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Final

Remedial Investigation Report
Solid Waste Management Unit (SWMU) 7

Former Naval Ammunition Support Detachment
Vieques, Puerto Rico

NAVFAC
Naval Facilities Engineering Command

Prepared for

Department of the Navy

NAVFAC ATLANTIC

Contract No. N62470-02-D-3052
CTO-007

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Prepared by

CH2MHILL

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Under the

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Acronyms and Abbreviations

AB	Ambient Blank
ABS_{dermal}	Dermal Absorption factor
ABS_{GI}	Gastrointestinal Absorption
AD	Average Daily Intake
AOC	Area of Concern
ASTM	American Society for Testing and Materials
atm-m^3/M	Atmosphere-Cubic Meter per Mole
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
BEHP	Bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
bls	Below Land Surface
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BW	Body Weight
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	Cubic Feet per Minute
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chemicals of Concern
COPC	Chemical of Potential Concern
CS	Confirmation Study
CSM	Conceptual Site Model
CTC	CERCLA Technical Committee
CWA	Clean Water Act
DAF	Dilution Attenuation Factor
DGPS	Differential Global Positioning System
DOI	Department of the Interior
DQE	Data Quality Evaluation
EBS	Environmental Baseline Survey
ECOPC	Ecological Chemical of Potential Concern
ED	Exposure Duration
EDMS	Environmental Data Management System
EDS	Environmental Data Services Inc.

EF	Exposure Frequency
ELCR	Excess Lifetime Cancer Risk
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERB	Equipment Rinsate Blank
ERL	Effects Range-Low
°F	Degrees Fahrenheit
FB	Field Blank
FS	Feasibility Study
ft	Feet
ft/day	Feet per Day
ft/year	Feet per Year
gpm	Gallons per Minute
GPS	Global Positioning System
H	Henry's Law Constant
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
hp	Horsepower
HQ	Hazard Quotient
HRS	Hazardous Rank Scoring
IR	Ingestion Rate
IR	Installation Restoration
IRA	Immediate Response Action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
Kp	Permeability Constant
L	Liter
LANTDIV	Atlantic Division
lb	Pound
LCS	Laboratory Control Standard
LCSD	Laboratory Control Standard Duplicate
LNAPL	Light Non-Aqueous Phase Liquid
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
MB	Method Blank
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
MDL	Method Detection Limit

MEC	Munitions and Explosives of Concern
MEK	Methyl Ethyl Ketone
mg/d	Milligrams per Day
mg/kg	Milligrams per Kilogram
MHSPE	Ministry of Housing, Spatial Planning, and Environment
MNA	Monitored Natural Attenuation
MOU	Memorandum of Understanding
MOV	Municipality of Vieques
MS/MSD	Matrix Spike/Matrix Spike Duplicate
msl	Mean Sea Level
MW	Monitoring Well
NA	Not Applicable
NAPL	Non-Aqueous Phase Liquid
NASD	Naval Ammunition Support Detachment
NAVFACENGCOM	Naval Facilities Engineering Command
NC	Reading not collected
NCEA	National Center for Environmental Assessment
NFA	No Further Action
NFG	National Functional Guidelines
NM	Not Measured
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NPL	National Priorities List
NRHP	National Registry of Historic Places
NSRR	Naval Station Roosevelt Roads
OE	Ordnance and Explosives
ORC	Oxygen-Releasing Chemicals
ORP	Oxidation-Reduction Potential
ORS	Ordnance-Related Scrap
OSWER	Office of Solid Waste and Emergency Response (of EPA)
OVM	Organic Vapor Meter
PA/SI	Preliminary Assessment/Site Investigation
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCOC	Preliminary Chemical of Concern
PEF	Particulate Emission Factor
PID	Photoionization Detector
PPM	Parts per Million
PQL	Practical Quantitation Limit
PREQB	Puerto Rico Environmental Quality Board

PRG	Preliminary Remediation Goal
PPT	Parts per Thousand
PVC	Polyvinyl Chloride
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
RME	Reasonable Maximum Exposure
SB	Soil Boring
SC	Site Characterization
SDG	Sample Delivery Group
SDWA	Safe Drinking Water Act
SERA	Screening Ecological Risk Assessment
SMDP	Scientific Management Decision Point
SMP	Site Management Plan
SQG	Soil Quality Guidelines
SSL	Soil Screening Level
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TB	Trip Blank
TCL	Target Compound List
TDS	Total Dissolved Solids
TEF	Toxicity Equivalent Factor
TOC	Top of Casing
TTAL	Treatment Technique Action Limit
UCL	Upper Confidence Limit
ug/L	Micrograms per Liter
USCS	Unified Soil Classification System
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	Upper Tolerance Limit
UXO	Unexploded Ordnance
VOA	Volatile Organic Aromatic
VOC	Volatile Organic Compound

Executive Summary

Solid Waste Management Unit (SWMU) 7 is a former solid waste disposal site on the former Naval Ammunition Support Detachment (NASD) in the western portion of Vieques Island, Puerto Rico. In March 2004, the Draft Remedial Investigation (RI) Report for SWMU 7 was submitted for regulatory agency review. Samples were collected primarily adjacent to waste piles rather than directly through the waste piles (due to safety concerns), and the conclusions drawn based on those data were that the site does not pose an unacceptable risk to human health or the environment. While uncertainty is inherent (and at some level, acceptable) in all findings, conclusions, and decisions made in the environmental investigation and remediation process, the Navy and regulatory agencies have concurred that the uncertainty associated with the waste representing a potential future source of contamination and potential future risks is unacceptable.

In 2005, the Navy, United States Environmental Protection Agency Region II (USEPA), and the Puerto Rico Environmental Quality Board (PREQB) concurred that a waste removal action, coupled with a robust waste characterization and confirmatory sampling protocol, will address the uncertainty associated with waste representing a potential future source of contamination and ensure residual media concentrations are protective of human health and the environment. Prior to the removal action, soil samples will be collected across the disposal area, including within the waste piles, to determine the appropriate disposal alternative(s).

Following the removal action, confirmatory samples will be collected from the excavated area and a risk assessment will be performed to ensure residual media concentrations are protective of human health and the environment. The risk assessment will take into consideration the information presented in the Comprehensive Conservation Plan for the Vieques National Wildlife Refuge provided by the Department of Interior (DOI). Additionally, the risk assessment will be performed in accordance with the human health and ecological risk assessment protocols in the Master Quality Assurance Project Plan (CH2M HILL, May 2007).

In order to efficiently focus resources to achieve timely removal of the waste at SWMU 7 and confirm residual media concentrations are protective of human health and the environment, this report has been finalized as originally presented in draft form with the following modifications:

- Because the risk assessments for SWMU 7 are going to be redone using the confirmatory data collected as part of the removal action, the human health and ecological risk assessments have been relocated to Appendix L to help emphasize that they will be obsolete following the removal action and the fact that their findings are not the basis for conducting the removal action (i.e., removal is being conducted to address uncertainty of debris being a potential future source of contamination).
- All agency comments are presented in Appendix M.

- Rather than address individual agency comments, the substantial comment themes (e.g., uncertainties associated with sample locations, conclusions regarding potential risk, etc.), are acknowledged by text insertions (and some text deletions) throughout the final RI report to show that the findings/conclusions drawn by the Navy in the draft report are not necessarily concurred upon by the regulatory agencies, but that the uncertainties associated with the waste piles will be addressed by the removal action.

SWMU 7 is located approximately 1,100 feet south of Vieques Passage. The site is on a steep incline of 25 to 105 feet above mean sea level (msl), and is accessed by a dirt road extending southeast from Highway 200 to an ephemeral stream that is wet only after rainstorms. From the early 1960s to the late 1970s, this ephemeral stream was used for disposal of solid waste materials, including old tires, sheet metal, scrap metal, empty containers such as drums, cans, and bottles, used batteries, and construction rubble. The disposal activities were concentrated in a segment of the ephemeral stream approximately 300 feet along the length of the dirt access road where waste materials were pushed over the edge. Most of the material appears to be confined to the steep slopes, and no waste material has been observed upgradient of the slopes.

This RI was conducted to supplement the previous investigations to (1) characterize the nature and extent of environmental contamination associated with the site and (2) assess whether site-related contaminants pose an unacceptable risk to human health and the environment. Due to safety concerns, samples were collected adjacent to the debris piles, rather than directly through them. It is possible that additional constituents or constituents at higher concentrations would have been identified if samples had been collected through the waste piles. Therefore, there is uncertainty whether the conclusions drawn in the draft report with respect to human health and ecological risk would be the same if data from within and beneath the waste piles had been collected and included in the assessment. This uncertainty will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol. Human health and ecological risk assessments will be conducted using the post-removal confirmatory sampling data.

Remedial Investigation Activities

To meet the RI objectives, a number of tasks were completed, including the following:

- Examination of previous environmental investigations and contaminant-related activities completed at SWMU 7 to understand the physical characteristics, soil profiles, groundwater interfaces, and groundwater quality.

- Geophysical surveys to define the debris boundaries and avoidance and clearance surveys for possible presence of active munitions and explosives of concern (MEC) items, formerly known as unexploded ordnance (UXO). The debris boundaries have been identified. No MEC items were identified within the site during the MEC avoidance survey.

- Collection and interpretation of groundwater data in the SWMU 7 study area to establish baseline static groundwater levels.

- Collection of 15 surface soil and 11 subsurface soil samples for laboratory analysis and reporting.

- Installation of six additional permanent monitoring wells to supplement the existing monitoring well network constructed during the site characterization (SC) and preliminary assessment/site investigation (PA/SI) completed at SWMU 7 in 1999 and 2000, respectively.
- Collection of nine groundwater samples from existing and newly installed monitoring wells for laboratory analysis and reporting.
- Analysis of soil, groundwater, and sediment samples for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, perchlorate, pesticides, polychlorinated biphenyls (PCBs), and munitions-related chemicals.

The RI was completed in accordance with the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and followed the interim final *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (Environmental Protection Agency [EPA], 1988). A work plan for the proposed RI activities was reviewed by the CERCLA Technical Committee (CTC) consisting of representatives from the Navy, Puerto Rico Environmental Quality Board (PREQB), EPA, Department of the Interior (DOI), and others. The work plan was finalized after comments were received from these and the other participating agencies.

RI field program findings, archives data, and previous studies at the site were used to develop and update the conceptual site model (CSM) for SWMU 7. The CSM identifies and describes potential source areas, environmental media affected by past disposal activities, potential migration pathways for the contaminants across the media, and exposure points for the identified chemicals. The CSM also identifies the potential human and ecological receptors for SWMU 7 and their exposure routes based on current and future land use conditions and flow directions of groundwater and rainwater.

Nature and Extent of Chemical Distribution at SWMU 7

The discussion below is a summary of the nature and extent of contamination, based on the sample distribution from the Expanded PA/SI and RI. It should be noted that the representation of the nature and extent does not include data from directly through the waste piles, so it is possible that additional constituents or constituents at higher concentrations would have been identified if samples had been collected through the waste piles. This uncertainty will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol, the results of which will be presented in a removal action report.

All the samples were analyzed for metals, VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and explosives. Several metals and one SVOC, benzo(a)pyrene, were detected in surface soil samples above screening criteria. Pesticides, PCBs, and explosives were not detected above their applicable screening criteria in soil.

The site soils were sampled in 24 surface soil and 11 subsurface soil locations. The surface soil analytical results indicated the presence of inorganic chemicals in all of the samples. Polycyclic aromatic hydrocarbons (PAHs) were detected in surface soil samples, along with three pesticides (heptachlor, DDT, and DDE). Of these two PAHs, benzo(a)pyrene, and pyrene, and two pesticides, DDE and DDT were identified as exceeding the screening criteria. Subsurface soil had detections of inorganic chemicals. PAHs were detected in one sample. Of these chromium exceeded criteria. All the detected chemicals were included for human health and ecological risk assessment.

Several inorganic chemicals were detected in unfiltered (total metals) groundwater samples exceeding the maximum contaminant levels (MCLs) and/or risk-based concentrations (RBCs). Filtered (dissolved) metals results showed aluminum, iron, manganese, and vanadium above MCLs and/or RBCs. Metals were detected in all wells including the upgradient well, and no distribution patterns indicative of a release from the site were identified. The maximum arsenic and iron detections were in a sample taken in 2000 from NDW07MW01 (located 500 feet from the waste disposal area); however, this well was dry in 2003 and could not be sampled again. One well (NDW07MW03) in which low-level perchlorate was detected in 2000 was resampled in 2003 to confirm its presence, and perchlorate was not detected in that sampling. None of the other munitions/explosives-group chemicals were detected in any site groundwater or soil samples. The detected perchlorate analytical result was for a groundwater sample analyzed using EPA method 314.0. This method has become recognized by EPA and DoD as potentially unreliable as it often yields falsely elevated results, especially at low concentrations(<4 ug/L), as well as when used for analysis of other matrices such as soils, and confirmation is recommended for any detections by an alternative analytical method (DoD, 2004), as perchlorate is found in several commonly used laboratory detergents (Internal email from analytical lab STL, 2003, in Appendix J). Since the latest round of sampling did not indicate the presence of perchlorate, an alternative analysis was not needed. Therefore, it can be concluded that perchlorate's presence in site media is unlikely.

Fate and Transport Evaluation

The discussion below is a summary of the fate and transport of constituents, primarily those identified as contaminants, based on the sample distribution from the Expanded PA/SI and RI. It is recognized that there is uncertainty associated with constituents identified as contaminants and their associated concentrations because soil samples were not collected directly through the waste piles. It is possible that additional contaminants or contaminants at higher concentrations would have been identified under those circumstances. However, the general discussion of fate and transport is appropriate based on the data collected. Further, the removal action will address the potential contamination present in the waste, which will address the uncertainty associated with contaminant types and levels and their associated fate and transport.

A fate and transport evaluation was performed for potential contaminants at SWMU 7. The primary migration pathways for transport of contaminants from the disposal area are stormwater runoff down the steep slope of the upland area into the ephemeral stream and leaching of contaminants from soil and residual waste into groundwater.

Metals are ubiquitous at the site in soil and groundwater. The concentrations of inorganics in soil samples collected downgradient of the site were either less than or comparable to background concentrations, suggesting that surface runoff is not likely transporting metal contamination from the source area. Iron is the only metal detected above health protection-based concentrations and background levels in three of the surface soil samples. However, iron was not detected in any of the downstream soil samples above background, indicating that it is not likely migrating from the site. Elevated metals concentrations in groundwater samples may be a function of suspended solids or due to natural geochemical processes. The groundwater at the site has variable oxidative and reducing conditions. In several wells, hydrogen sulfide odor was reported, which indicates a reducing environment that is generally conducive to the presence of higher dissolved metals.

Human Health Risk Assessment

The discussion below is a summary of the HHRA conducted for SWMU 7, based on the data from the sample distribution discussed previously. It should be noted that the assessment of risk does not account for soil constituent concentrations within and beneath the waste piles, so there is uncertainty associated with the constituents of potential concern (COPCs) identified and the risk assessment conclusions drawn based on those COPCs. However, this is an uncertainty that will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol.

An HHRA was conducted to evaluate whether the elevated levels of COPCs detected above PRGs pose an unacceptable risk to human health. Detected chemicals were screened against criteria to determine the nature and extent of contamination. The chemicals identified as COPCs were inorganic chemicals, one PAH in soils, and perchlorate in groundwater based on one low-level detection. The inorganic chemicals were also present in background samples and are likely part of the natural soil mineralogy. Most metals in soil (with the exception of iron in three surface soil samples) were generally found at concentrations similar to those in background soils of the former NASD. Site groundwater metals in general were higher than those detected in the upgradient well (NDW07MW08) at the site but were found within the levels of facility-wide background wells. The only exceptions were arsenic, iron, and vanadium detected above background levels in selected wells at the site. All metals exceeding screening criteria in groundwater were included as COPCs in accordance with the conservative approach to risk estimation selected for this project. The recommendations were based on this screening analysis, results of the risk assessment, and comparisons with the background levels as appropriate for the inorganic chemicals.

This area is designated by the Puerto Rico Planning Board as a potential low-density residential and tourism area, with no specific plans for the site. Based on anticipated future land use considerations, the following potentially exposed populations were evaluated in the risk assessment:

- Maintenance workers
- Construction workers
- Industrial workers
- Recreational receptors (adult, youth, and child)
- Residential receptors (adult and child)

The residential scenario evaluated represents the most conservative exposure scenario available in a risk assessment. The estimated risks from soils were within the EPA's target risk range for maintenance workers, industrial workers, construction workers, and recreational receptors. The Hazard Index (HI) for soils was above the target risk range for the residential adult and child due to the presence of iron and vanadium in soils. The site soil concentrations of iron were above the human health Preliminary Remediation Goals

(PRGs) and background levels at three sample locations, and all of the vanadium detections were within the range of background.

The cancer risk from groundwater exposure through potable use was above the target cancer risk range due to the total arsenic level in the unfiltered sample from NDW07MW06. No arsenic was detected in the filtered groundwater sample from this well, indicating that the arsenic detected in the unfiltered sample is likely due to soil arsenic in suspended particulates. Furthermore, the monitoring wells within the identified waste area did not have arsenic above detection limits. Thus, the distribution of arsenic does not likely indicate association with the wastes. Therefore, the observed levels of arsenic and risks estimated from arsenic do not appear to be attributable to the site.

The non-cancer HI for groundwater was above 1 due to levels of iron and vanadium detected in some of the wells. The maximum iron levels in groundwater at the site were reported to be in the same well (NDW07MW01) where arsenic was reported in 2000. This well was dry and could not be resampled in 2003. All other iron levels from groundwater samples were within basewide background levels. All the detected vanadium levels in groundwater were within basewide background levels. The potable use assumption for site groundwater is a conservative assumption, as the site is located on a steep slope and installation of wells in the ephemeral stream is unlikely in the future.

Based on the results of the HHRA, site-related constituents do not likely pose an unacceptable risk for existing and anticipated land uses, but it is recognized that this conclusion is uncertain because samples were collected adjacent to the waste piles, rather than directly within or beneath them. Because there is uncertainty associated with the risk conclusions and the debris being a potential future source of contamination, the agencies have concurred that in order to address the uncertainty and ensure the residual media concentrations at the site are protective of human health, a removal action will be performed.

Ecological Risk Assessment

The discussion below is a summary of the ERA conducted for SWMU 7, based on the data from the sample distribution discussed previously. It should be noted that the assessment of risk does not account for potentially higher soil constituent concentrations within and beneath the waste piles, so there is uncertainty associated with the COPCs identified and the risk assessment conclusions drawn based on those COPCs. However, this is an uncertainty that will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol.

The ERA for SWMU 7 was conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) and the EPA *Ecological Risk Assessment Guidance for Superfund* (EPA, 1997a).

SWMU 7 has been undisturbed since the late 1970s and currently supports a diverse vegetative community of trees, shrubs, and vines, along with associated birds, reptiles, and some mammals. There is no aquatic habitat onsite. The exposure pathways evaluated in the ERA included direct exposure of wildlife to contaminants in the soil, as well as soil contaminants potentially accumulating in the onsite food web. Chemical data from 24 soil sampling locations within SWMU 7 were used in the ERA. Metals were detected in most of the samples, while organic chemical detections were infrequent.

Based on the results of the ERA, it was concluded that chemicals detected in soil do not likely pose unacceptable risks to directly exposed organisms and chemicals in the surface soil do not likely pose a risk to upper trophic level wildlife feeding on various prey at the site. Many of the metals detected onsite were generally comparable to background. Average concentrations of remaining soil metals and the few detected organic chemicals were either below screening ecotoxicity values or had a low magnitude of exceedance.
As with the HHRA conclusions, because the uncertainty associated with the ERA conclusions made in the draft report, the agencies have concurred that in order to address the uncertainty and ensure the residual media concentrations at the site are protective of the environment, a removal action will be performed.

Recommendations

Based on the results of the RI , the site conditions at SWMU 7 do not likely pose an unacceptable risk above background levels to human health or the environment. Based on this conclusion, no remedial actions would be recommended for the site. However, because there is uncertainty associated with the risk conclusions and unacceptable uncertainty associated with the debris being a potential future source of contamination, the agencies have concurred that in order to address the uncertainty and ensure the residual media concentrations at the site are protective of human health and the environment, a removal action will be performed.

Resumen Ejecutivo

La Unidad de Manejo de Desperdicios Sólidos 7 (SWMU, por sus siglas en inglés) es el antiguo sitio de disposición de desperdicios sólidos en el Antiguo Destacamento Naval de Apoyo de Municiones (NASD, por sus siglas en inglés) en la parte oeste de la isla de Vieques, Puerto Rico. En marzo del 2004, se sometió a las agencias reguladoras el Borrador al Reporte de Remediación para SWMU 7 (RI, por sus siglas en inglés). La mayoría de muestras se recolectaron de sitios adyacentes a las pilas de desechos y no fueron colectadas directamente de la pila de desechos (por motivos de seguridad), sin embargo se llegó a la conclusión de que el área no representa un riesgo inaceptable a la salud humana o al ambiente. Aunque en todos los resultados, conclusiones y decisiones que se toman en investigaciones ambientales y durante el proceso de remediación existe una incertidumbre inherente (y hasta cierto punto aceptable), la Marina y las agencias reguladoras acordaron en este caso que es inaceptable la incertidumbre asociada con la posibilidad de que los desechos que pudieran representar fuentes de contaminación potenciales (y los riesgos potenciales asociados).

