1.1	2		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Nickel	73	--		4	3	24.4 - 87.7	1	NA	NA	4	4	3.8 - 37.4	0	NA	NA
Potassium	--	--		4	2	10,400 - 12,000	NA	NA	NA	4	1	8,360	NA	NA	NA
Selenium	18	50		4	1	5.6	0	0	NA	4	2	4.4 - 5.5	0	0	NA
Silver	18	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Sodium	--	--		4	3	137,000 - 152,000	NA	NA	NA	4	1	146,000	NA	NA	NA
Thallium	0.24	2		4	0	NA	NA	NA	NA	4	2	5.2 - 6.6	2	2	NA
Vanadium	3.6	--		4	2	175 - 489	2	NA	NA	4	4	14.2 - 90.3	4	NA	NA
Zinc	1,100	--		4	2	248 - 377	0	NA	NA	4	2	60.5 - 134	0	NA	NA
Dissolved Metals (µg/L)															
Aluminum	3,600	--		4	0	NA	NA	NA	NA	4	2	84.6 - 84.9	0	NA	NA
Antimony	1.5	6		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Arsenic	0.045	10		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Barium	730	2,000		4	2	173 - 247	0	0	NA	4	3	118 - 413	0	0	NA
Beryllium	7.3	4		4	0	NA	NA	NA	NA	4	1	0.37	0	0	NA
Cadmium	1.8	5		4	1	0.46	0	0	NA	4	0	NA	NA	NA	NA
Calcium	--	--		4	2	89,400 - 99,500	NA	NA	NA	4	2	69,200 - 117,000	NA	NA	NA
Chromium	11	100		4	1	3.9	0	0	NA	4	3	1.3 - 3.6	0	0	NA
Cobalt	73	--		4	1	2.8	0	NA	NA	4	1	1.8	0	NA	NA
Copper	150	1,300		4	0	NA	NA	NA	NA	4	1	5	0	0	NA
Iron	1,100	--		4	0	NA	NA	NA	NA	4	1	1320	1	NA	NA
Lead	15	15	50	4	3	1.2 - 1.6	0	0	0	4	0	NA	NA	NA	NA
Magnesium	--	--		4	2	44,000 - 45,600	NA	NA	NA	4	2	45,400 - 59,100	NA	NA	NA
Manganese	88	--		4	2	2,510 - 3,110	2	NA	NA	4	2	77 - 5,450	1	NA	NA
Nickel	73	--		4	3	4.5 - 6.3	0	NA	NA	4	1	4.9	0	NA	NA
Potassium	--	--		4	1	6,440	NA	NA	NA	4	1	3,740	NA	NA	NA
Selenium	18	50		4	2	2.4 - 4.6	0	0	NA	4	2	3 - 4.3	0	0	NA
Silver	18	--		4	0	NA	NA	NA	NA	4	0	NA	NA	NA	NA
Sodium	--	--		4	3	133,000 - 151,000	NA	NA	NA	4	1	150,000	NA	NA	NA
Thallium	0.24	2		4	0	NA	NA	NA	NA	4	2	5.8 - 6.4	2	2	NA
Vanadium	3.6	--		4	0	NA	NA	NA	NA	4	2	12.9 - 15.1	2	NA	NA
Zinc	1,100	--		4	0	NA	NA	NA	NA	4	1	68.4	0	NA	NA
Total Petroleum Hydrocarbons (µg/L)															
TPH-gas range	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA

Notes:

- Criteria not established
- NA - Not Analyzed / Not Applicable
- ¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

TABLE 8-3
Groundwater Summary Statistics
AOC E Remedial Investigation Report
Vieques, Puerto Rico