En el 2005, la Marina, la Agencia de Protección Ambiental de los Estados Unidos Región II (USEPA, por sus siglas en inglés), y la Junta de Calidad Ambiental de Puerto Rico (JCA) acordaron que una acción de remoción de los desechos, en conjunto con un plan de caracterización de desechos robusto y un protocolo de confirmación de muestreo, atenderían la incertidumbre (duda) asociada de que estos deshechos pudieran representar una posible fuente de contaminación futura; la remoción también asegurará que las concentraciones residuales del medio protejan la salud humana y el ambiente. Antes de iniciar la acción de remoción, se colectarán muestras de suelos a lo largo del área de disposición (incluyendo muestras de dentro de las pilas de desechos) para determinar la(s) alternativa(s) de disposición adecuadas.

Una vez concluida la acción de remoción, se recolectarán muestras confirmatorias de dentro del área excavada y se llevará a cabo una evaluación de riesgo para re-asegurar que las concentraciones residuales del medio protegen la salud humana y el ambiente. La evaluación de riesgo considerará la información presentada en el Plan Abarcador de Conservación para el Refugio Nacional de Pesca y Vida Silvestre de Vieques presentado por el Departamento del Interior (DOI, por sus siglas en inglés). Además, la evaluación de riesgo se llevará a cabo en base a los protocolos establecidos para la evaluación de la salud humana y riesgo ecológico del Plan Maestro para el Proyecto de Control de Calidad (QUAPP, por sus siglas en inglés) (CH2M HILL, Mayo 2007). Para poder enfocar los recursos eficientemente y lograr la disposición de los desechos de SWMU 7 en un tiempo adecuado, y confirmar que las concentraciones residuales protegen la salud humana y el ambiente, este reporte se finalizó tal y como se presentó en el borrador original con las siguientes modificaciones:

- Debido a que la evaluación de riesgo para SWMU 7 será realizada nuevamente usando los datos confirmatorios que se obtendrán durante la acción de remoción, la evaluación de riesgo ecológico y a la salud humana se han movido al Anejo L, con el fin de enfatizar que éstos serán obsoletos una vez que se concluya la acción de remoción, y el hecho de que los resultados presentados en este anejo no son la base para llevar a cabo la acción de remoción (en este caso, se está implementando esta remoción para atender la incertidumbre de que desechos pudieran ser fuentes de contaminación en un futuro).

- Todos los comentarios de las agencias se presentan en el Anejo M.
- En vez de atender los comentarios individuales de las agencias, los grupos de comentarios sustanciales (por ejemplo, las incertidumbres asociadas con la localización de las muestras, conclusiones relacionadas a un riesgo potencial, etc.), se han atendido y se identifican con inserciones de texto nuevo (y borrando en algunos casos texto) a lo largo del ahora Reporte Final del RI, demostrando así que las agencias reguladoras no necesariamente estuvieron de acuerdo con los resultados/conclusiones de la Marina presentados en el Borrador del Reporte, es por eso que se acordó que la incertidumbre asociada con las pilas de desechos sean atendidas durante la acción de remoción.

SWMU 7 se encuentra aproximadamente a 1,100 pies al sur del Pasaje de Vieques. El sitio está localizado en la porción de los terrenos transferidos a DOI. El sitio se encuentra en una pendiente escarpada de 25 a 105 pies sobre el nivel del mar (msl), y se llega a él por una carretera sin asfaltar que se extiende desde el sureste de la carretera 200 hasta una corriente efímera que se humedece sólo después de lluvias tormentosas. Entre los años 1960s y 1970s, ésta corriente efímera se usó como sitio de disposición de desechos de materiales sólidos, incluyendo neumáticos, hojas de metal, desechos de metal, envases vacíos tales como contenedores, latas y botellas, baterías usadas, y materiales de construcción. Las actividades de disposición se concentraron en un segmento de la corriente efímera aproximadamente a 300 pies a lo largo del acceso a la carretera sin asfaltar donde los desechos de materiales han sido empujados sobre el borde. La mayoría de los materiales parecen estar confinados a las pendientes escarpadas y no se ha observado material de desecho declive arriba.

Este RI se llevó a cabo para suplementar las investigaciones previas y (1) caracterizar la naturaleza y extensión de la contaminación ambiental asociada al sitio, (2) evaluar si la contaminación relacionada al sitio posee un riesgo inaceptable para la salud humana y el ambiente. Por preocupaciones de seguridad, las muestras se tomaron adyacentes a las pilas de desechos, en vez de dentro de ellas. Es posible que se pueda identificar compuestos adicionales o concentraciones de compuestos más altas si es que se hubiera recolectado las muestras de la pila de desecho. Por lo que, existe cierta incertidumbre de que si las conclusiones a las que se llegó en el Borrador del Reporte con respecto al riesgo ecológico y a la salud humana serían las mismas si es que se hubieran obtenido las muestras de dentro y debajo de las pilas de desechos y si estos datos se hubieran incluido en las evaluaciones de riesgo. Esta incertidumbre será atendida por medio de la acción de remoción, la caracterización de los desechos y su protocolo de muestreo asociados. La evaluación de riesgo a la salud humana y la ecológica se llevarán a cabo usando los datos de muestras confirmatorias tomadas luego de la remoción.

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.

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Actividades de Investigación para la Remediación

Para alcanzar los objetivos del RI, se completó un número de actividades, incluyendo las siguientes:

- Se examinaron las investigaciones ambientales previas y las actividades completadas en SWMU7 relacionadas con la contaminación para entender las características físicas del sitio, los perfiles del terreno, interfaces del agua subterránea y la calidad del agua subterránea.
- Se realizaron investigaciones geofísicas para determinar los límites de los escombros y monitoreos de seguridad (evitar) para determinar la posible presencia de municiones activas y explosivos de preocupación (MEC por sus siglas en ingles), anteriormente conocidos como municiones sin explotar (UXO por sus siglas en ingles). Durante el monitoreo de seguridad no se encontraron artefactos MEC.
- Se recolectaron e interpretaron los datos de aguas subterráneas en el área de estudio del SWMU 7 para establecer líneas base de los niveles estáticos de aguas subterráneas.
- Se colectaron 15 muestras de superficie de suelo y 11 muestras de subsuelos para análisis y reporte de laboratorio.
- Se instalaron seis pozos de monitoreo permanentes adicionales para suplementar la cadena existente de pozos de monitoreo construidos durante la caracterización del sitio (SC, por sus siglas en inglés) y se completó una evaluación preliminar/ investigación del sitio (PA/SI, por sus siglas en inglés) para SWMU 7 en el 1999 y 2000, respectivamente.
- Se colectaron nueve muestras subterráneas de pozos de monitoreos existentes y recién instalados para análisis y reporte de laboratorio.
- Se analizaron muestras de suelos, aguas subterráneas y sedimentos para compuestos orgánicos volátiles (VOCs), compuestos orgánicos semi- volátiles (SVOCs), metales, perclorato, pesticidas, bifenilos policlorinados (PCBs), y sustancias químicas relacionadas con municiones.

El RI se completó de acuerdo con las provisiones de la Ley de Respuesta Ambiental, Responsabilidad y Compensación Comprensiva (CERCLA, por sus siglas en inglés) y el documento interino final de la Agencia de Protección Ambiental (EPA, por sus siglas en inglés) *Guidance for Conducting Remedial Investigations and Feasibility Studies* bajo *CERCLA* (EPA, 1988). El Comité Técnico de CERCLA (CTC, por sus siglas en inglés) que está formado por representantes de la Marina, Junta de Calidad Ambiental de Puerto Rico (JCA), Agencia de Protección Ambiental (EPA), Departamento del Interior (DOI), y otros revisó un Plan de Trabajo para las actividades RI propuestas. Se finalizó el Plan de Trabajo luego de recibir los comentarios de éstas y otras agencias participantes.

Se utilizaron los hallazgos del programa de campo RI, datos de archivos, y estudios previos en el sitio para desarrollar y actualizar el modelo conceptual del sitio (CSM, por sus siglas

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en inglés) para SWMU 7. El CSM identifica y describe áreas de fuentes potenciales, medios ambientales afectados por las actividades de disposición pasadas, vías de migración potenciales para los contaminantes a través del medio, y puntos de exposición para las sustancias identificadas. El CSM también identifica los receptores humanos y ecológicos potenciales para el SWMU 7 y sus rutas de exposición (contacto) en base a las condiciones de uso actual y futuro de tierras y las direcciones del flujo de aguas subterráneas y aguas de lluvia.

Naturaleza y Extensión de la Distribución de Sustancias Químicas *en* SWMU 7

Aquí se presenta un resumen de la naturaleza y extensión de la contaminación en base a la distribución de muestras del PA/SI y RI Extendido. Se debe notar que la representación de la naturaleza y extensión no incluye los datos de las pilas de desechos en sí, por lo que es posible que se pudieran haber detectado niveles más altos de constituyentes de dentro o directamente bajo las pilas de desechos. Se atenderá ésta incertidumbre a través de la acción de remoción y de la caracterización del protocolo de muestreo de confirmación de desechos, estos resultados se presentarán en el reporte de la acción de remoción.

Todas las muestras fueron analizadas para metales, VOCs, compuestos orgánicos semi-volátiles (SVOCs), pesticidas, bifenilos policlorinados (PCBs), y explosivos. Se detectaron sobre los criterios de evaluación varios metales y un SVOC, benzo(a) pirene en muestras de suelos de superficie. No se detectaron pesticidas, PCBs, y explosivos sobre los niveles de evaluación de suelo aplicables.

Se tomaron 24 muestras de suelos de superficie y 11 localizaciones de subsuelos. Los resultados analíticos de los suelos de superficie indicaron la presencia de sustancias inorgánicas en todas las muestras. En muestras de superficie se detectaron Hidrocarburos Aromáticos Policíclicos (PAHs), además de tres pesticidas (heptachloro, DDT, y DDE). De éstos dos PAHs, benzo(a)pirene, y pirene, y dos pesticidas, DDE y DDT excedieron los criterios de evaluación. En los subsuelos, se encontraron detecciones de sustancias orgánicas. Se detectaron PAHs en una muestra. Sólo cromo excedió los niveles de evaluación. Todas las sustancias químicas detectadas se incluyeron en la evaluación de riesgo ecológico y a la salud humana.

En aguas subterráneas sin filtrar (metales totales) se detectaron varias sustancias químicas inorgánicas excediendo los niveles máximos de contaminantes (MCLs por sus siglas en ingles) y/o concentraciones basadas en riesgo (RBCs por sus siglas en ingles). Los resultados de metales filtrados (disueltos) mostraron aluminio, hierro, manganeso y vanadio sobre MCLs y/o RBCs. En todos los pozos, incluyendo los pozos vertiente arriba se detectaron metales aunque no se identificaron en el sitio patrones de distribución indicativos de escapes. Las detecciones máximas de arsénico y hierro se encontraron en una muestra tomada en el año 2000 en el pozo denominado NDW07MW01 (localizado a 500 pies del área de disposición de desechos); sin embargo, este pozo se secó en el 2003 por lo que no pudo ser muestreado nuevamente. El pozo (NDW07MW03) en el cual se detectaron niveles bajos de perclorato en el 2000, fue re-muestreado en el 2003 para confirmar su presencia; durante este último muestreo

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no se detectó perclorato. En ninguna localidad las muestras de aguas subterráneas o muestras de suelo se detectaron otras sustancias químicas relacionadas a municiones/grupos de explosivos. El único resultado analítico de perclorato detectado proviene de una muestra de agua subterráneas analizada la que obtuvo usando el método 314.0 de la EPA. Este método ha sido reconocido por la EPA y DoD como no de confianza ya que frecuentemente presenta resultados elevados, especialmente en bajas concentraciones (<4 ug/L), así como cuando es usado para análisis de otros medios como suelos, y se recomienda sea confirmado para corroborar cualquier detección con un método analítico alternativo (DoD, 2004), debido a que el perclorato se encuentra en muchos detergentes comunes usados en los laboratorios (correo electrónico interno del laboratorio analítico STL, 2003, ver el Anejo J). Debido a que no se detectó perclorato en la última ronda de muestreo, no fue necesaria la verificación de los resultados siguiendo otro método alterno. Por lo tanto, se puede concluir que la presencia de perclorato en el sitio es poco probable.

Evaluación de Destino y Transporte

A continuación se presenta un resumen del destino y transporte de los compuestos, principalmente de aquellos que se identificaron como contaminantes, en base a la distribución de muestras tomadas durante el PA/SI y el RI. Se reconoce que hay cierta incertidumbre asociada con los compuestos identificados como contaminantes y las concentraciones asociadas debido a que las muestras de suelo no se tomaron directamente de dentro de las pilas de desechos. Es posible que otros contaminantes ó concentraciones más altas se pudieran haber detectado bajo éstas circunstancias. Sin embargo, en base a los datos obtenidos, ésta discusión general sobre el destino y transportación es adecuada. Más aún, la acción de remoción atenderá la incertidumbre asociada con los tipos, los niveles de contaminantes y el destino y transporte relacionados.

Para SWMU7 se llevó a cabo una evaluación del destino y transporte de los contaminantes potenciales. Los pasajes migratorios primarios para el transporte de los contaminantes desde el área donde los desechos fueron dispuestos son infiltración de lluvia hacia el subsuelo por medio de aguas de escorrentía hacia la corriente efímera y la lixiviación de contaminantes del suelo y desechos residuales a las aguas subterráneas. Los metales son ubicuos en el sitio y aguas subterráneas. En muestras de suelos recolectadas declive abajo del sitio las concentraciones de inorgánicos (metales) se encontraron concentraciones más bajas o comparables a las concentraciones de trasfondo, sugiriendo que es poco probable que las escorrentías de superficie transporten contaminación de metales desde el área fuente. En tres de las muestras de superficie de suelos, el hierro es el único metal que se detectó sobre los niveles de evaluación que protegen la salud y los niveles de trasfondo. Sin embargo, no se detectó hierro sobre el nivel de trasfondo en ninguna otra muestra de suelo de corriente abajo, indicando, que es poco probable la migración desde este sitio. Las concentraciones elevadas de metales en muestras de aguas subterráneas puede ser una función de sólidos suspendidos o debido a procesos geo-químicos naturales. El agua subterránea de este sitio tiene oxidantes variables y condiciones reductoras. En varios pozos

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se reportó olor de sulfuro de hidrógeno, lo cual indica un ambiente reducido que generalmente conduce a la presencia de concentraciones más altas de metales disueltos.

Evaluación de Riesgo a la Salud Humana

La información que se presenta a continuación es un resumen del HHRA preparado para el SWMU 7, basado en la distribución de muestras previamente discutidas. Debe tomarse en cuenta que la evaluación de riesgo no incluye concentraciones de sustancias químicas dentro y debajo de las pilas de desechos, por lo que existe cierta incertidumbre asociada con los Constituyentes de Preocupación Potencial (COPCs, por sus siglas en inglés) identificados y las conclusiones de la evaluación de riesgo basados en dichos COPCs. Sin embargo, esta es una incertidumbre que será atendida durante la acción de remoción, junto con la caracterización del sitio y el protocolo de muestreo confirmatorio.

Se realizó el HHRA para evaluar si las concentraciones de COPCs que exceden los PRGs presentan un riesgo inaceptable a la salud humana. Las sustancias químicas detectadas fueron clasificadas contra los criterios de evaluación para determinar la naturaleza y extensión de la contaminación. Las sustancias químicas identificadas como COPCs incluyeron sustancias químicas inorgánicas (metales), un PAH en suelos, y una detección de bajo nivel de perclorato en aguas subterráneas. Las sustancias químicas inorgánicas también estuvieron presentes en muestras de trasfondo y posiblemente sean parte de la mineralogía de los suelos naturales. La mayoría de los metales en el suelo (con la excepción del hierro en tres muestras de suelos de superficie) se encontraron generalmente en concentraciones similares a aquellos en suelos de trasfondo en el Antiguo NASD. Los metales en las aguas subterráneas del sitio generalmente se encontraron en concentraciones mayores que aquellos detectados en el pozo vertiente arriba (NDW07MW08), pero están dentro de los niveles de trasfondo de pozos localizados en todo lo largo de la instalación (facilidad). Las únicas excepciones fueron arsénico, hierro y vanadio que se detectaron sobre los niveles de trasfondo en pozos del sitio seleccionados. Todos los metales que excedieron los niveles de evaluación en aguas subterráneas se incluyeron como COPCs de acuerdo con el acercamiento conservador de riesgo estimado seleccionado para este proyecto. Las recomendaciones se basan en estos análisis de clasificación, resultados de la evaluación de riesgo, y la comparación con los niveles de trasfondo para los las sustancias inorgánicas adecuadas.

Esta área ha sido designada por la Junta de Planificación de Puerto Rico como un área de turismo y baja densidad poblacional, con ningún plan especifico para este sitio. Basado en el uso anticipado del sitio, se evaluaron las siguientes poblaciones potencialmente expuestas:

- Trabajadores de mantenimiento
- Trabajadores de construcción
- Trabajador Industrial
- Receptores recreativos (adultos, jóvenes, y niños)
- Receptores residenciales (adultos y niños)

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El escenario residencial evaluado representa el escenario de exposición más conservador disponible en una evaluación de riesgo. El riesgo estimado de los suelos se encontraba dentro del criterio de riesgo de la EPA para trabajadores de mantenimiento, trabajadores industriales, trabajadores de construcción, y receptores recreativos. El Índice de Peligro (HI, por sus siglas en inglés) para suelos estaba por sobre el criterio de riesgo para el adulto y niño residencial debido a la presencia de hierro y vanadio en suelos. Las concentraciones de hierro en los suelos del sitio estaban sobre las Metas de Remediación Preliminares de la salud humana (PRGs) y los niveles de trasfondo en tres localizaciones de muestreo, todas las detecciones de vanadio estaban dentro del rango de las concentraciones de de trasfondo.

El riesgo de cáncer por exposición al agua subterránea a través del uso potable excede el criterio de riesgo de cáncer debido a los niveles de arsénico total en las muestras sin filtrar del pozo NDW07MW06. No se detectó arsénico en las muestras de aguas subterráneas filtradas de este pozo, lo que indica que probablemente el arsénico detectado en la muestra sin filtrar se deba a partículas de arsénico suspendidas en el suelo. Además, los otros pozos de monitoreo dentro del área de desechos identificada no muestran arsénico sobre los limites de detección. Por lo tanto, la distribución de arsénico no parece estar asociada a los desechos. Por lo tanto, los niveles de arsénico observados y sus riesgos estimados no parecen poder ser atribuida al sitio.

El HI no cancerígeno para aguas subterráneas estaba sobre 1 debido a los niveles de hierro y vanadio detectado en algunos de los pozos. Los niveles máximos de hierro en aguas subterráneas en el sitio fueron reportados en el mismo pozo (NDW07MW01) donde también se reportó arsénico en el 2000. Este pozo estaba seco y no pudo ser muestreado en el 2003. Todos los otros niveles de hierro muestreados de aguas subterráneas se encontraban dentro del rango de niveles de trasfondo. Todos los niveles de vanadio detectados en aguas subterráneas estaban dentro de los niveles de trasfondo. Si se asume el uso potable del agua subterránea del sitio, es una acción conservadora, ya que el sitio está localizado en una pendiente escarpada y es muy poco probable la instalación de pozos en la corriente efímera en un futuro.

Basado en los resultados del HHRA, los constituyentes relacionados con el sitio probablemente no presentan un riesgo inaceptable para el uso actual o anticipado para sitio, pero se reconoce que esta conclusión es incierta debido a que las muestras del suelo fueron tomadas junto a las pilas de desechos, en vez de tomarse directamente dentro y debajo de ellos. Debido a que existe incertidumbre asociada con las conclusiones de la evaluación de riesgo y los desechos y el potencial de que se conviertan en una fuente de contaminación en un futuro, las agencias acordaron implementar una acción de remoción para despejar así esta incertidumbre y asegurar que las concentraciones residuales protegen la salud humana.

Evaluación de Riesgo Ecológico

La información que se presenta a continuación es un resumen del ERA preparado para el SWMU 7 en base a la distribución de los datos de las muestras previamente discutidas. Debe

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de considerarse que la evaluación de riesgo ecológico no incluye la posibilidad de obtener concentraciones más altas de muestras de dentro y debajo de las pilas de desechos, por lo que hay cierta incertidumbre con los COPCs identificados y las conclusiones presentadas en una evaluación de riesgo basadas en dichos COPCs. Sin embargo, ésta es una incertidumbre que será tratada durante la acción de remoción, junto con la caracterización y el protocolo de muestreo de confirmación.

Se llevó a cabo el ERA para el SWMU 7 de acuerdo con el *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) y el *Ecological Risk Assessment Guidance for Superfund de la EPA* (EPA, 1997a).

SWMU 7 no ha sido perturbado desde finales de los años 1970s y actualmente sostiene una comunidad de vegetación diversificada que incluye árboles, arbustos y viñas, además de pájaros, reptiles y ciertos mamíferos. No se encuentran hábitats marinos en el sitio. Las vías de exposición evaluadas en el ERA incluyen exposición directa de vida silvestre a los contaminantes en el suelo, así como contaminantes que potencialmente se estén acumulando en la cadena alimenticia del sitio. Se usaron dentro del ERA los datos químicos de 24 localizaciones de muestreo de suelos dentro del SWMU 7. Se detectaron metales en la mayoría de las muestras, mientras que las detecciones orgánicas se encontraron con menor frecuencia.

En base a los resultados del ERA, se concluye que no es probable que las substancias químicas presentes en el suelo presenten un riesgo inaceptable a los organismos expuestos directamente, y las sustancias químicas en la superficie del suelo no parece presenta un riesgo a la comunidad trófica superior que se alimentan de varias presas en este sitio. Varios de los metales detectados en el sitio, son comparables con las concentraciones de trasfondo. Las concentraciones promedio de los otros metales y algunos compuestos orgánicos detectados, se encuentran por debajo de los valores ecotóxicos o excedieron levemente estos valores.

Al igual que las conclusiones presentadas en el HHRA, debido a la incertidumbre asociada con las conclusiones del ERA presentadas en el Borrador del Reporte, las agencias acordaron que para tratar la incertidumbre y asegurar que las concentraciones residuales en los diferentes medios protegen el medio ambiente, se implementará una acción de remoción.

Recomendaciones

Basado en los resultados del RI, las condiciones del sitio en el SWMU 7 no parecen presentar un riesgo inaceptable sobre los niveles de trasfondo a la salud humana o al ambiente. En base a esta conclusión, no se recomienda implementar acciones de remediación para el sitio. Sin embargo, debido a que hay cierta incertidumbre asociada con las conclusiones de la evaluación de riesgo y una incertidumbre inaceptable asociada con los desechos como fuentes potenciales de contaminación en un futuro, las agencias acordaron implementar una acción de remoción para tratar la incertidumbre asociada y asegurar que las concentraciones residuales en el sitio protegen la salud humana y el medio ambiente.

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SECTION 1

Introduction

This Remedial Investigation (RI) report presents the results of the RI completed at Solid Waste Management Unit (SWMU) 7 in the former Naval Ammunition Support Detachment (NASD), Vieques Island, Puerto Rico. This RI report incorporates results from previous investigations conducted at SWMU 7. In March 2004, the Draft RI Report for SWMU 7 was submitted for regulatory agency review. Samples were collected primarily adjacent to waste piles rather than directly through the waste piles (due to safety concerns), and the conclusions drawn based on those data were that the site does not pose an unacceptable risk to human health or the environment. While uncertainty is inherent (and at some level, acceptable) in all findings, conclusions, and decisions made in the environmental investigation and remediation process, the Navy and regulatory agencies have concurred that the uncertainty associated with the waste representing a potential future source of contamination and potential future risks is unacceptable.

In 2005, the Navy, United States Environmental Protection Agency Region II (USEPA), and the Puerto Rico Environmental Quality Board (PREQB) concurred that a waste removal action, coupled with a robust waste characterization and confirmatory sampling protocol, will address the uncertainties associated with the findings and conclusions of the RI Report and ensure residual media concentrations are protective of human health and the environment. Prior to the removal action, soil samples will be collected across the disposal area, including within the waste piles, to determine the appropriate disposal alternative(s).

Following the removal action, confirmatory samples will be collected from the excavated area and a risk assessment will be performed to ensure residual media concentrations are protective of human health and the environment. The risk assessment will take into consideration the information presented in the Comprehensive Conservation Plan for the Vieques National Wildlife Refuge provided by the Department of Interior (DOI). Additionally, the risk assessment will be performed in accordance with the human health and ecological risk assessment protocols in the Master Quality Assurance Project Plan (CH2M HILL, May 2007).

In order to efficiently focus resources to achieve timely removal of the waste at SWMU 7 and confirm residual media concentrations are protective of human health and the environment, this report has been finalized as originally presented in draft form with the following modifications:

- Because the risk assessments for SWMU 7 are going to be redone using the confirmatory data collected as part of the removal action, the human health and ecological risk assessments have been relocated to Appendix L to help emphasize that they will be obsolete following the removal action and the fact that their findings are not the basis for conducting the removal action (i.e., removal is being conducted to address uncertainty of debris being a potential future source of contamination).
- All agency comments are presented in Appendix M

Rather than address individual agency comments, the substantial comment themes (e.g., uncertainties associated with sample locations, conclusions regarding potential risk, etc.), are acknowledged by text insertions (and some text deletions) throughout the document to show that the findings/conclusions drawn by the Navy in the draft report are not necessarily concurred upon by the regulatory agencies, but that the uncertainties associated with the waste piles will be addressed by the removal action.This report has been prepared for the Commander of the U.S. Navy's Atlantic Fleet and the Naval Facilities Engineering Command (NAVFACENGCOM), Atlantic Division (LANTDIV or Atlantic Division) by CH2M HILL under Navy Contract N62470-02-D-3052, Navy Comprehensive Long-Term Environmental Action (CLEAN), District III, Contract Task Order 007.

1.1 Purpose and Scope

This RI was designed to accumulate sufficient site data to characterize the nature and extent of contamination from the known or suspected sources on site; to assess potential human health and ecological risks; and to evaluate recommendations for remedial actions, if any, from site data. To achieve this, the following primary objectives were developed for executing this project:

1. Complete a field data collection program to evaluate the type, extent, and magnitude of contamination present in site media (soils and groundwater);
2. Determine the current and potential future risks to human health and the environment from the analytical results from site media and the planned future land use for the site.

To meet these two objectives, a number of field-specific tasks were implemented at the site. A work plan and a sampling and analysis plan (CH2M HILL, 2003b) were prepared for gathering information from field activities that would help form conclusions on the potential site risks posed by surface and subsurface contamination within the study area. These tasks included:

- Examination of previous environmental investigations and construction activities completed within SWMU 7 to evaluate and establish a baseline of the physical characteristics and contamination conditions using previous investigation results
- Surveys at potential sampling locations to identify, define, and clear scrap metal and solid wastes that may be related to MEC
- Collection of additional analytical data to determine the nature and extent of previously identified COPCs in the SWMU 7 area through sampling surface and subsurface soil, groundwater, and downgradient sediment
- Collection and interpretation of data on groundwater levels to establish baseline static groundwater levels within the SWMU 7 study area
- Installation of subsurface soil borings to further classify the subsurface geologic profile
- Installation of permanent monitoring wells to supplement the monitoring well network constructed during the SC and Expanded PA/SI completed at SWMU 7 in 2000

- Sampling for groundwater from existing and newly installed monitoring wells for submittal for laboratory analysis and reporting

The scope for the RI field program was completed in accordance with the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and followed the interim final Environmental Protection Agency (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988).

1.2 Report Organization

As indicated above, the main objective of the SWMU 7 RI was to collect sufficient data to make remedial action recommendations for the site. Because the Navy and regulatory agencies have concurred that a removal action will be conducted, the objective of investigation has been met even though there is uncertainty associated with the findings, conclusions, and recommendations of this report. The removal action will remove debris and potentially contaminated soil posing an unacceptable risk to human health and the environment. Pre-removal waste profiling sampling will be conducted to determine the appropriate disposal alternative(s) for the debris and soil. Confirmatory sampling and human health and ecological risk assessments will be conducted following the removal action to ensure residual media concentrations are protective of human health and the environment.

This RI Report contains 7 sections, presented in Volume I, and 13 appendixes, presented in Volume II. The sections in Volume I are organized as follows:

Section 1. Introduction presents a summary of the purpose and scope of the RI and the organization of this report**.**

Section 2. Physical Setting, Site History, and Previous Investigations presents general information about SWMU 7, such as its former uses, climate, topography, and natural and cultural resources, as well as a discussion of the regulatory status of the site.

Section 3. Summary of Field Investigation -- presents site-specific descriptions and summaries of the various tasks completed as part of the RI for SWMU 7 and the approach, methods, and operational procedures employed to perform these tasks. In addition, this section presents the data management and quality control measures used during collection of SWMU 7-related data and a data quality evaluation (DQE) of analyzed data.

Section 4. Nature and Extent of Contamination presents the nature and extent of soil and groundwater contamination present at SWMU 7.

Section 5. Contaminant Fate and Transport presents a CSM and discussion that evaluates the potential for site chemicals to migrate downgradient or vertically downward to deeper soils or groundwater using the results of the previous sections and information on site physical characteristics, nature of chemicals detected, contaminant source characteristics, and extent of contamination.

Section 6. RI Conclusions and Recommendations presents the conclusions and recommendations from the RI conducted at the site.

Section 7. References presents a list of sources cited in this RI report or used in developing it.

A human health risk assessment (HHRA) and a screening ecological risk assessment (SERA), constituting Steps 1 and 2 of the ecological risk assessment (ERA) process and the first step (Step 3) of a baseline ecological risk assessment (BERA), were conducted for SWMU 7, as proposed in the work plan (CH2M HILL, 2003). These risk assessments are presented in Appendix L. It is important to emphasize that the risk assessment conclusions are based on the data discussed in Section 4. There is recognized uncertainty associated with the number, type, and concentrations of soil contaminants at the site because soil samples were generally collected adjacent to the waste piles, rather than directly through them, due to safety concerns. This may have resulted in an underestimation of the soil contaminant levels and, therefore, the potential risks posed by the contamination. While the results of the HHRA and ERA summarized in Appendix L are appropriate for the data collected, the level of uncertainty associated with the HHRA and ERA conclusions as they relate to the site as a whole (i.e., including the waste piles themselves) warrants action to address the uncertainty. It is the planned removal action, and its associated waste characterization and confirmatory sampling protocol, that will appropriately address this uncertainty. Additionally, the removal action will address the waste as a potential future source of contamination.

It is also important to note that since the HHRA and ERA were performed for the draft report, some information utilized in the risk assessments may have changed, and more will change as a result of the planned removal action. For example, published toxicity values and other health-based criteria for various chemicals have been modified. Another example is that specifics about the future land use have become known. In August 2007, the DOI issued the Comprehensive Conservation Plan for the Vieques National Wildlife Refuge (USDOI, October 2006), which provides details of planned land uses. In order to efficiently focus resources to achieve timely removal of the waste at SWMU 7 and confirm residual media concentrations are protective of human health and the environment, the HHRA and ERA in this report have been finalized as originally presented in draft form, rather than modified with the updated information, because new site data will be collected as part of the removal action and a new risk assessments performed. These new risk assessments will incorporate new information about future land uses and the most up-to-date risk criteria. Further, the new risk assessments will be performed in accordance with the HHRA and ERA protocols in the Master Quality Assurance Project Plan (CH2M HILL, May 2007). Therefore, the HHRA and ERA presented in this RI Report were moved to Appendix L because they will not be representative of the site as a whole once the removal action takes place and, hence, will be re-performed.

SECTION 2

Physical Setting, Site History, and Previous Investigations

This section presents the site setting, history, and previous environmental investigations conducted at SWMU 7. This section also contains brief descriptions of natural and cultural resources in the former NASD and the regulatory status of the site.

2.1 Location

Figure 2-1 illustrates the location of Vieques Island, Puerto Rico, in the Caribbean Sea approximately 7 miles southeast across Vieques Passage from the eastern tip of the main island of Puerto Rico. Vieques is the second-largest island in the Commonwealth of Puerto Rico. It is approximately 20 miles long and 3 miles wide, with an area of 33,088 acres, or 51 square miles.

The SWMU 7 site is part of the former NASD area on the western side of Vieques Island; SWMU 7 is approximately 1,100 feet south of Vieques Passage at the coordinates of 18° 07′ 04.36″ N latitude and 65° 32′10.94″ W longitude. The site is on a steep incline of 25 to 105 feet above msl; it is accessed by a dirt road extending southeast from Highway 200 to an ephemeral stream. This stream, which is wet only after rainstorms, was used for solid waste disposal. In the past, disposal activities were concentrated along a segment on the eastern edge of the stream approximately 300 feet in length along the dirt road where waste materials were pushed over the edge. The bulk of the material is confined to the steep slopes of the ephemeral stream, and no waste material has been observed upgradient of the slopes. Figure 2-2 shows the location of SWMU 7 within the former NASD property and its location within the property transferred to the Municipality of Vieques (MOV), along with the approximate waste boundaries assessed in the geophysical survey.

2.2 Site History and Past Operations

2.2.1 History

The disposal site was used by the U.S. Navy between the early 1960s and late 1970s. The discarded material includes old tires, sheet metal, empty containers such as drums, cans, and bottles, used batteries, and construction rubble. No known hazardous chemical or waste disposal occurred at this site. A visual site inspection was conducted by an MEC avoidance team, and a magnetometer survey was conducted within the sampling locations as part of the MEC avoidance survey as a safety measure prior to intrusive sampling work at SWMU 7 during the Expanded PA/SI. The survey concluded that no unexploded ordnance (UXO) or ordnance and explosives (OE) were identified throughout the sampling areas, however Ordnance Related Scrap (ORS) was identified which does not pose a safety concern at SWMU 7. Dense vegetation is present throughout the area, making it difficult to access the site for investigation purposes. Figure 2-3 is an aerial photograph of SWMU 7 that shows the dense vegetation at the site.

2.2.2 Former Operations

No activity at SWMU 7 has been reported since the late 1970s. The U.S. Navy ceased facility-wide operations on the former NASD on April 30, 2001, in accordance with the January 30, 2000, Presidential Directive to the Secretary of Defense relating to the transfer of lands of the Navy-owned western portion of Vieques. The land transfer was completed on May 1, 2001, and the Navy has had no presence at the main operational area since that date. Additional land transfer details are provided in Section 2.7 regarding the regulatory status of the site.

The main operational area of the former NASD remained largely undisturbed from May 2001 until early 2003, when the MOV began using a few of the buildings for public works vehicle storage and maintenance activities. SWMU 7 is located within the area transferred to the MOV on May 1, 2001. The site currently is not being used.

2.3 Physical Setting

2.3.1 Weather and Climate

The climate of Vieques is tropical-marine. Temperatures are nearly constant at an annual average of about 79°F; August is the warmest month at 82°F average and February the coolest at 76°F (Greenleaf/Telesca, 1984). Vieques lies directly in the path of the prevailing easterly trade winds that 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 to November. Heavy precipitation may be induced by tropical storms from June to November, which is considered normal for this area of the Caribbean. The western part of the island, where the site is located, averages approximately 50 inches of rainfall per year, 50 percent of which occurs during the rainy season (United States Geological Survey [USGS], 1989).

2.3.2 Topography

The topography of the former NASD is characterized by low hills and small valleys intersected by a series of ephemeral streams. The highest elevations occur along a west-to-east axis near the center of the former NASD. The highest point is Mount Pirata, approximately 987 feet above sea level. In general, the former NASD slopes gradually from the center to the coastal areas, with the exception of steep slopes in the vicinity of Mount Pirata.

Topography at SWMU 7 is characterized by a gently sloping hill but very steep embankments along an ephemeral stream, which runs north toward Vieques Passage. The ephemeral stream varies from 20 to 40 feet in width and 10 to 20 feet in depth. The site elevation is 25 to 105 feet above msl, as shown in Figure 2-4.

2.3.3 Vegetation

Most of the former NASD property is undeveloped and heavily vegetated with trees and low-lying thorny brush (Geo-Marine, 2000).

Historically, portions of this site were cleared, but clearings have been discontinued long enough for the plant community to become reestablished in the upland area. This plant community consists of shrub and tree canopy layers that provide nearly 100 percent cover in some areas. The dominant shrubs in this community are wild tamarind, *Foresteria eggersiana*, and catch and keep, also called white police. The area has a lower density of trees; tree species such as bastard mahogany and manjack were the dominant species observed in the plant community. The dense canopy has precluded the development of a herbaceous stratum. *Lasiacis divaricata* was present in scattered areas. No vegetation stresses were observed at SWMU 7. The ephemeral stream is also heavily vegetated with shrubs and mature trees established on the banks and streambed.

2.3.4 Geology

The geology of western Vieques is characterized by plutonic rocks generally overlain by alluvial deposits. The plutonic rocks consist of granodiorites that were intruded by a quartz-diorite plutonic complex; they are exposed over a large part of the island. A gradual change in texture from coarse- to fine-grained quartz-diorite has been observed from western to eastern Vieques. A saprolite formation occurs at the surface of the plutonic complex. The alluvial deposits are generally of Quaternary age, consisting of a mixture of sand, silt, and clay that together have an average thickness of 30 feet in western Vieques. The sediments consist of alluvial deposits, beach and dune deposits, and swamp and marsh deposits. The floodplains consist of beach and dune deposits formed by calcite, quartz, plutonic rock fragments, and minor magnetite (USGS, 1989).

More specific geologic profiles for SWMU 7 were developed through the evaluation of soil boring logs and the associated geologic cross-section (Figure 2-5). Soil samples collected during the installation of soil borings and monitoring wells associated with the Confirmation Study (CS) completed in 1988, the Expanded PA/SI completed in 2000, and this RI indicate that the soils encountered beneath SWMU 7 consist of a mixture of silty sand from ground surface to a depth of 4 to 8 feet below land surface (bls), followed by a saprolite or weathered granodiorite (plutonic rock). Soil colors ranged from primarily yellowish brown in the silty sand to a greenish gray in the saprolite.

The materials in this silty sand zone generally exhibit low plasticity when moist, are medium dense when dry, and are easily crumbled under hand pressure. The materials in the saprolite zone exhibit low plasticity when moist, are generally soft, and can be easily crumbled under hand pressure.

Geologic logs prepared from soil borings completed during the RI at SWMU 7 indicate similar subsurface geology as documented in prior investigations at the site, including the CS and Expanded PA/SI. Four soil borings were completed for well installation along with 10 shallower (1.5- to 4-foot) soil borings for soil sampling purposes. Most of the geology consists of silty sand and weathered granodiorite (saprolite) at the site. The SWMU 7 area does not contain the 30-foot-thick sediment units described in the USGS 1989 study. The water-bearing layer (the silty sand) is within the top 8 feet of SWMU 7 and is relatively dry. This sandy layer appears much thinner than sediments described in the Mount Pirata area by the USGS. The water-bearing zone (within the saprolite) is located approximately 75 feet bls in the disposal area.

2.3.5 Hydrology

Surface water on the former NASD consists of several lagoons and intermittent streams. Most of the streams on the former NASD are ephemeral, flowing only for a short time after rainstorms. These streams are located throughout the former NASD, generally flowing in a northerly direction.

Water flows in the ephemeral stream at SWMU 7 only in the event of a rainstorm. Distinct scouring marks along the embankment indicate rapid flows during storm events. No standing water has been observed in the streambed during any of the recent sampling events. The ephemeral stream drains to the north through a culvert under Highway 200 to Vieques Passage.

The Resolución Valley aquifer, estimated by the USGS to extend across much of northwestern Vieques Island, is the only known groundwater aquifer on the former NASD property that contains potentially potable water. The Navy installed the only potable wells on the island but plugged and abandoned all potable wells in the summer of 2000 as part of the transfer process. The Resolución Valley encompasses approximately 8 square miles and slopes from Mount Pirata toward Vieques Passage. No perennial streams are present in the valley, although this area receives more rainfall than any other area of Vieques. The geology of the Resolución Valley aquifer consists of sedimentary deposits that overlie a saprolite formation derived from plutonic rocks. Geophysical surveys show that the thickness of alluvial deposits averages approximately 30 feet (USGS, 1989).

SWMU 7 is underlain by a potentially semiconfined groundwater system, which is composed of alluvial deposits made up of silty sands and weathered granodiorite (saprolite). Groundwater was encountered at the site at a depth of 75 feet bls during monitoring well installation; however, the water levels eventually stabilize at depths of approximately 33 to 71 feet bls. The Resolución Valley aquifer does not occur under this site. General groundwater flow is to the north in the direction of Vieques Passage. At SWMU 7 the local groundwater flow is in a northwesterly direction. Figure 2-6 illustrates the groundwater flow direction at the site.

2.4 Wildlife

During the wildlife survey conducted on this site, a few species such as red-tailed hawk, bananaquit, adilaidae warbler, green-throated carib, pearly eyed thrasher, northern mockingbird, Puerto Rican lizard cuckoo, Louisiana waterthrush, loggerhead shrike, gray kingbird, white-winged dove, and anolis lizards were observed. No federally protected species or preferred habitat were observed at this site. The bird species observed consisted of coastal forest and shore species. Numerous anolis lizards were also observed at this site. There was no evidence that past waste disposal activities at SWMU 7 have had an impact on the wildlife or on wildlife habitat.

2.5 Cultural Resources

A number of resources on the former NASD property are of interest from a cultural perspective, including conservation zones, cultural resources, and prehistoric and historic sites. U.S. Navy surveys have located more than 100 sites on Vieques with the potential to contain significant cultural resources. Eleven of these sites are listed in the National Registry of Historic Places (NRHP).

The sugarcane industry was the major economic base of Vieques during the late 19^{th} century and early 20^{th} century. Several sugarcane factories operated at or near the former NASD property, including the Arcadia, Playa Grande, Resolución, and Santa Elena factories. Sugarcane operations in Vieques were largely discontinued in the early 1940s when the U.S. Navy purchased large portions of the island; operations were discontinued entirely by the early 1950s.

A total of 17 archeological sites and districts are listed on the NRHP for Vieques, with 12 of these on the western end of the island (Geo-Marine, 1996). This information has been confirmed in the review of other cultural resource maps of Vieques. None of these 12 archeological sites occurs within the SWMU 7 area. No cultural resources are expected to be encountered at SWMU 7 based on its history and lack of documented evidence of such resources.