Chemical Name	Vieques HHRA GW	MCL - GW	PREQB UST Corrective Action Criteria	2004						2005					
				Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹	Number of Analyses	Number of Detects ¹	Range of Concentrations ¹	Number of Detects Above Human Health Screening Value ¹	Number of Detects Above MCL ¹	Number of Detects above PREQB UST Corrective Action Criteria ¹
Volatile Organic Compounds (µg/L)															
1,2-Dichlorobenzene	37	600		7	3	3.7 - 4.6	0	0	NA	0	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.12	5		7	2	0.59 - 7.2	2	1	NA	0	NA	NA	NA	NA	NA
Acetone	550	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Benzene	0.35	5	5	7	3	0.21 - 4.1	2	0	0	0	NA	NA	NA	NA	NA
Chlorobenzene	11	100		7	3	0.69 - 1.1	0	0	NA	0	NA	NA	NA	NA	NA
Chloroform	0.17	80		7	3	0.3 - 1.2	3	0	NA	0	NA	NA	NA	NA	NA
Cyclohexane	1,000	--		7	2	0.31 - 1.3	0	NA	NA	0	NA	NA	NA	NA	NA
Ethylbenzene	130	700	700	7	2	0.71 - 10.9	0	0	0	0	NA	NA	NA	NA	NA
Isopropylbenzene	66	--		7	2	0.22 - 6.3	0	NA	NA	0	NA	NA	NA	NA	NA
Methyl-tert-butyl ether (MTBE)	11	--		7	3	234 - 1,220	3	NA	NA	0	NA	NA	NA	NA	NA
Methylcyclohexane	520	--		7	3	0.61 - 2.9	0	NA	NA	0	NA	NA	NA	NA	NA
Toluene	230	1,000	1,000	7	2	0.21 - 0.3	0	0	0	0	NA	NA	NA	NA	NA
Xylene, total	--	10,000	10,000	7	2	1.8 - 26.2	NA	0	0	0	NA	NA	NA	NA	NA
m- and p-Xylene	21	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
o-Xylene	21	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Semi-volatile Organic Compounds(µg/L)															
2-Methylnaphthalene	2.4	--		7	1	12	1	NA	NA	0	NA	NA	NA	NA	NA
Acenaphthene	37	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Acetophenone	61	--		7	1	8.1	0	NA	NA	0	NA	NA	NA	NA	NA
Butylbenzylphthalate	730	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Caprolactam	1,800	--		7	2	6.8 - 33	0	NA	NA	0	NA	NA	NA	NA	NA
Di-n-butylphthalate	360	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Diethylphthalate	2,900	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Fluorene	24	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Naphthalene	0.62	--		7	1	9.5	1	NA	NA	0	NA	NA	NA	NA	NA
Phenanthrene	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	4.8	6		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Pesticide/Polychlorinated Biphenyls (µg/L)															
Dieldrin	0.0042	--		5	2	0.0019 - 0.027	1	NA	NA	0	NA	NA	NA	NA	NA
Total Metals (µg/L)															
Aluminum	3,600	--		7	6	147 - 287	0	NA	NA	0	NA	NA	NA	NA	NA
Arsenic	--	--		0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Antimony	1.5	6		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Barium	0.045	10		7	7	10.1 - 15.2	7	7	NA	0	NA	NA	NA	NA	NA
Beryllium	730	2,000		7	4	186 - 405	0	0	NA	0	NA	NA	NA	NA	NA
Bismuth	7.3	4		7	1	0.23	0	0	NA	0	NA	NA	NA	NA	NA
Cadmium	1.8	5		7	1	7.2	1	1	NA	0	NA	NA	NA	NA	NA
Calcium	--	--		7	3	81,200 - 117,000	NA	NA	NA	0	NA	NA	NA	NA	NA
Chromium	11	100		7	6	3.45 - 28	1	0	NA	0	NA	NA	NA	NA	NA
Cobalt	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Copper	150	1,300		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Cyanide	73	200		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Iron	1,100	--		7	7	130 - 3,190	3	NA	NA	0	NA	NA	NA	NA	NA
Lead	15	15	50	7	3	4.12 - 5.15	0	0	0	0	NA	NA	NA	NA	NA
Magnesium	--	--		7	4	48,700 - 61,800	NA	NA	NA	0	NA	NA	NA	NA	NA
Manganese	88	--		7	3	1,990 - 5,810	3	NA	NA	0	NA	NA	NA	NA	NA
Mercury	1.1	2		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Nickel	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Potassium	--	--		7	2	1,940 - 2,400	NA	NA	NA	0	NA	NA	NA	NA	NA
Selenium	18	50		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Silver	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Sodium	--	--		7	3	152,000 - 165,000	NA	NA	NA	0	NA	NA	NA	NA	NA
Thallium	0.24	2		7	2	0.232 - 0.237	0	0	NA	0	NA	NA	NA	NA	NA
Vanadium	3.6	--		7	4	13.9 - 17.1	4	NA	NA	0	NA	NA	NA	NA	NA
Zinc	1,100	--		7	4	2.99 - 5.2	0	NA	NA	0	NA	NA	NA	NA	NA
Dissolved Metals (µg/L)															
Aluminum	3,600	--		7	2	95.4 - 211	0	NA	NA	0	NA	NA	NA	NA	NA
Antimony	1.5	6		7	1	3.25	1	0	NA	0	NA	NA	NA	NA	NA
Arsenic	0.045	10		7	5	12.5 - 16.7	5	5	NA	0	NA	NA	NA	NA	NA
Barium	730	2,000		7	4	186 - 403	0	0	NA	0	NA	NA	NA	NA	NA
Beryllium	7.3	4		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Cadmium	1.8	5		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Calcium	--	--		7	4	62,600 - 114,000	NA	NA	NA	0	NA	NA	NA	NA	NA
Chromium	11	100		7	5	1.82 - 3.85	0	0	NA	0	NA	NA	NA	NA	NA
Cobalt	73	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Copper	150	1,300		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Iron	1,100	--		7	5	62.9 - 2,880	1	NA	NA	0	NA	NA	NA	NA	NA
Lead	15	15	50	7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Magnesium	--	--		7	4	42,200 - 60,600	NA	NA	NA	0	NA	NA	NA	NA	NA
Manganese	88	--		7	3	1,980 - 6,080	3	NA	NA	0	NA	NA	NA	NA	NA
Nickel	73	--		7	3	254 - 343	3	NA	NA	0	NA	NA	NA	NA	NA
Potassium	--	--		7	2	2,000 - 2,390	NA	NA	NA	0	NA	NA	NA	NA	NA
Selenium	18	50		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Silver	18	--		7	0	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Sodium	--	--		7	3	150,000 - 166,000	NA	NA	NA	0	NA	NA	NA	NA	NA
Thallium	0.24	2		7	1	0.344	1	0	NA	0	NA	NA	NA	NA	NA
Vanadium	3.6	--		7	4	13.4 - 17.8	4	NA	NA	0	NA	NA	NA	NA	NA
Zinc	1,100	--		7	4	4.26 - 15.5	0	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (µg/L)															
TPH-gas range	--	--	50,000	0	NA	NA	NA	NA	NA	5	1	180	NA	NA	0
Total Petroleum Hydrocarbons, C10-C28	--	--	50,000	5	2	460 - 610	NA	NA	NA	0	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons, C6-C10	--	--	50,000	5	2	36 - 160	NA	NA	NA	0	NA	NA	NA	NA	NA
Total recoverable TPH	--	--	50,000	0	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA

Notes:

- Criteria not established
- NA - Not Analyzed / Not Applicable
- ¹ For inorganics, it is number of detects above background, range of concentrations above background, and number of detects above screening values and background.

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