2.6 Summary of Previous Investigations

Several investigations have been conducted on the site to evaluate the presence of contaminants from the historical disposal operations in the 1960s through the late 1970s. These investigations included analyses of soil, subsurface soil, and groundwater and ecological surveys of the habitats and wildlife occurrences. Table 2-1 presents a summary the previous investigations to date and the findings.

2.6.1 Confirmation Study, 1988

A CS was conducted at SWMU 7 in 1988 to evaluate potential contamination from the historical Navy disposal activities (ESE, 1988). Three groundwater samples, six soil samples, and three sediment samples were collected and analyzed for pH, priority pollutants, oil and grease, VOCs, methyl ethyl ketone (MEK), methyl isobutyl ketone, ethylene dibromide, chromium (total and hexavalent), xylene, and lead. The study found that the metals cadmium, total chromium, and nickel exceeded drinking water and ambient water quality criteria in groundwater. No soil or sediment samples collected had elevated levels of chemicals of concern (COCs) for this site. Metals were the only chemicals that were detected in the groundwater samples. These metals are generally representative of background levels. Therefore, this report recommended no additional investigation of the site.

2.6.2 Expanded PA/SI, 2000

CH2M HILL performed field activities related to the Expanded PA/SI in April and May 2000. Two groundwater monitoring wells were installed, since two of the previous wells could not be found at the locations (ESE, 1988). In addition, six surface soil samples and three sediment (dry streambed soil) samples were collected. The samples were analyzed for metals, VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), and explosives. Concentrations of the chemicals were compared to EPA Region 3 Risk-Based Concentrations (RBCs) screening criteria for each matrix.

In analytical results from unfiltered (total metals) groundwater samples, aluminum, antimony, arsenic, iron, manganese, vanadium, and zinc were detected at concentrations exceeding the maximum contaminant levels (MCLs) and/or RBCs. Filtered metals (dissolved) results showed aluminum, iron, manganese, and vanadium above MCLs and/or RBCs. Metals were detected in all wells including the upgradient well and are likely indicative of background concentrations, not site-related activities. One well (NDW07MW03R) in which low-level perchlorate had been detected was resampled to confirm the presence of perchlorate; perchlorate was not detected.

Above-criteria concentrations of aluminum, arsenic, chromium, copper, iron, lead, manganese, thallium, vanadium, and benzo(a)pyrene were detected in surface soil samples. The metals were in similar concentrations and were regarded as not site-related. Benzo(a)pyrene was detected at low concentrations slightly exceeding the residential RBC. Pesticides, PCBs, and explosives were either not detected or detected below their applicable screening criteria.

Several metals at concentrations exceeding the ecological screening criteria and lower than background concentrations were detected in sediment (dry streambed soil) samples; these are not likely due to site-related activities. All VOCs, SVOCs, pesticides, PCBs, and explosives were either not detected or detected below their applicable screening criteria.

An MEC avoidance survey noted the presence of ORS (ordnance-related scrap) items in the ephemeral stream; however, no UXO/OE items were found and thus present no safety-related concerns at the site.

The Expanded PA/SI report found no evidence to suggest that a release of hazardous materials to surface soil has occurred at this site as a result of site-related activities. However, a risk assessment was recommended for constituents detected in the groundwater above risk-based criteria. Additional surface soil sampling through the full RI process was recommended to delineate the extent of benzo(a)pyrene, along with a recommendation to conduct a soil background investigation.

2.7 Regulatory Status

The investigations of SWMU 7 are being conducted in accordance with the CERCLA process. The PA/SI and RI were conducted with the Puerto Rico Environmental Quality Board (PREQB) as the lead regulatory agency, as SWMU 7 was not a National Priorities List (NPL) site. However, in March 2005, Vieques was placed on the NPL, with USEPA as the lead regulatory agency.

SWMU 7 was originally identified as a potential release location and addressed during the CS (ESE, 1988) and again investigated in the Expanded PA/SI (CH2M HILL, 2000d). EPA Region 2 has reviewed the Expanded PA/SI report and has provided comments. These comments were incorporated in the work plan and included recommendations for additional sampling of soil, subsurface soil, and groundwater. Regulatory comments regarding collecting soil samples through the debris piles were not incorporated due to potential safety concerns. However, soil samples were collected in locations immediately adjacent to waste piles.

Based on EPA and PREQB comments, analytical results from the previous investigations indicated a need for further investigation at SWMU 7. Additional data were collected during August and September 2003 as part of this effort to further characterize the site and define the nature and extent of contamination in site media.

Figures 2-7 through 2-10 are photographs taken at SWMU 7 showing the nature of waste, the dense vegetation, and other features of the site.

TABLE 2-1
PREVIOUS SAMPLING AT SWMU 7
SWMU 7, Former NASD, Vieques, Puerto Rico

Event/Activity	Samples	Purpose	Findings
Confirmation Study (1988)	Groundwater from 3 monitoring wells 6 Soil 3 Sediment (dry streambed soil) samples	Determine if hazardous chemicals are present. Samples analyzed for selected VOCs, priority pollutant metals, and hexavalent chromium	No organic contamination. Metals were reported above criteria in groundwater samples.
Expanded PA/SI (2000) included following investigations			
Ecological Survey	Plant and animal survey	Characterize ecology, identify threatened and endangered species, qualitative impact analysis	No protected species identified, no impacts from SWMU 7 reported
MEC Avoidance Survey	Visual inspection by a certified MEC technician, and magnetometer survey in selected areas	Determine presence of any MEC items	Only ORS items were identified; no MEC/OE items were identified in the sampling areas
Expanded PA/SI Sampling	Resampling of one well from CS, 2 new wells, 6 Surface Soil and 3 Sediment (dry streambed soils)	Determine if remedial investigation/feasibility study (RI/FS) is required or proceed with No Further Action (NFA)	Polycyclic aromatic hydrocarbons (PAHs) and inorganic chemicals in surface soil, inorganics in sediments, and groundwater had metals above criteria
Field Screening for VOCs	One soil boring extended to 87 feet bls had 19 parts per million (ppm) Organic Vapor Meter (OVM) reading, and second boring to 56 feet bls had 12 ppm OVM readings	Determine if subsurface soil had more mobile VOCs	No VOCs were detected in any of the 31 readings

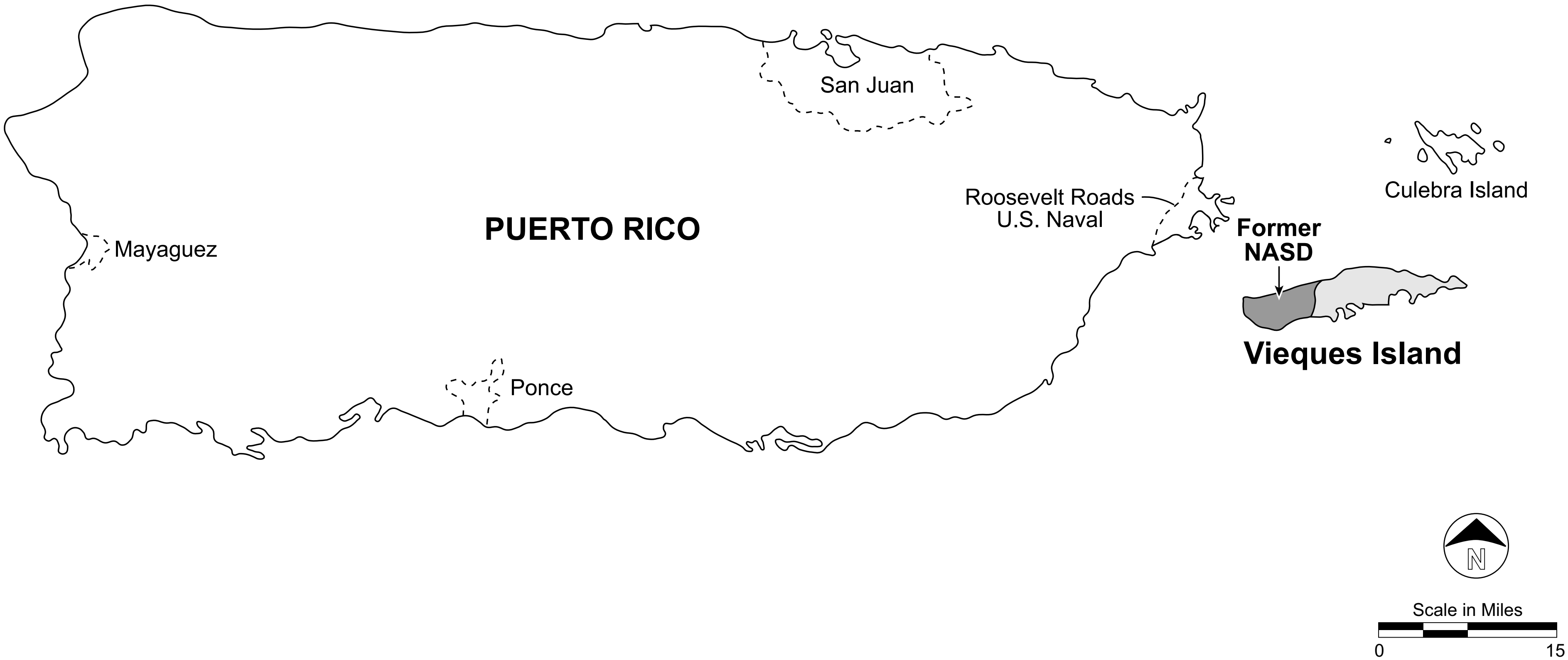
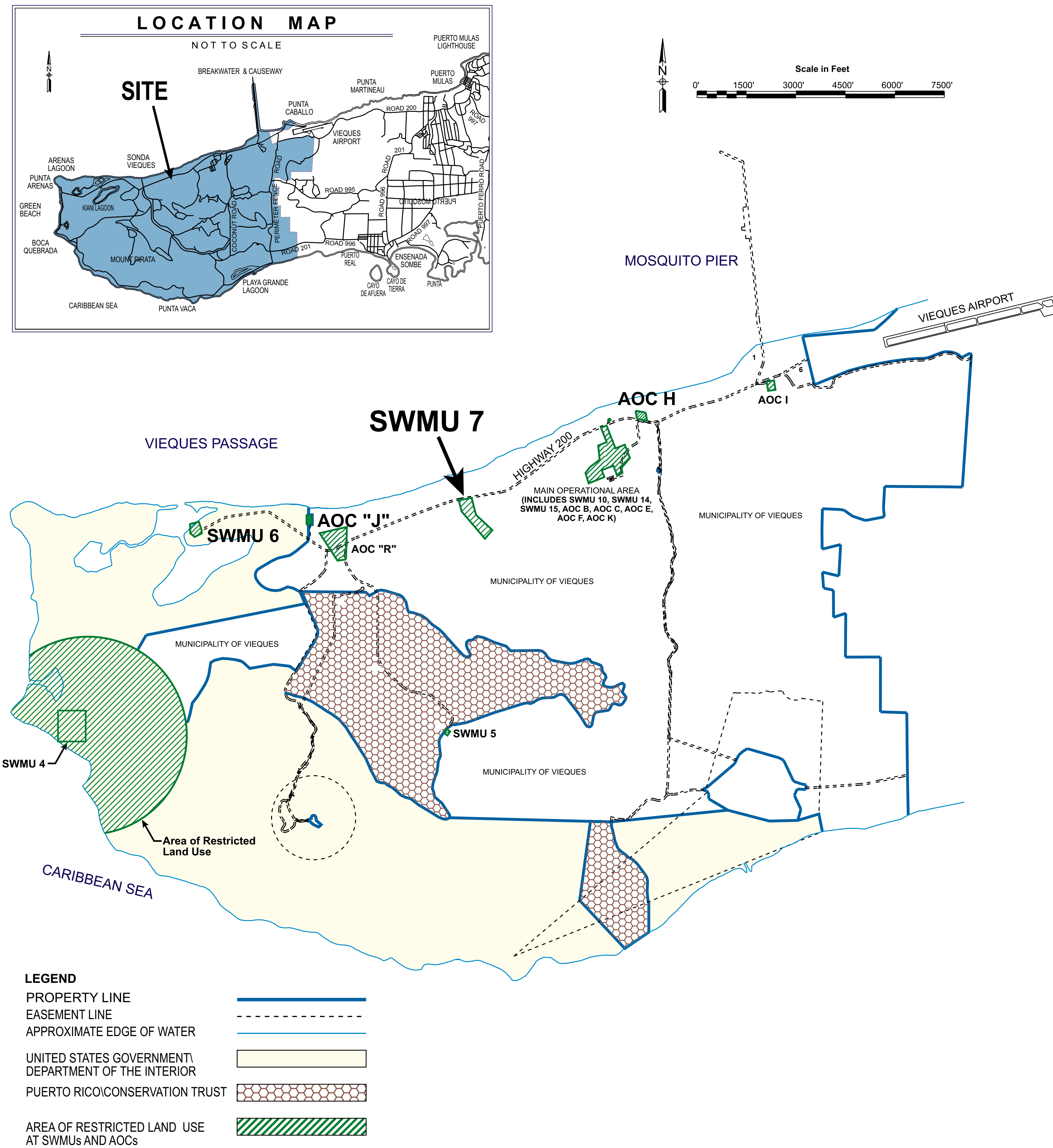


FIGURE 2-1
Regional Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

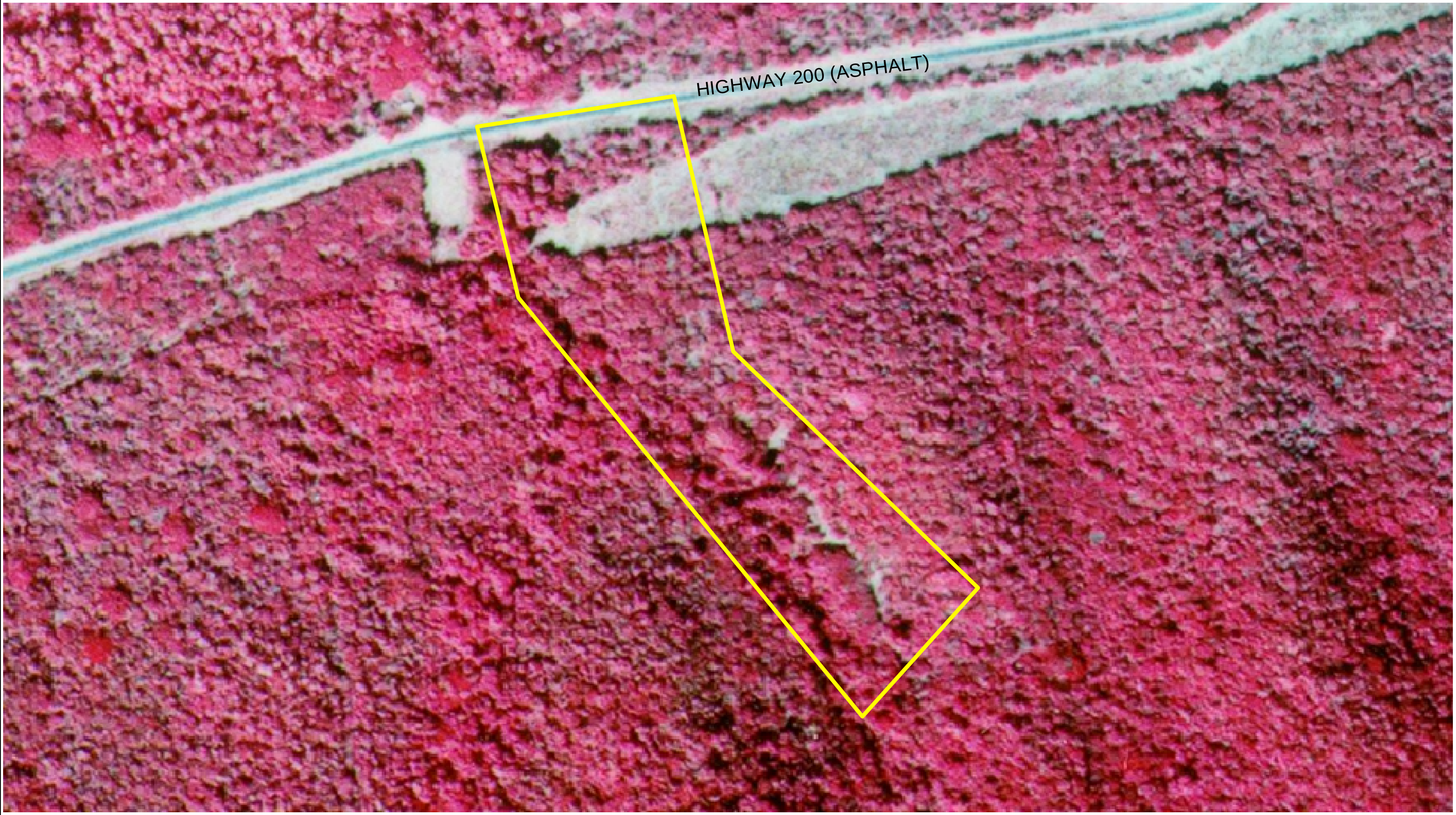
CH2MHILL



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

Figure 2-2
SWMU 7 and Other IR Sites Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL



Legend

Access Restriction Boundary

Source: 1994 Aerial Photograph

Figure 2-3
Aerial Photograph
SWMU 7,Former NASD, Vieques, Puerto Rico

CH2MHILL

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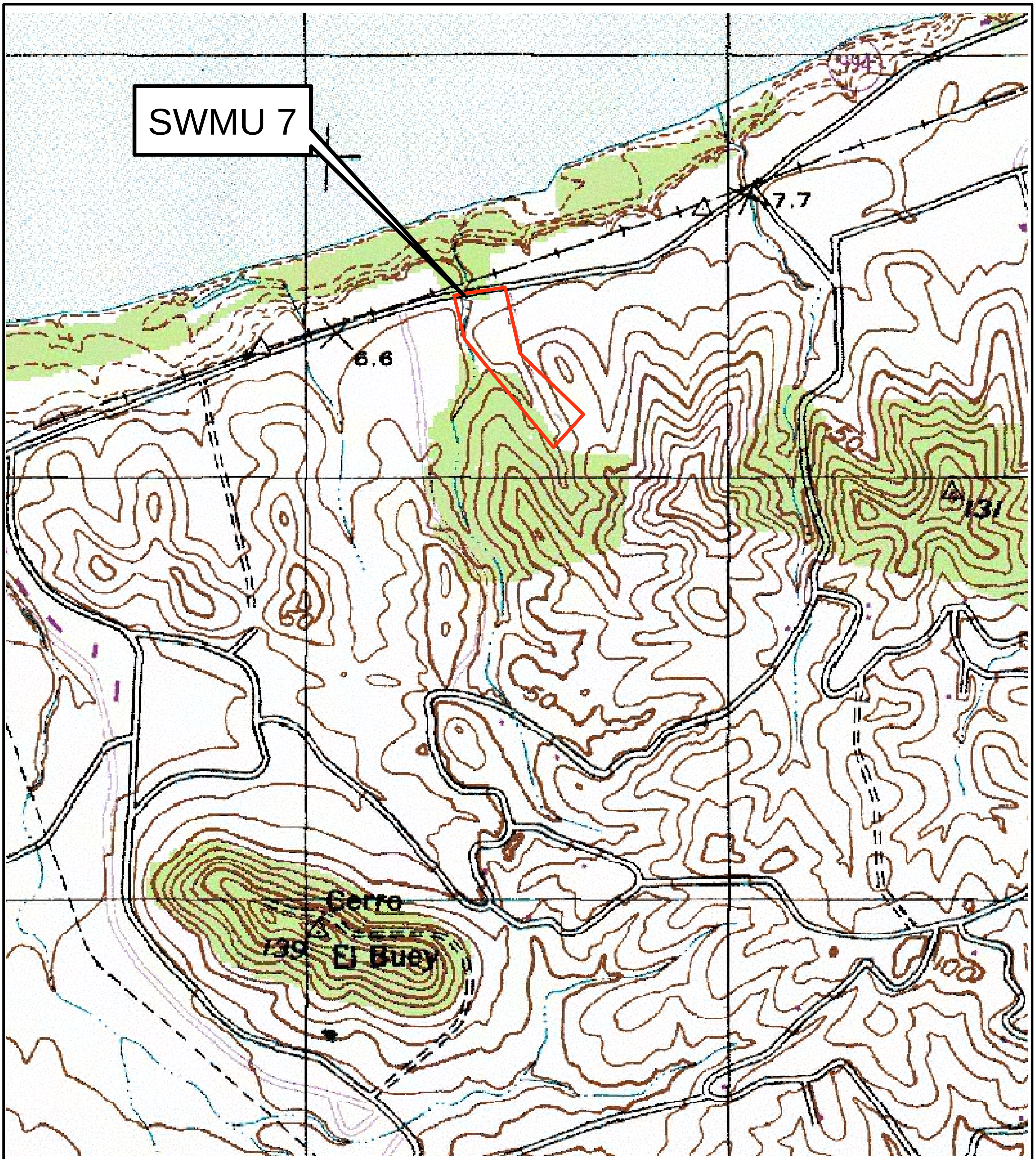


Legend

Access Restriction Boundary

Note: Dashed lines indicate 1 meter contours.
Solid lines indicate 10 meter contours.

Source: USGS, NOS/NOAA. Isla de Vieques Quadrangle 1941, revised 1982.

N W E S

280 0 280 Feet

Figure 2-4
SWMU 7 Topographic Location Map
Former NASD, Vieques, Puerto Rico

CH2MHILL File Path: \\tampa\projects\Environmental\Navy CLEAN II_Vieques_ PR\Former NASD\GIS\Facility Location Map Portrait.mxd, Date: February 16, 2004, User: JRIVERA1

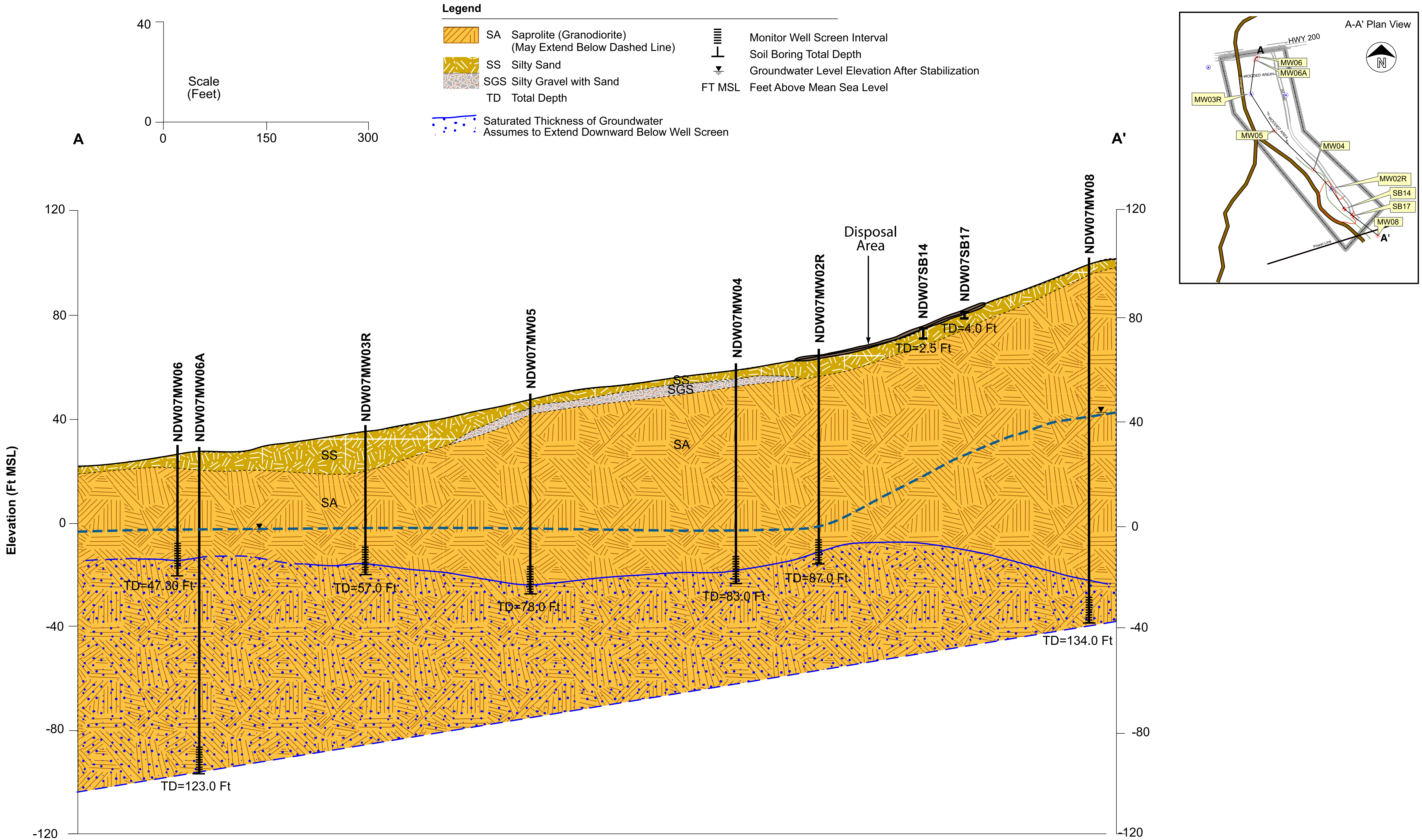


FIGURE 2.5
Geologic Cross-Section A-A'
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

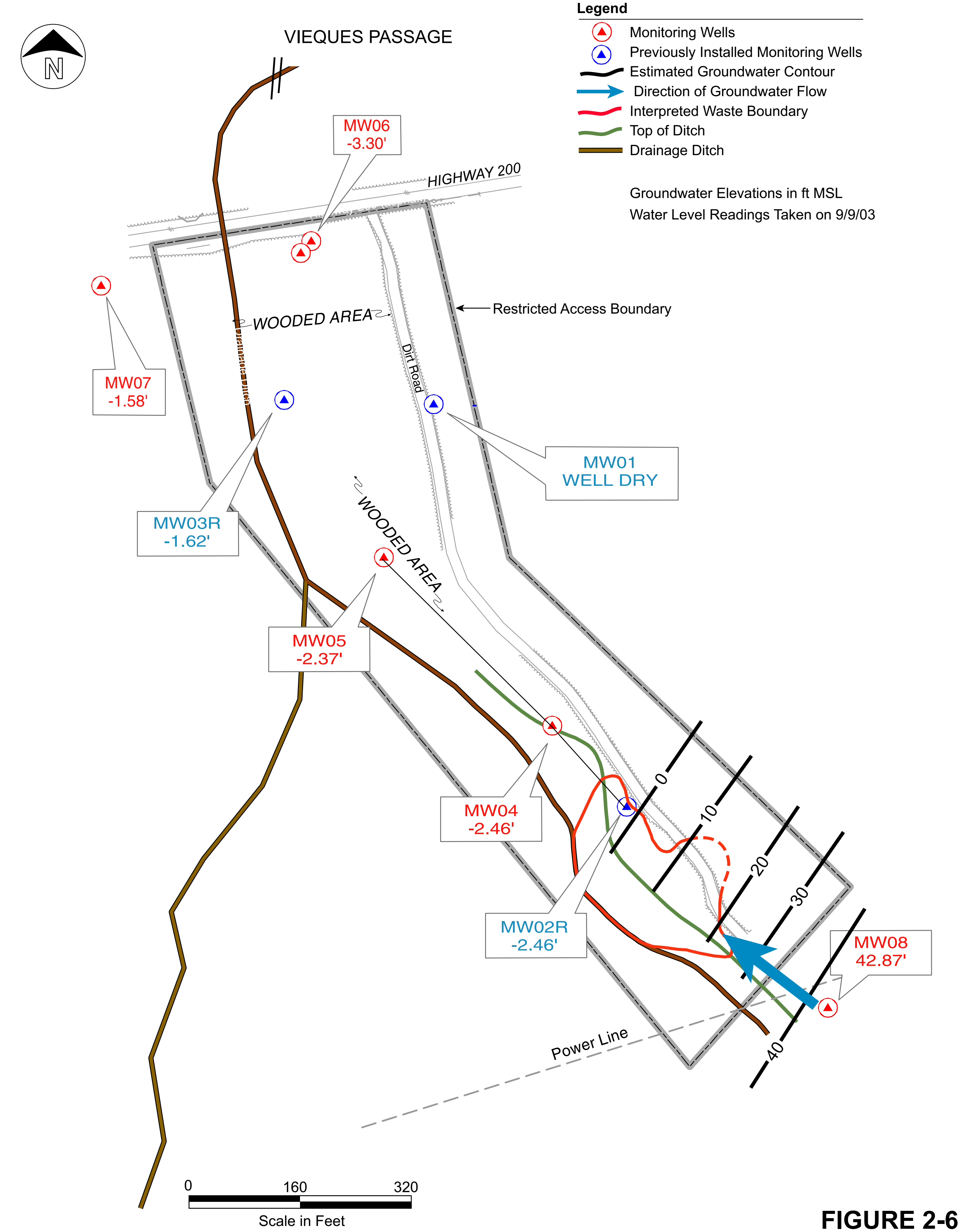


FIGURE 2-6
Groundwater Flow Map
SWMU 7, Former NASD, Vieques, Puerto Rico

SECTION 3

Summary of Field Investigations

The RI field investigation at SWMU 7 was conducted during 2003 and included monitoring well installation and sampling, surface and subsurface soil sampling, offsite sediment sampling, groundwater elevation monitoring and surveying, and a geophysical study to delineate waste boundaries.

Data collected were in accordance with the standard operating procedures presented in the facility-wide Master Work Plan (CH2M HILL, 2001a) and with the Field Sampling Plan presented in the Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan (CH2M HILL, 2003b); both work plans were reviewed by EPA and PREQB. Brief descriptions of the field procedures used during the RI field investigations are provided in the following subsections. Detailed descriptions of the field investigations can be found in the Final RI/FS Work Plan (CH2M HILL, 2003b).

A description of the MEC avoidance survey, environmental media sampling, and geophysical surveys are included below.

3.1 Munitions and Explosives of Concern Avoidance Survey

An MEC avoidance survey was conducted by USA Environmental Inc. to clear all surface and subsurface sampling locations and well drilling locations within SWMU 7. MEC avoidance activities were also conducted during the brush-clearing phase in June 2003 before initiation of environmental sampling activities. USA Environmental activities were prescribed in the MEC avoidance plan, which is part of the work plan that described the procedures to clear sites for environmental investigations. An MEC sweep was conducted by certified MEC technicians for any visible objects at the surface. Subsurface inspection of the subsurface soil sampling areas and new well locations was conducted using downhole magnetometers for every 2 feet of subsurface advancement up to a maximum 10-foot depth for the identification of any metal objects. USA Environmental also conducted a visual sweep of the waste area and did not find any MEC. The ORS items identified include empty ordnance containers such as 2.75-inch rocket pods and empty propellant charge containers were observed in the ephemeral stream. No safety-related concerns are identified with ORS at the site. The MEC avoidance survey report is included in Appendix A.

3.2 Soil Sampling

3.2.1 OVM Soil Screening

Soil samples were collected and screened according to the procedures outlined in the work plan. The samples were screened in the field with a photoionization detector (PID), also known as an organic vapor meter (OVM). PID readings were recorded on the soil boring logs (Appendix B). No OVM readings indicative of the presence of organic vapor were noted during the screening.

3.2.2 Surface and Subsurface Soil Samples and Analysis

Surface soil samples were collected from the surface to 6 inches bls. The top layer of grass and soil (approximately 1 inch) was scraped away before sampling began. Surface soil samples were collected using a stainless steel spoon, a stainless steel hand auger, or both. The soil was placed in a stainless steel bowl. Samples for VOC analysis were collected first using an Encore™ sampling device, followed by samples for SVOCs, metals, pesticides, PCBs, perchlorate, and explosives. The soil was thoroughly mixed after collection of VOC samples and transferred to appropriate laboratory jars. The perchlorate was analyzed in soil samples using the EPA-approved analytical method 314.0 for water, as there is no EPA-approved method for perchlorate analysis in soils. The method is not very reliable for any of the environmental media other than drinking water. If detections are reported, perchlorate should be analyzed using more reliable alternative methods (DoD, 2004).

Four surface soil samples (NDW07SS18, NDW07SS19, NDW07SS20, and NDW07SS21) were collected along the ephemeral stream that extends downgradient from the site to the north of Highway 200 to assess potential impacts on the stream from stormwater runoff. These represent the streambed soils. The locations of the surface soil samples are shown on Figure 3-1. Eleven new surface and subsurface soil samples were collected from the waste area (NDW07SS/SB07 through NDW07SS/SB17). This effort resulted in a total of 26 new soil (15 surface and 11 subsurface) samples as shown in Tables 3-1 and 3-2, in addition to Quality Assurance/Quality Control (QA/QC) samples from SWMU 7. Surface soil samples and subsurface soil samples were collected from each of these 11 borings to define the horizontal and vertical extent of soil contamination in the potential source area. As noted in Section 2, soil samples were not collected within the debris piles due to potential safety concerns. However, soil samples were collected in locations immediately adjacent to waste piles. Previous surface soil sample locations are shown on Figure 3-1. The nomenclature for the previous samples was changed in figures and data tables to match the current nomenclature. Previous samples W7-SB01 through W7-SB06 were redesignated NDW07SS01 through NDW07SS06.

Figure 3-2 presents the locations of subsurface soil samples. Subsurface soil samples were collected using stainless steel hand augers or a split-spoon sampler with an auger drilling rig. A hole was advanced to a depth of up to 4 feet bls using an auger of 4.25 inches inside diameter. All soil borings were logged in the field during drilling (Appendix B). To collect a sufficient amount of soil for all of the analyses, a 3-inch-diameter split spoon was driven an additional 2 feet from the bottom of the boring. The split spoon was removed from the hole and opened, and the VOC sample was collected immediately using the Encore™ sampling device. After the VOC sample was collected, the soil was removed from the split spoon, placed in a stainless steel bowl, and thoroughly mixed with a stainless steel spoon. Samples for SVOCs, metals, pesticides, PCBs, perchlorate, and explosives were transferred to appropriate laboratory jars.

Drill rigs and auger flights were decontaminated after every use by washing with potable water using a high-pressure cleaner. Sampling equipment, including sampling spoons, split spoons, hand augers, and bowls, was decontaminated between sample locations using the following procedure:

- Rinse with potable water to remove most of the soil
- Wash with scrub brush using potable water and Alconox (nonphosphate soap)

- Rinse with potable water
- Rinse with laboratory-grade deionized water
- Rinse with isopropyl alcohol
- Rinse with laboratory-grade deionized water
- Air dry

3.3 Groundwater Monitoring Well Installation, Development, and Sampling

3.3.1 Monitoring Well Installations

Six new monitoring wells were installed in addition to the three existing wells. The monitoring wells were constructed of 2-inch-diameter, Schedule 40 polyvinyl chloride (PVC) well casing and 10 feet of 0.01-inch-slot PVC well screen with flush joint threads. The annular space between the well screen and borehole was filled with a silica sand pack that extends above the well screen. A bentonite seal was installed above the sand pack, and the annular space above the bentonite seal was filled with a cement/bentonite grout. Each monitoring well was equipped with a protective surface casing, concrete pad, and locking cap to deter unauthorized access to the wells.

The monitoring wells at SWMU 7 were installed at the first encountered groundwater within the bedrock using downhole hammer drilling methods. During the drilling of the boreholes for these monitoring wells, drill cuttings were examined for lithology at approximately 5-foot intervals or at changes in drilling conditions. All wells were logged in the field during drilling. The soil boring logs are included in Appendix B. Table 3-3 summarizes well construction details. Appendix C presents well construction diagrams.

The rationale for the well location selection was as follows:

- NDW07MW04 was installed approximately 100 feet north of the waste area boundary to provide a monitoring well directly downgradient of the waste area of SWMU 7.

- NDW07MW05 was installed approximately 300 feet west by northwest of monitoring well NDW07MW04 to provide a monitoring well downgradient of well NDW07MW04.

- NDW07MW06A and NDW07MW06 were installed along Highway 200 approximately 200 feet east of the ephemeral stream to provide a well approximately 1,100 feet downgradient from the waste area. Monitoring well NDW07MW06A was installed first at a greater depth due to the apparent lack of water at the shallower depths. Monitoring well NDW07MW06 was then installed in the shallower zone to determine if water would slowly be released from the fine-grained sediment at that depth. Water eventually entered the shallow zone (NDW07MW06), and this well was sampled as a downgradient well. The deep well (NDW07MW06A) was not sampled and will not be used in the investigation.

- NDW07MW07 was also installed along Highway 200 approximately 1,100 feet downgradient from the waste area and 300 feet west of NDW07MW06 to assess potential downgradient groundwater quality impacts.

- NDW07MW08 was installed approximately 100 feet to the southeast of the site to provide an upgradient (background) well to assess whether the metal concentrations detected in the groundwater are associated with the site or are attributed to background conditions.

Monitoring well locations are illustrated in Figure 3-3. Well depths and screen intervals are shown in Table 3-3. Well location and top of casing (TOC) elevations are shown in Table 3-4.

Previous monitoring well locations are shown on Figure 3-3. The nomenclature for the previous monitoring wells was changed to match the current nomenclature scheme. Previous monitoring wells W7-MW01, W7-MW02R, and W7-MW03R were redesignated NDW07MW01, NDW07MW02R, and NDW07MW03R, respectively.

Drill cuttings generated during monitoring well installation were collected and stored onsite in 55-gallon drums. The disposal method for these cuttings was determined based on results of the soil and groundwater analyses as specified in the *Investigation-Derived Waste Management Plan* (CH2M HILL, 2000f).

Drill rigs and auger flights were decontaminated by using a high-pressure cleaner with potable water before use and between borings. Sampling equipment, including sampling spoons, split spoons, hand augers, and bowls, was decontaminated between sample locations using the following procedure:

- Rinse with potable water to remove most of the soil
- Wash with scrub brush using potable water and Alconox (nonphosphate soap)
- Rinse with potable water
- Rinse with laboratory-grade deionized water
- Rinse with isopropyl alcohol
- Rinse with laboratory-grade deionized water
- Air dry

3.3.2 Monitoring Well Development and Purging

Well development was performed after the grout used to construct the well had been allowed to adequately set for at least 24 hours. Development consisted of removing at least three borehole volumes of water. Development continued until groundwater appeared clear. Well development information is included in Appendix D.

Monitoring well development was performed either by using a Whale pump (centrifugal submersible pump) with a combination of pumping and swabbing with the pump or by the air lifting method with a compressor mounted on the drill rig. Development water was discharged into 55-gallon drums.

The submersible pump was placed at the bottom of the screen, and the well was pumped until clear water (minimal turbidity) was produced. The pump was then moved up and down (swabbed) through the screened interval to force water in and out of the screen. The turbidity increased when the pump was moved to a new portion of the screen. Pumping and swabbing continued until the water was clear and free of sediment. This procedure was used for NDW07MW06 and NDW07MW07.

During air lifting, air was forced to the bottom of the well and all water was evacuated. This procedure was continued until the water was clear (minimal turbidity). This borehole development procedure was used at NDW07MW04, NDW07MW05, and NDW07MW08.

Pumps were decontaminated between sample locations using the following procedure:

- Rinse with potable water
- Wash with scrub brush using potable water and Alconox (nonphosphate soap) and run pump in large tub
- Rinse and cycle pump with potable water
- Rinse with laboratory-grade deionized water
- Air dry

3.3.3 Groundwater Elevation Measurements

Groundwater elevation measurements were obtained from all monitoring wells at SWMU 7 on September 9, 2003, except NDW07MW06A, which was not included in this investigation because it is screened in a deeper zone. An electronic water level meter was used to measure the depth to water from the TOC of each monitoring well. The groundwater levels were measured to the nearest 0.01 foot from the top of the PVC casing. Table 3-5 summarizes the results of these measurements. Figure 2-6 illustrates the results of the groundwater measurements recorded at SWMU 7.

3.3.4 Monitoring Well Sampling and Analysis

Five newly installed monitoring wells (NDW07MW04 through NDW07MW08) and three earlier wells (NDW07MW01R through NDW07MW03R) were sampled for total and dissolved metals, explosives, pesticides, and perchlorate to evaluate the potential presence of these constituents. The filtered samples were field filtered prior to preservation using a 0.45 micron filter.

The wells were sampled with either a stainless steel Grundfos® submersible pump with Teflon® tubing or with a Whale pump with Teflon® tubing, depending on the depth to water and the water recharge rate of the well. NDW07MW06 was sampled with the Whaler® Pump; all others were sampled using the Grundfos® submersible pump. New separate Teflon® tubing was used for each well.

A minimum of three well volumes of water were pumped from each well prior to sampling. The wells were pumped at a rate of approximately 0.06 to 0.22 gallon per minute (gpm). Water quality data, including temperature, conductivity, oxidation-reduction potential (ORP), dissolved oxygen, turbidity, and pH, were monitored during purging, and the well was sampled after the parameters stabilized (to less than 10 percent fluctuation).

The pump and cables were decontaminated between wells by the following procedures:

- Wash with scrub brush using potable water and Alconox (nonphosphate soap)
- Rinse with potable water
- Rinse with laboratory-grade deionized water
- Rinse with isopropyl alcohol (cables only)
- Rinse with laboratory-grade deionized water
- Air dry

Appendix E includes monitoring well groundwater sampling logs.

3.3.5 Background Groundwater Well Sampling

NDW07MW08 was installed approximately 100 feet to the southeast of the site to provide an upgradient (background) well to assess background inorganic levels in the groundwater. The groundwater elevation at this location is approximately 40 feet above the groundwater elevation of the rest of the site. The groundwater flow at SWMU 7 is shown in Figure 2-6. NDW07MW08 was sampled using the Grundfos® submersible pump.

3.4 Sediment Sampling

3.4.1 Sediment Sampling and Analysis

During the Expanded PA/SI, three soil samples collected from the dry streambed were referred to as sediment samples. Because these samples were collected from the dry streambed, they are considered soil samples in this RI. Previous sediment sample locations are included with surface soils in Section 4. The nomenclature for the previous samples was changed to match the current nomenclature scheme. Previous samples W7-SD01 through W7-SD03 were redesignated NDW07SD01 through NDW07SD03, respectively.

As part of the RI, two sediment samples, NDW07SD04 and NDW07SD05, were collected in the streambed in the offsite location near the beach using a stainless steel hand auger (Figure 3-4). Table 3-6 shows the locations and elevations of the two sediments samples. These samples were collected to determine if extreme downgradient sediment samples off the site would indicate the presence of contamination. The sediment was removed from the hand auger and placed in a stainless steel bowl. Samples for VOC analysis were collected first using an Encore™ sampling device, followed by samples for SVOCs, metals, pesticides, PCBs, perchlorate, and explosives. Appendix F includes sediment sampling logs.

Sampling equipment, including hand augers and bowls, was decontaminated between sample locations using the following procedure:

- Rinse with potable water to remove most of the soil
- Wash with scrub brush using potable water and Alconox (nonphosphate soap)
- Rinse with potable water
- Rinse with laboratory-grade deionized water
- Rinse with isopropyl alcohol
- Rinse with laboratory-grade deionized water
- Air dry

3.4.2 Background Sediment Sampling

Because the site contains no sediments, no upgradient/background sediment samples were collected in the RI.

3.5 Surveying

The monitoring well locations and sampling locations (surface soil, soil borings, and sediment) were surveyed in the field using differential global positioning system (DGPS) techniques by Transystems Inc. The survey established the latitude and longitude coordinates for each location. In addition, the elevation in feet above msl was established to the nearest 0.01 foot for the TOC of the monitoring wells using traditional surveying techniques and DGPS techniques for remote areas. Survey data points are presented in Appendix G, and Tables 3-1 through 3-6 provide the survey data. These data survey points are included in the database for plotting in the figures created using GIS.

3.6 Geophysical Survey

NAEVA Geophysics Inc. was contracted to conduct a geophysical investigation at SWMU 7. The purpose of this investigation was to delineate the lateral extent of waste resulting from historical dumping activities at the site. The site was investigated using a combination of grids and transect lines based on terrain conditions and site-specific objectives. Within the grids established between the road and the ephemeral stream, an electromagnetic (EM) survey was conducted using an EM-31 device at 5-foot intervals along lines spaced 12.5 feet apart. Transect lines established across the ephemeral stream were spaced approximately 25 feet apart, and data also were collected every 5 feet. NAEVA used global positioning system (GPS) equipment to survey the corners of grids and the endpoints of transect lines, allowing the data to be plotted in NAD 83/UTM Zone 20N coordinates. A total of 1.5 acres was investigated in this manner at SWMU 7.

The results of the geophysical investigation indicated that the waste boundary at SWMU 7 appears to be delineated on all sides with the exception of a small lobe in the southeast. Both conductivity and in-phase data indicate that some metal material extends across the road to the east. Data collected along the transects in the southwest do not indicate that debris extends westward of the bottom of the ephemeral stream. The geophysical survey documentation is presented in Appendix H.

TABLE 3-1
SURFACE SOIL SAMPLING LOCATIONS AND ELEVATIONS
SWMU 7, Former NASD, Vieques, Puerto Rico

Boring #	Northing	Easting	Elevation (ft amsl)
NDW07SS07	2005070.1236	231587.6962	14.787
NDW07SS08	2005069.5062	231583.9881	13.576
NDW07SS09	2005036.3430	231604.9954	18.379
NDW07SS10	2005017.5126	231611.5464	16.314
NDW07SS11	2005082.0002	231577.2839	11.249
NDW07SS12	2005086.2228	231584.1098	15.489
NDW07SS13	2005088.8284	231588.8651	18.52
NDW07SS14	2005037.5924	231626.1489	23.206
NDW07SS15	2005006.6368	231631.9268	18.764
NDW07SS16	2005016.7041	231635.3390	24.185
NDW07SS17	2005025.1036	231641.4145	25.305
NDW07SS18	2005004.7932	231632.4951	18.222
NDW07SS19	2004989.2000	231646.4100	21.51
NDW07SS20	2005160.2407	231477.0480	8.484
NDW07SS21	2005361.7041	231406.5809	1.447

TABLE 3-2
SOIL BORING LOCATIONS AND ELEVATIONS
SWMU 7, Former NASD, Vieques, Puerto Rico

Boring #	Northing	Easting	Elevation (ft amsl)
NDW07SB07	2005070.1236	231587.6962	14.787
NDW07SB08	2005069.5062	231583.9881	13.576
NDW07SB09	2005036.3430	231604.9954	18.379
NDW07SB10	2005017.5126	231611.5464	16.314
NDW07SB11	2005082.0002	231577.2839	11.249
NDW07SB12	2005086.2228	231584.1098	15.489
NDW07SB13	2005088.8284	231588.8651	18.52
NDW07SB14	2005037.5924	231626.1489	23.206
NDW07SB15	2005006.6368	231631.9268	18.764
NDW07SB16	2005016.7041	231635.3390	24.185
NDW07SB17	2005025.1036	231641.4145	25.305

TABLE 3-3
SUMMARY OF WELL CONSTRUCTION DETAILS
SWMU 7, Former NASD, Vieques, Puerto Rico

Well ID	Date Installed	Ground Elevation (ft amsl)	Boring Depth (ft bls)	Well Depth (ft bls)	Screen Interval Depth (ft bls)	Depth to Bentonite (ft bls)	Depth to Sandpack (ft bls)
SWMU 7 MW04	08/16/03	NA	83.0	83.0	73 – 83	71.0	69.0
SWMU 7 MW05	08/15/03	NA	78.0	78.0	68 – 78	63.0	65.0
SWMU 7 MW06A	08/20/03	NA	123.0	123.0	113 – 123	110.0	108.0
SWMU 7 MW06	08/24/03	NA	47.0	47.0	35 – 45	33.0	31.0
SWMU 7 MW07	08/22/03	NA	43.0	43.0	33 – 43	30.0	28.0
SWMU 7 MW08	08/21/03	NA	134.0	134.0	124 – 134	121.0	118.5

Notes: amsl = above mean sea level; bls = below land surface

TABLE 3-4
MONITORING WELL LOCATIONS AND TOP OF CASING ELEVATION
SWMU 7, Former NASD, Vieques, Puerto Rico

Boring #	Northing	Easting	Elevation TOC (ft amsl)
NDW07MW04	2005111.1373	231568.0382	63.268
NDW07MW05	2005185.0927	231494.2009	50.728
NDW07MW06A	2005318.7675	231457.7330	30.850
NDW07MW06	2005323.9983	231462.3911	30.443
NDW07MW07	2005304.3575	231370.2007	32.401
NDW07MW08	2004987.4453	231689.1040	104.068

Notes: amsl = above mean sea level

TABLE 3-5
SUMMARY OF MONITORING WELL WATER LEVEL MEASUREMENTS
SWMU 7, Former NASD, Vieques, Puerto Rico

Well ID	Date	Top of PVC Elevation (ft amsl)	Depth to Water (ft)	Groundwater Level (ft amsl)
NDW07MW01	09/09/03	41.72	Dry	NA
NDW07MW02R	09/09/03	69.46	71.92	-2.46
NDW07MW03R	09/09/03	39.03	40.65	-1.62
NDW07MW04	09/09/03	63.27	65.73	-2.46

TABLE 3-5
SUMMARY OF MONITORING WELL WATER LEVEL MEASUREMENTS
SWMU 7, Former NASD, Vieques, Puerto Rico

Well ID	Date	Top of PVC Elevation (ft amsl)	Depth to Water (ft)	Groundwater Level (ft amsl)
NDW07MW05	09/09/03	50.73	53.10	-2.37
NDW07MW06A	09/09/03	30.85	Not taken	NA
NDW07MW06	09/09/03	30.44	33.74	-3.30
NDW07MW07	09/09/03	32.40	33.98	-1.58
NDW07MW08	09/09/03	104.07	61.20	42.87

Notes: amsl = above mean sea level

TABLE 3-6
SEDIMENT SAMPLING LOCATIONS AND ELEVATIONS
SWMU 7, Former NASD, Vieques, Puerto Rico

Boring #	Northing	Easting	Elevation (ft amsl)
NDW07SD04	2005562.6557	231639.5762	-0.204
NDW07SD05	2005463.7283	231534.3847	0.838

Notes: amsl = above mean sea level

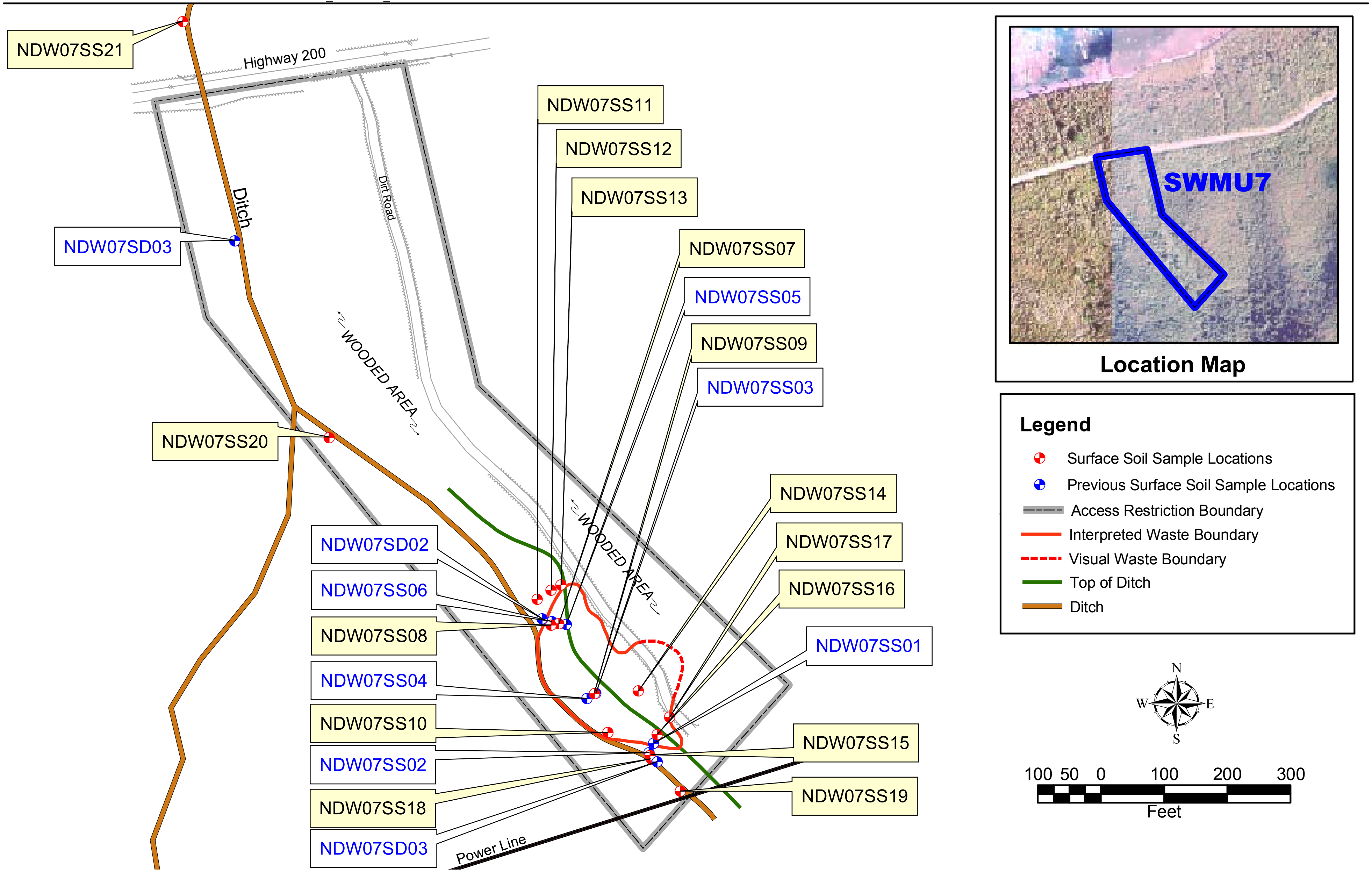


Figure 3-1
Remedial Investigation Surface Soil Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

TPA \\TAMPA\PROJECTS\ENVIRONMENTAL\NAVY CLEAN II_VIEQUES_ PR\FORMER NASD\GIS\REPORT-FIGURES\AOC-SMWU-SOILBORINGFIGURES.MXD 2/12/2004

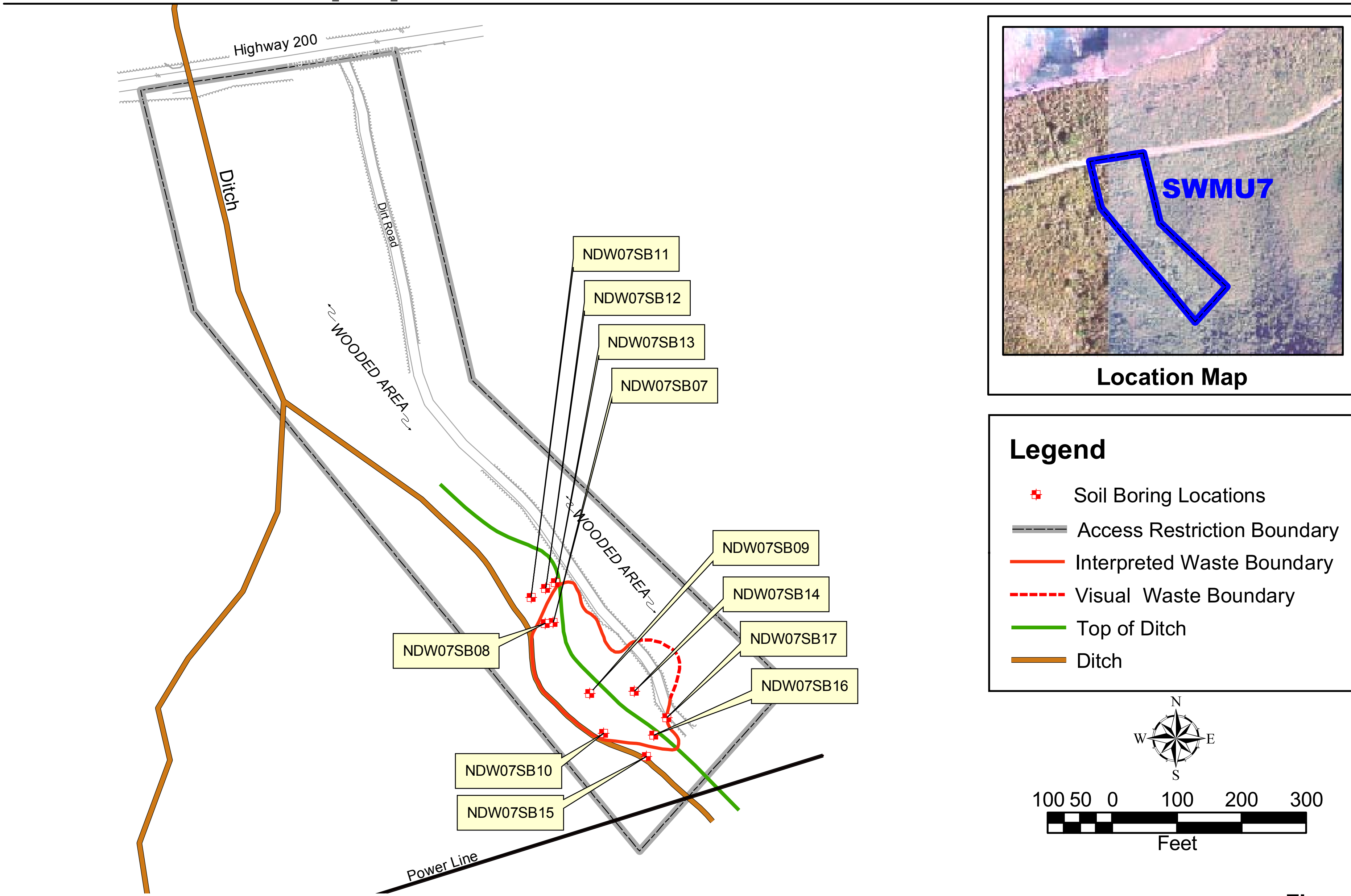


Figure 3-2
Remedial Investigation Soil Boring Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

TPA \\TAMPA\PROJECTS\ENVIRONMENTAL\NAVY CLEAN II_VIEQUES_ PR\FORMER NASD\GIS\REPORT-FIGURES\AOC-SMWU-MONITORWELLFIGURES.MXD 2/13/2004

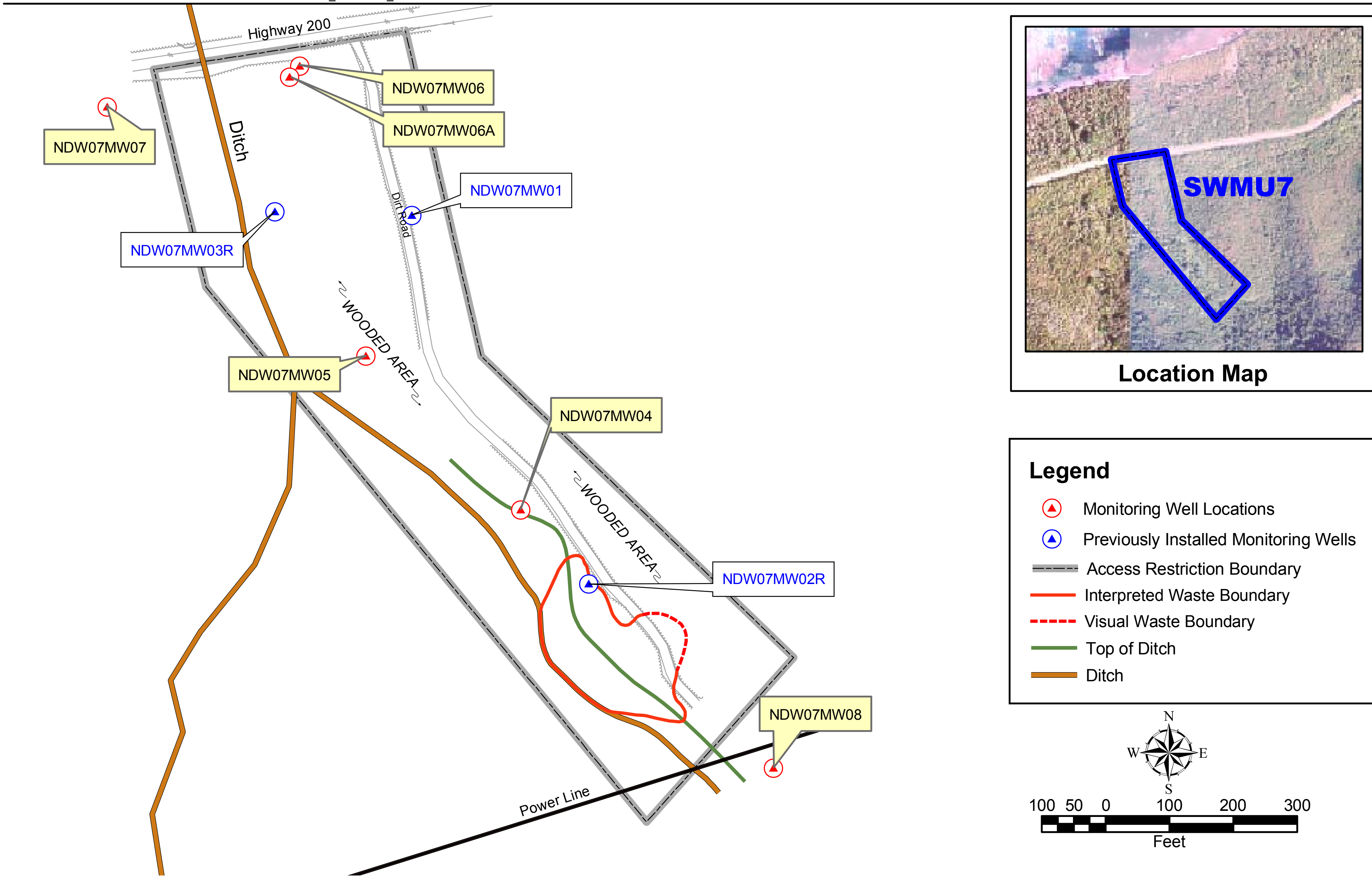
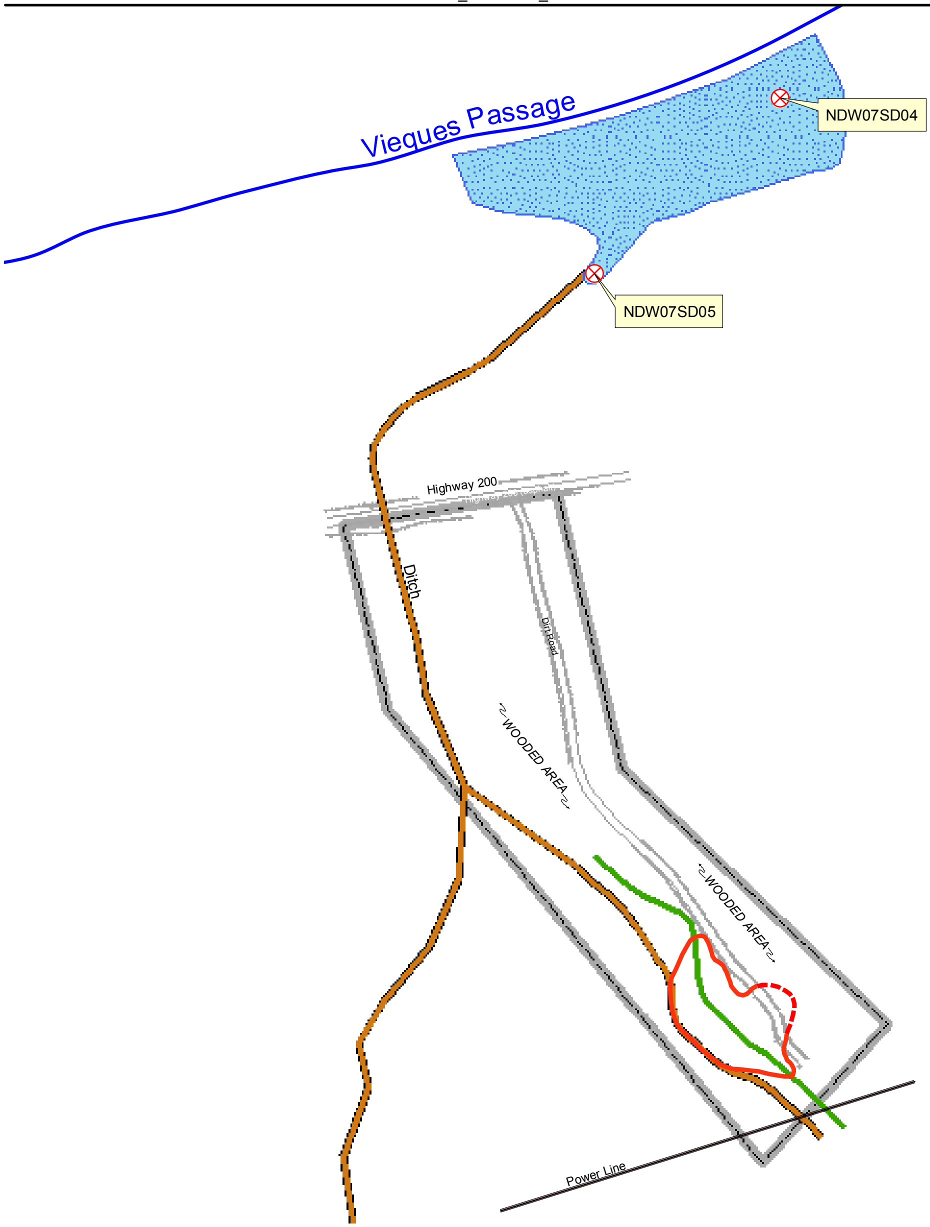
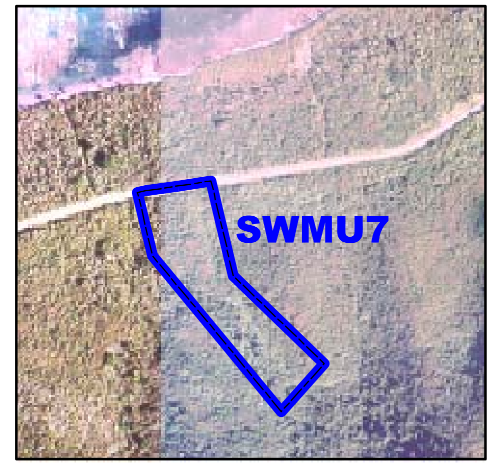


Figure 3-3
Remedial Investigation Monitoring Well Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

TPA \\TAMPA\PROJECTS\ENVIRONMENTAL\NAVY CLEAN II_VIEQUES_ PR\FORMER NASD\GIS\REPORT-FIGURES\AOC-SMWU-SEDIMENTFIGURES.MXD 2/13/2004





Location Map

Legend

- Sediment Sample Locations
- Access Restriction Boundary
- Interpreted Waste Boundary
- Visual Waste Boundary
- Top of Ditch
- Ditch
- Mangrove Area

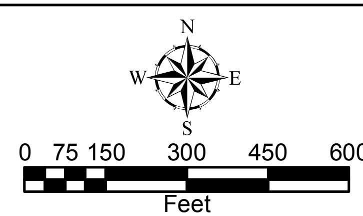


Figure 3-4
Remedial Investigation Sediment Sample Location Map
SWMU 7, Former NASD, Vieques, Puerto Rico

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SECTION 4

Nature and Extent of Contamination

This section presents a discussion of the nature and extent of contamination found in the soil, groundwater, and offsite sediment at SWMU 7 during the RI. The discussion of SWMU 7 RI results is divided into two parts. Section 4.1 presents a summary of the management and evaluation of laboratory analytical data quality for the media sampled during the RI for the site. Section 4.2 presents a discussion of the results of the sampling activities for each medium at the site. The nature and extent discussion of SWMU 7 addresses surface soil, subsurface soil, and groundwater. The results of the site-specific background groundwater sample and the soil background results (CH2M HILL, 2002c) are also presented and discussed.

In addition to 2003 RI data, the Expanded PA/SI data are also presented and discussed in this section to characterize more completely the nature and extent of contamination at the site.

It should be noted that the description of the nature and extent of contamination at SWMU 7 is based on the sample distribution from the RI and Expanded PA/SI. Therefore, while the assessment of the nature and extent of contamination described herein may be appropriate for the dataset generated by the samples collected, it is uncertain whether the assessment would be the same if samples had been collected directly through the waste piles. However, this uncertainty will be addressed via the removal action and its associated waste characterization, confirmatory sampling protocol, and residual risk assessment.

4.1 Data Management and Evaluation

This section presents information on the analytical data collected during the RI and the documentation process used to assure data quality. Data tracking and management, from the collection of data in the field through data validation, are presented. Non-site-related analytical results are discussed in relation to laboratory contaminants and naturally occurring elements. The screening criteria used in the evaluation of the analytical results also are presented and defined.

4.1.1 Data Tracking and Validation

The management and tracking of data are the evidentiary portion of the quality assurance (QA) process. Custody is assured from the time of field collection to receipt of validated electronic analytical results. Complete analytical reports are provided as Appendix I. Field samples and their required analytical methods were recorded on the chain-of-custody documents, which are included with the data validation reports compiled in Appendix J. Chain-of-custody document entries were verified against the Final RI/FS Work Plan (CH2M HILL, 2003b) to determine whether all designated samples were collected and submitted for the appropriate analytical methods. Upon receipt of the samples by the laboratory, the field information was compared to determine whether each sample was logged and analyzed for the correct methods and for the correct target analytes. Field-specified quality control samples annotated on the chain of custody were logged in as part of the specific sample delivery group (SDG). Field QC samples include field blanks, equipment blanks, trip blanks, field duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples.

PEL Laboratories of Tampa, Florida, analyzed the RI samples. Analytical data reports for the RI were submitted to Environmental Data Services Inc. (EDS) for third-party data validation. Data reports were submitted in hard copy and electronic versions. Electronic versions were specifically formatted to enable automatic downloading of data into the Environmental Data Management System (EDMS) database. Validation procedures established by the National Functional Guidelines (NFGs) for organic analyses (EPA, 1999) and NFGs for inorganic analyses (EPA, 2002a) as modified by Region 2 were followed during the validation process.

Data that were not within the acceptance limits were appended with a qualifying flag, which consists of a single- or double-letter abbreviation that indicates the nature of the identified nonconformance. The qualifying flags are appended to data records during the database query process and included in the final data summary tables deliverable so that the data will not be used indiscriminately. The following primary flags were used to qualify the data:

- Data qualified with "U" indicate that the analyte was not detected, and the associated number indicates the approximate sample concentration necessary for detection.
- Data qualified with "UJ" indicate that the analyte was not detected, and the quantitation limit may be inaccurate or imprecise.
- Data qualified with a "J" indicate that the analyte is present. Numerical sample results that are greater than the method detection limit (MDL) but less than the laboratory reporting limit (RL) are qualified with a "J" to indicate that they are estimates.
- Data qualified with "=" indicate that the analyte is present. The reported value is the measured concentration.
- Data qualified with "R" indicate an unusable result. The analyte may or may not be present in the sample. Data can be rejected because of matrix interference, dilution of the sample, and other reasons.

4.1.2 Evaluation of Non-Site-Related Analytical Results

Many of the organic and inorganic constituents detected in soil and groundwater at SWMU 7 may be attributed to non-site-related conditions or activities. Non-site-related results include laboratory contaminants and naturally occurring or background concentrations of organic and inorganic analytes. A discussion of non-site-related analytical results is provided in the following subsections.

4.1.2.1 Laboratory and Field Sampling Blank Contamination

Four types of blank samples were used to monitor potential contamination introduced during field sampling, sample handling, and shipping activities, as well as during sample preparation and analysis in the laboratory. Types of blank samples included:

- **Trip Blank.** A trip blank (TB) is a sample of American Society for Testing and Materials (ASTM) Type II water that is prepared in the laboratory prior to the sampling event. The water is stored in VOC sample containers and is not opened in the field, and it travels back to the laboratory with the other samples for VOC analysis. This blank is used to monitor the potential for sample contamination during the sample container trip. One TB should be included in each sample cooler that contained samples for VOC analysis.

- **Equipment Rinsate Blank.** An equipment rinsate blank (ERB) is a sample of the target-free water used for the final rinse during the equipment decontamination process. This blank sample is collected by rinsing the sampling equipment after decontamination and is analyzed for the same analytical parameters as the corresponding samples. This blank is used to monitor potential contamination caused by incomplete equipment decontamination. One ERB should be collected per day of sampling for each type of sampling equipment.
- **Field Blank or Ambient Blank.** The field blank (FB) is an aliquot of the source water used for equipment decontamination. This blank monitors contamination that may be introduced from the water used for decontamination. One FB should be collected from each source of decontamination water and analyzed for the same parameters as the associated samples.
- **Laboratory Method Blank or Method Blank.** A laboratory method blank (MB) is ASTM Type II water that is treated as a sample in that it undergoes the same analytical process as the corresponding field samples. MBs are used to monitor laboratory performance and contamination introduced during the analytical procedure. One MB was prepared and analyzed for every 20 samples or per analytical batch, whichever was more frequent.

According to the NFGs (EPA, 1999, 2002a), concentrations of common organic contaminants detected in samples at less than 10 times the concentration of the associated blanks can be attributed to field sampling and laboratory contamination rather than environmental contamination from site activities. Common organic contaminants include acetone, methylene chloride, 2-butanone, and the phthalates. For all inorganic and the other organic contaminants, 5 times the concentration detected in the associated blanks is used to qualify results as potential field and/or laboratory contamination rather than environmental contamination. These rules were applied on an SDG-by-SDG basis and not globally. Many results reported in blanks (especially metals) are well below a defined practical quantitation limit (PQL) and may represent Type I errors when associated with a matrix. A Type I (or alpha) error occurs when the value reported is dismissed as a biased high, or false positive.

Perchlorate was analyzed using EPA analytical method 314.0. The EPA analytical method 314.0 for groundwater analysis is recommended for drinking water analysis, and the results are reliable at concentrations greater than 4 ug/L. This method is unreliable for other matrixes such as soils and groundwater at low concentrations; confirmation is recommended for any detection by an alternative analytical method (DoD, 2004). It is important to note that perchlorate is found in several commonly used laboratory detergents (see Internal email from analytical lab STL, 2003, Appendix J).

Many metals are ubiquitous at low levels; these include aluminum, barium, chromium, copper, calcium, iron, lead, magnesium, manganese, nickel, mercury, potassium, sodium, and zinc. Other metals, such as antimony, cobalt, beryllium, selenium, thallium, vanadium, cadmium, and silver, are not common contaminants and generally are quantitated just above the MDL. Instrument noise at this level coupled with the matrix effects may elicit Type I errors for these elements at these levels.

Methylene chloride and acetone are used as extraction solvents and are common laboratory contaminants. Other organics are often seen as field contaminants from equipment decontamination solvents such as isopropanol.

Phthalates are used as plasticizers and are common laboratory and field contaminants. The most common is bis(2-ethylhexyl)phthalate (BEHP). Phthalates are often introduced into samples from gloves used for handling sampling equipment, samples, and extracts. Gloves are coated with plasticizers such as BEHP to facilitate release of the gloves from the skin.

4.1.2.2 Background Conditions

Environmental media samples were collected and analyzed to evaluate background soil conditions at the former NASD. The data from these samples were evaluated to statistically calculate basewide background concentrations for soil, groundwater, surface water, and sediment. Background concentrations were calculated for inorganic analytes only. The project team agreed to use only the soil data for comparison to site data. Section 4.2.1 presents basewide background data for soil and a discussion of the data.

A site-specific background sample was collected for groundwater at SWMU 7. Background concentrations were determined from this upgradient monitoring well. This was not done on a statistical basis. The site-specific background data are also discussed in Section 4.2.1 for each sampled medium at SWMU 7.

4.1.3 Regulatory, Health-Based, and Ecological Screening Levels

Analytical results for all media were compared against common regulatory, human health-based, and ecological standards or criteria. Overall, seven sets of standards or criteria were used. The screening levels are identified below according to each medium.

- **Surface soil** results were compared to the EPA (2002) Region 9 residential risk-based concentrations preliminary remediation goals (PRGs) adjusted to a hazard index (HI) of 0.1 for noncarcinogenic chemicals; the EPA (2002) Region 9 leachability criteria for soil (soil screening level [SSL] based on a dilution attenuation factor [DAF] of 20); and appropriate ecological screening criteria. The ecological screening criteria were the most conservative values derived from either *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants* (Efroymson, 1997a) or *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process* (Efroymson, 1997b). In some instances when soil screening values were not available from these primary sources, three other references were consulted including the Canadian protocol for deriving environmental soil quality guidelines (SQGs; Canadian Council of Ministers of the Environment [CCME], 1996), Dutch Soil Quality Standards (Ministry of Housing, Spatial Planning, and Environment [MHSPE], 1994), and U.S. Fish and Wildlife Service (USFWS) soil screening values presented by Beyer (1990). The lowest screening value from these three sources was selected for screening.

- **Subsurface soil** results were compared to the EPA Region 9 leachability criteria for soil (SSL, DAF = 20). For risk assessment, subsurface soil was compared against industrial PRGs, as discussed in Section 6.
- **Groundwater** results were screened against EPA Region 9 tap-water PRGs, adjusted to an HI of 0.1. For chemicals for which a drinking-water MCL is available but no PRG exists, the MCL value was used for screening.
- **Sediment** results were compared to screening values presented in either *Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments* (Long et al., 1995) or the EPA memorandum *Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders* (EPA, 2000a).

These are conservative screening values based on human health or ecological risk factors. Brief descriptions of the screening values follow.

- Region 9 PRGs for Residential Surface Soil, Tap Water, and Soil Screening Levels (October 2002) -- The criteria presented in the Region 9 preliminary remediation goal (PRG) table correspond to a systemic hazard quotient of 1.0 or a lifetime cancer risk of 10E-6 (1 additional cancer case per 1 million people). For screening purposes, the PRGs were adjusted to correspond to a systemic hazard quotient of 0.1 to account for an exposure to multiple constituents on the same target organ. The risk-based concentrations (RBCs) are developed using protective default exposure scenarios recommended by EPA (1991) and the best available reference doses and carcinogenic potency slopes. In the absence of Puerto Rico regulatory standards for soil, these criteria are commonly used as a basis of comparison for the nature and extent of soil contamination. They also provide a solely health-based level of comparison for potable water at the point of use. The SSL for protection of groundwater provides soil concentrations that are generally considered to be protective of shallow groundwater. Soil concentrations above the SSL may pose a leaching hazard. However, the size of the affected area and the soil characteristics can have a significant impact on the potential for contaminants to migrate from soil to groundwater. As noted above, an SSL at a DAF of 10 was used for comparison to soil constituent concentrations. Because the DAF is dependent on such site-specific soil characteristics as bulk density, moisture content, organic carbon content, porosity, and pH, there is uncertainty whether an SSL based on a DAF of 10 is appropriate for the site. However, because waste disposal at the site took place over 30 years ago, and because groundwater occurs at relatively shallow depths (i.e., 5 to 12 feet), the groundwater constituent concentrations measured during the RI are very likely more representative of any leaching that has or is occurring than the predictive nature of the SSLs. Further, the removal action will include confirmatory sampling to ensure residual media concentrations are acceptable.
- Ecological protection-based toxicological benchmarks for screening COPCs for effects to soil invertebrates and microbial processes were taken from Efroymson et al. (1997a) and for terrestrial plants from Efroymson et al. (1997b).

  The Oak Ridge National Laboratory has identified soil screening values specific to soil invertebrates and microbial processes (Efroymson et al., 1997a) and terrestrial plants

(Efroymson et al., 1997b). The soil benchmarks for invertebrates were derived using National Oceanic and Atmospheric Administration (NOAA) effects range-low (ERL) approach (Long and Morgan, 1990), supported by information from field and laboratory studies, bibliographic databases, and the published literature. Lowest Observed Effect Concentrations (LOECs) were rank-ordered, and a value was selected that most closely approximated the 10th percentile of the distribution. If fewer than 10 values were available, the lowest No Observed Effect Concentration (NOEC) was used. If 10 or more values were available, the 10th percentile was used. Values for plant benchmarks were derived in the same way as for invertebrates and microbial processes (Efroymson et al., 1997b).

In the absence of Oak Ridge National Laboratory soil screening values, alternate screening values were selected from the following references:

Evaluating soil contamination (Beyer, 1990) -- One of the earliest compilations of soil screening values was presented by Beyer (1990) of the USFWS. Screening levels from the Netherlands were taken from the interim Dutch Soil Cleanup Act values issued in the 1980s, which identified three categories: (1) Category A refers to background concentrations in soil or detection limits; (2) Category B refers to moderate soil contamination that requires additional study; and (3) Category C refers to threshold values that require immediate cleanup.

A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines, (CCME, 1996) **--** The Canadian protocol for deriving environmental SQGs takes into consideration levels of ecological protection, endpoints, availability of soil toxicity data, receptor arrays, and exposure pathways for four types of land use. In 1997, the CCME issued soil quality guidelines for 20 constituents. The guidelines were derived specifically for the protection of ecological receptors in the environment or for the protection of human health associated with agricultural, residential/parkland, commercial, and industrial land use types. The land use most closely associated with ecological resources was agricultural.

Dutch Soil Quality Standards (MHSPE, 1994) **--** The Dutch government issued three categories of soil quality values: target values, sum of the target value and intervention value divided by 2, and intervention values. The target values indicate the soil quality required for sustainability or, expressed in terms of remedial policy, the soil quality required for the full restoration of the soil's functionality for human, animal, and plant life. Target values were based on standards for drinking water and surface waters.

4.1.4 Data Presentation

Complete analytical results for all media are presented in Appendix I. Data validation reports are included in Appendix J. Within the text, data are summarized within groups of samples that represent the various media (surface soil, subsurface soil, groundwater, and sediment) at SWMU 7. The data are presented in two ways. Tables 4-3 through 4-6 present chemicals with concentrations above screening criteria for organic chemicals and, for inorganic chemicals, concentrations above background and a screening criteria value for each parameter. Tables 4-7 through 4-10 present summaries of the maximum and minimum concentrations, along with the detection frequencies, for parameters that exceed screening criteria. In addition, figures are presented that illustrate detected concentrations of only those parameters that exceed their respective screening criteria and their background concentrations.

4.2 Analytical Results

4.2.1 Basewide Background

This section presents basewide background data and discussion of the data for western Vieques Island that are being used to evaluate background conditions in the various media at SWMU 7. Two sources for background concentrations are basewide background concentrations for western Vieques developed on a regional basis and the results from site-specific background samples. Basewide background concentrations were evaluated for soil, groundwater, surface water, and sediment (CH2M HILL, 2002b) for the western portion of the former NASD. The project team agreed to use the basewide soil background concentrations for site soil comparisons. For groundwater, a site-specific background groundwater sample was collected from monitoring well NDW07MW08. The site-specific groundwater background concentrations are also discussed in this section. The two offsite sediment samples may be representative of background conditions as well, as there are no installation restoration (IR) sites near these two samples, and they were collected at a considerable distance from the SWMU 7 disposal site.

4.2.1.1 Background Surface Soil

The *Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report* (CH2M HILL, 2002b) evaluated 26 surface and 11 subsurface soil samples collected from the western portion of Vieques Island to determine background levels of inorganic constituents to be used for comparing site data. Inorganic background concentrations can be used as reliable indicators of the commonly occurring inorganic constituents at the former NASD and can be used to evaluate whether constituents detected during investigations are the result of natural conditions or activities related to historical military operations. If the site inorganic data are below the background concentrations, it can be assumed that these constituents are not related to historical site activities but are more likely from background conditions. The upper tolerance limit (UTL) values for the combined soil data were selected as appropriate screening criteria for single point comparisons. The EPA Region 2 risk assessment process requires that all chemicals detected above risk-based screening criteria be carried through the risk assessment. Therefore, all inorganics detected above screening criteria were retained as COPCs and carried through the risk assessment process even if the detected concentrations were consistent with background concentrations. For presentation, only chemicals exceeding screening criteria and background levels are presented in figures for inorganics.

4.2.1.2 Groundwater

Background groundwater concentrations were determined on a site-specific basis. At SWMU 7, one monitoring well (NDW07MW08) was installed as a site-specific background monitoring point. A summary of the analytical results from this site-specific background sample is provided in Table 4-1.

4.2.1.3 Essential Human Nutrients

In accordance with EPA guidance, the presence of several essential human nutrients was investigated to determine if they should be further evaluated. *Risk Assessment Guidance for Superfund, Part A* (EPA, 1989) specifies that essential human nutrients that are present at concentrations that marginally exceed background concentrations and are toxic only at very high doses can be eliminated from further consideration during the initial screening process. To meet these requirements, the percentage of the recommended daily intake was calculated for each essential human nutrient based on soil consumption and the maximum detected concentration in surface soil. Table 4-2 presents the data used in the calculation and the results of the evaluation. This method is considered conservative because the calculation is based on the maximum detected concentration of the essential nutrient and the recommended daily intake rather than a level at which adverse effects are observed. The recommended daily intake is the median value (where a range is presented) from the *Recommended Dietary Allowances*, 10th Edition, National Academy of Sciences, National Research Council, Food and Nutrition Board (1989).

As can be seen in Table 4-2, daily intake of the essential nutrients calcium, magnesium, potassium, and sodium from soil consumption (based on the maximum soil concentration) generally represents less than 1 percent of the recommended daily intake of these essential nutrients. Additionally, these nutrients were detected at concentrations that are consistent with background levels (CH2M HILL, 2002b). Based on these data, the maximum concentrations of these essential nutrients are well below toxic levels and will not be considered further in this report.

4.2.2 SWMU 7 Disposal Site

The sampling activities conducted at SWMU 7 during the Expanded PA/SI and RI fieldwork of 2000 through 2003 consisted of surface and subsurface soil sampling, groundwater sampling from permanent wells, and sediment sampling. The results of these sampling activities and the nature and extent of contamination in the soil and groundwater are discussed in this subsection. Appendix I presents all the results compared against screening criteria.

4.2.2.1 Surface Soil

Results from surface soil samples collected during both the 2000 Expanded PA/SI sampling events and the 2003 RI event are presented and evaluated in this subsection. Six surface soil samples (0 to 6 inches bls) were collected during the Expanded PA/SI from locations sampled during the 1988 CS conducted at SWMU 7. Because these samples were collected at the same locations as the 1988 investigation, only the more recent samples were evaluated. Three samples, originally referred to as sediment samples, were also collected during the Expanded PA/SI sampling event. These sediment samples were collected from the dry streambed at SWMU 7. This area is generally dry and does not provide suitable habitat for aquatic species. Therefore, these samples are considered soil samples and are included in the surface soil evaluation. The Expanded PA/SI soil and sediment samples were analyzed for inorganics, VOCs, SVOCs, pesticides, PCBs, and explosives.

Fifteen surface soil samples were collected at SWMU 7 during the RI. Surface soil samples were analyzed for target compound list (TCL) VOCs, SVOCs, pesticides, and explosives and for perchlorate and target analyte list (TAL) inorganics. Table 4-3 presents a summary of the detected concentrations and exceedances of each chemical for the SWMU 7 RI surface soil samples. Table 4-7 presents statistical summaries of those chemicals that exceed screening criteria. Figures 4-1 through 4-5 illustrate the detected concentrations of those parameters that exceed screening criteria and background concentrations in at least one surface soil sample at SWMU 7.

4.2.2.1.1 Inorganic Analytes

A total of 23 inorganic analytes were detected in surface soil samples at SWMU 7 (see Table 4-3). Thirteen inorganic analytes were detected above screening criteria in at least one surface soil sample. Nine metals (aluminum, arsenic, cadmium, copper, iron, lead, manganese, thallium, and vanadium) exceeded their respective EPA Region 9 residential PRGs (HI = 0.1). Human health-based screening criteria were not available for calcium, magnesium, potassium, and sodium. As previously discussed, these essential human nutrients were not identified as COPCs in accordance with EPA RAGS Part A guidance (EPA, 1989).

Twelve metals (aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, thallium, vanadium, and zinc) exceeded their respective ecological screening criteria in at least one surface soil sample.

Chromium was detected at concentrations that exceed its leachability criteria in at least one surface soil sample. Leaching criteria were not available for 12 metals (aluminum, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, and thallium).

Each inorganic chemical that exceeded background and one of the human health protection-based PRG values, ecological protection-based screening values, or leachability-based SSL values is discussed below. Chemicals that were compared against these criteria and did not exceed background and one of the above criteria are not discussed further in this section. However, comparison results are presented in Appendix I.

Arsenic was detected in 21 of 24 surface soil samples collected at SWMU 7. Sixteen samples contained arsenic at concentrations that exceeded its residential PRG. Two of the 21 detects were above background levels (CH2M HILL, 2002b). Arsenic was not detected above its ecological screening criterion or SSL at SWMU 7.

Cadmium was detected in 10 of 24 surface soil samples collected at SWMU 7. Nine surface soil samples contained cadmium concentrations above the background concentration of 0.04 mg/kg (CH2M HILL, 2002b). One sample contained cadmium at a concentration that exceeded its residential PRG and its ecological screening value. Cadmium was not detected above its SSL at SWMU 7.

Chromium was detected in all 24 surface soil samples at SWMU 7. Three samples contained chromium above its background concentration of 74 mg/kg (CH2M HILL, 2002b). No samples contained chromium at concentrations that exceed its residential PRG. All 24 surface soil samples contained chromium above its ecological screening criterion.

Chromium was detected at concentrations that exceed its leachability criteria in 21 surface soil samples. The chromium leaching criteria are based on the chemical properties of hexavalent chromium. The most stable and abundant form of chromium is the trivalent species. According to the EPA (1996), trivalent chromium does not present a leaching concern at any soil concentration. Based on this information, it is unlikely that chromium represents a leaching hazard. No data are available to determine the species of chromium present in SWMU 7 soil.

Cobalt was detected in all 24 surface soil samples at SWMU 7. Five samples contained cobalt above its background concentration of 25 mg/kg (CH2M HILL, 2002b). No samples contained cobalt at concentrations that exceed its residential PRG. Seven surface soil samples contained cobalt above its ecological screening criterion. An SSL was not available for cobalt.

Copper was detected in all 24 surface soil samples at SWMU 7. One sample contained copper above its background concentration of 68 mg/kg (CH2M HILL, 2002b) and its residential PRG. Five surface soil samples contained copper above its ecological screening criterion. An SSL was not available for copper.

Iron was detected in all 24 surface soil samples at SWMU 7. Three samples contained iron above its background concentration of 37,531 mg/kg (CH2M HILL, 2002b). All 24 samples contained iron at concentrations that exceed its residential PRG and its ecological screening criterion. An SSL was not available for iron.

Lead was detected in all 24 surface soil samples at SWMU 7. Ten samples contained lead above its background concentration of 6.9 mg/kg (CH2M HILL, 2002b). None of the samples contained lead at concentrations that exceed its residential PRG, and two samples contained lead above its ecological screening criterion. An SSL was not available for lead.

Manganese was detected in all 21 surface soil samples at SWMU 7. Twenty-four samples were collected, including the three sediment samples from the 2000 sampling event. Those three sediment sample results for manganese were rejected by the third-party validation process due to low matrix spike recoveries. One sample contained manganese above its background concentration of 1,167 mg/kg (CH2M HILL, 2002b). All 21 samples contained manganese at concentrations that exceed its residential PRG and its ecological screening criterion. An SSL was not available for manganese.

Nickel was detected in all 24 surface soil samples at SWMU 7. Two samples contained nickel above its background concentration of 40 mg/kg (CH2M HILL, 2002b). Nickel was not detected above its residential PRG or its SSL in any sample collected at SWMU 7. Nickel was detected above its ecological screening criterion in five samples.

Thallium was detected in 16 of 24 surface soil samples at SWMU 7. Eight samples contained thallium above its background concentration of 0.67 mg/kg (CH2M HILL, 2002b). Twelve samples contained thallium at concentrations that exceed its residential PRG, and two samples contained thallium above its ecological screening criterion. One sample also contained thallium at a concentration equal to the ecological screening criterion. An SSL was not available for thallium.

Zinc was detected in all 24 surface soil samples at SWMU 7. Nine samples contained zinc above its background concentration of 65 mg/kg (CH2M HILL, 2002b). Zinc was not detected above its residential PRG or its SSL in any sample collected at SWMU 7. Zinc was detected above its ecological screening criterion in 11 samples.

4.2.2.1.2 Pesticides

Three pesticides were detected in nine surface soil sample locations. None were found at concentrations above their respective human health protection-based residential PRGs (see Table 4-3).

Two pesticides, DDE and DDT, exceeded their respective ecological screening criteria. Ecological screening criteria were not available for heptachlor.

4.2.2.1.3 Semivolatile Organic Compounds

Sixteen SVOCs were detected in 18 of the 24 surface soil sample locations. The SVOCs detected consisted of 12 PAHs and three phthalates (see Table 4-3). Of the detected SVOCs, only benzo(a)pyrene was detected at a concentration that exceeded its residential PRG. It exceeded its human health-based screening criteria in only three samples.

Two SVOCs, benzo(a)pyrene and pyrene, exceeded their respective ecological screening criteria. Benzo(a)pyrene exceeded screening criteria in two samples, and pyrene exceeded screening criteria in three samples. Ecological screening criteria were not available for 10 SVOCs: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, pyrene, benzyl butyl phthalate, bis(2ethylhexyl)phthalate.

SVOCs were not detected above available SSLs in surface soil at SWMU 7.

4.2.2.1.4 Volatile Organic Compounds

VOCs were detected in 13 of the 24 samples during the RI; acetone was included in the TAL in 17 samples. Five VOCs were detected in the surface soil during the RI (see Table 4-3). VOCs were not detected above available human health-based screening criteria, ecological screening criteria, or SSLs in surface soil.

4.2.2.2 Subsurface Soil

No subsurface soil samples were collected from SWMU 7 during the Expanded PA/SI investigation. Eleven subsurface soil samples were collected during the RI. The subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides, and explosives and for perchlorate and TAL inorganics. Table 4-4 presents a summary of the exceedances of compounds for the RI SWMU 7 subsurface soil samples. Table 4-8 presents a statistical summary of chemicals that exceed screening criteria, in this case chromium. Figure 4-6 illustrates the concentrations of those parameters that exceed screening criteria and background concentrations in at least one subsurface soil sample at SWMU 7.

4.2.2.2.1 Inorganic Analytes

A total of 23 inorganic analytes were detected in subsurface soil samples at SWMU 7. One inorganic analyte, chromium, was detected above its SSL in 10 subsurface soil samples (see Table 4-4). One sample contained chromium above its background concentration of 74 mg/kg (CH2M HILL, 2002b).

4.2.2.2.2 Perchlorate

Perchlorate was detected in one of 11 subsurface soil samples collected at SWMU 7. An SSL was not available for comparison. The detected concentration is estimated and near the detection limit as indicated by the “J” qualifier.

4.2.2.2.3 Pesticides

Two pesticides were detected at two subsurface soil sample locations. None of the detected concentrations exceeds its respective SSL.

4.2.2.2.4 Semivolatile Organic Compounds

Seven SVOCs were detected at eight subsurface soil sample locations. The detected SVOCs consisted of five PAHs and two phthalates (see Appendix I). Detected SVOCs were not detected in subsurface soil above available SSLs. SSLs were not available for two SVOCs, benzo(g,h,i)perylene and bis(2-ethylhexyl)phthalate.

4.2.2.2.5 Volatile Organic Compounds

Two VOCs, 2-hexanone and methylene chloride, were detected in four of the 11 sample locations. Methylene chloride was detected below its SSL in the one sample where it was detected. An SSL was not available for 2-hexanone. It was not detected in surface soil or groundwater at the site.

4.2.2.3 Groundwater

Three monitoring wells were installed and sampled as part of the 1988 CS. During the Expanded PA/SI, two of these wells could not be located and were subsequently replaced. All three monitoring wells were sampled during the PA/SI. The samples were analyzed for dissolved and TAL metals, VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate.

During the RI, samples were collected from two of the existing monitoring wells. Monitoring well NDW07MW01 could not be sampled, as it was dry during RI sampling. Six more monitoring wells were installed, and five were sampled. Details of this sampling are presented in Section 3. Groundwater samples were analyzed for dissolved and TAL metals, pesticides, explosives, and perchlorate. One of the newly installed monitoring wells, NDW07MW08, was installed upgradient of the site as a site-specific background well. Table 4-5 presents the detected concentrations above the screening criteria for organic and inorganic chemicals. The inorganic chemicals were presented if they were also above background levels for each chemical in SWMU 7 groundwater samples. Table 4-9 presents the statistical summaries of chemicals compared against respective screening criteria. Figure 4-7 illustrates the detected concentrations of those parameters that exceed background and applicable screening criteria.

4.2.2.3.1 Inorganic Analytes

A total of 20 inorganic analytes were detected in unfiltered (total) groundwater samples. Twenty-one inorganic analytes were detected in filtered samples. Six analytes (aluminum, antimony, arsenic, manganese, vanadium, and zinc) were detected above their respective EPA Region 9 tap-water PRGs in unfiltered samples. Three analytes were detected above screening criteria in filtered samples; these were arsenic, manganese, and vanadium (see Table 4-5). Screening criteria were not available for chromium or lead.

Aluminum was detected in eight of nine unfiltered groundwater samples collected at SWMU 7. One unfiltered sample collected during the 2000 sampling effort contained aluminum at a concentration that marginally exceeded its tap-water PRG of 3,650 ug/L. Aluminum was not detected in the filtered sample from the same well. The unfiltered sample collected in 2003 from the same well contained aluminum at a concentration of 329 ug/L.

Antimony was detected in one of nine unfiltered groundwater samples collected at SWMU 7. One unfiltered sample collected during the 2000 sampling effort contained antimony at an estimated concentration that marginally exceeded its tap-water PRG of 1.46 ug/L. Antimony was not detected in the filtered sample from the same well.

Arsenic was detected in two of nine unfiltered and one of nine filtered groundwater samples collected at SWMU 7. Detected concentrations were all above background and the tap-water PRG for arsenic in wells NDW07MW01 (which is dry) and NDW07MW06, located at the northern end of the site .

Chromium was detected in eight of nine unfiltered and seven of nine filtered groundwater samples collected at SWMU 7. Filtered results were below the filtered background concentrations. One unfiltered sample exceeded its tap-water PRG of 11 ug/L.

Lead was detected in three of nine unfiltered and one of nine filtered groundwater samples collected at SWMU 7. A tap-water PRG was not available for lead; the drinking water treatment technique action limit (TTAL) of 15 ug/L was used as a screening criterion. Lead was not detected in the upgradient background sample. One unfiltered sample exceeded this screening criterion.

Manganese was detected in all nine unfiltered and eight of nine filtered groundwater samples collected at SWMU 7. Four unfiltered samples and three filtered samples contained manganese above its tap-water PRG of 87.6 ug/L. Seven samples, filtered and unfiltered, contained manganese at concentrations that exceeded the site-specific background concentrations of 23.4 ug/L unfiltered and 21.73 ug/L filtered.

Vanadium was detected in all nine unfiltered and filtered groundwater samples collected at SWMU 7. The detected levels of vanadium in five samples, filtered and unfiltered, exceeded the tap-water PRG of 25.5 ug/L.

Zinc was detected in all nine unfiltered and filtered groundwater samples collected at SWMU 7. The detected levels of zinc exceeded its tap-water PRG of 1,090 ug/L in a single unfiltered sample. Zinc was detected at an estimated concentration of 10 J ug/L in the filtered sample from the same well.

4.2.2.3.2 Volatile Organic Compounds

No VOCs were detected above screening criteria in the groundwater samples collected from SWMU 7. Acetone was the only VOC detected, and it was detected in a single sample collected in 2000. The reported concentration, 10 ug/L, was below the EPA Region 9 tap water PRG of 60.8 ug/L (see Table 4-5).

4.2.2.3.3 Semivolatile Organic Compounds

SVOCs were not detected in any of the groundwater samples collected from SWMU 7.

4.2.2.3.4 Pesticides

Pesticides were not detected in any of the groundwater samples collected from SWMU 7.

4.2.2.3.5 Polychlorinated Biphenyls

PCBs were not detected in any of the groundwater samples collected from SWMU 7.

4.2.2.3.6 Explosives

Explosives were not detected in any of the groundwater samples collected from SWMU 7.

4.2.2.3.7 Perchlorate

Perchlorate was detected in one of nine groundwater samples collected from SWMU 7. It was detected at an estimated concentration of 2.4 J ug/L in the sample collected in 2000. It was not detected in the sample collected in 2003 from the same well. A screening criterion was not available for perchlorate. The analytical method for perchlorates is prone to false positives (DoD, 2004) and has been replaced with a more reliable method.

4.2.2.4 Sediment

During the Expanded PA/SI, three samples, originally referred to as sediment samples, were collected from the dry streambed at SWMU 7 and analyzed for TAL metals, VOCs, SVOCs, PCBs, pesticides, and explosives. As previously discussed, these samples were incorporated into the surface soil dataset. During the RI, two new sediment samples were collected and analyzed for TAL metals, PCBs, pesticides, explosives, and perchlorate. The details of this sampling are presented in Section 3. The locations of the 2003 sediment samples were more than 500 feet north of the site, near the sea. The analytical results from the samples were compared to appropriate ecological screening criteria. Background sediment values were not available for comparison at SWMU 7. Therefore, comparison to background was not performed. Appendix I presents detected chemical concentration comparisons against criteria. Table 4-6 presents the detected concentrations, screening criteria, and exceedances of each chemical detected in the 2003 sediment sampling effort at SWMU 7. Table 4-10 presents the statistical summaries of chemicals that exceed screening criteria.

4.2.2.4.1 Inorganic Analytes

Twenty-three inorganic chemicals were detected in 2003 offsite sediment samples (see Appendix I). Two inorganic chemicals, barium and copper, exceeded their respective ecological screening criteria (Figure 4-8). Screening criteria were not available for 12 other inorganic chemicals.

Barium was detected in both sediment samples at concentrations that exceeded its ecological screening value.

Copper was detected in both sediment samples; it exceeded its ecological screening value in one sample.

4.2.2.4.2 Organic Analytes

VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate were not detected in sediment samples collected at SWMU 7.

TABLE 4-1
ANALYTICAL RESULTS FROM BACKGROUND GROUNDWATER SAMPLE
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Collection Date	Concentration			
			Total	Qualifier	Dissolved	Qualifier
Metals (ug/L)						
Aluminum	NDW07MW08	09/06/03	102	J	61.3	J
Antimony	NDW07MW08	09/06/03	2.5	U	2.5	U
Arsenic	NDW07MW08	09/06/03	2.04	UJ	2.04	UJ
Barium	NDW07MW08	09/06/03	50.4	J	41.6	J
Beryllium	NDW07MW08	09/06/03	0.0945	U	0.219	J
Cadmium	NDW07MW08	09/06/03	0.356	U	0.356	U
Calcium	NDW07MW08	09/06/03	41800	J	41100	=
Chromium, Total	NDW07MW08	09/06/03	13.6	=	8.41	J
Cobalt	NDW07MW08	09/06/03	0.569	U	0.569	U
Copper	NDW07MW08	09/06/03	2.98	J	1.26	J
Iron	NDW07MW08	09/06/03	16.7	U	16.7	U
Lead	NDW07MW08	09/06/03	1.76	UJ	1.76	UJ
Magnesium	NDW07MW08	09/06/03	41200	J	45900	J
Manganese	NDW07MW08	09/06/03	21.7	J	23.4	=
Mercury	NDW07MW08	09/06/03	0.024	J	0.0162	U
Nickel	NDW07MW08	09/06/03	1.54	J	1.14	J
Potassium	NDW07MW08	09/06/03	9930	J	7050	J
Selenium	NDW07MW08	09/06/03	2.1	U	2.26	J
Silver	NDW07MW08	09/06/03	0.472	U	0.823	J
Sodium	NDW07MW08	09/06/03	195000	J	200000	=
Thallium	NDW07MW08	09/06/03	2.54	U	2.54	U
Vanadium	NDW07MW08	09/06/03	8.64	J	8.67	J
Zinc	NDW07MW08	09/06/03	2.67	J	0.492	J
Explosives (ug/L)						
1,3,5-Trinitrobenzene	NDW07MW08	09/06/03	2.5	U	-	
1,3-Dinitrobenzene	NDW07MW08	09/06/03	2.5	U	-	
2,4,6-Trinitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
2,4-Dinitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
2,6-Dinitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
2-Nitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
3-Nitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
4-Nitrotoluene	NDW07MW08	09/06/03	2.5	U	-	
Hexahydro-1,3,5-Trinitro-1,3,5,7-Tetrazocine	NDW07MW08	09/06/03	2.5	U	-	
Nitrobenzene	NDW07MW08	09/06/03	2.5	U	-	
Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine	NDW07MW08	09/06/03	2.5	U	-	
Tetryl	NDW07MW08	09/06/03	2.5	U	-	
Perchlorate (ug/L)						

TABLE 4-1
ANALYTICAL RESULTS FROM BACKGROUND GROUNDWATER SAMPLE
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Collection Date	Concentration Total	Qualifier	Dissolved	Qualifier
Perchlorate	NDW07MW08	09/06/03	20	U	-	
		Pesticides (ug/L)				
Aldrin	NDW07MW08	09/06/03	0.01	U	-	
Alpha BHC (Alpha Hexachlorocyclohexane)	NDW07MW08	09/06/03	0.01	U	-	
Alpha Endosulfan	NDW07MW08	09/06/03	0.01	U	-	
Alpha-Chlordane	NDW07MW08	09/06/03	0.01	U	-	
Beta BHC (Beta Hexachlorocyclohexane)	NDW07MW08	09/06/03	0.01	U	-	
Beta Endosulfan	NDW07MW08	09/06/03	0.02	U	-	
Delta BHC (Delta Hexachlorocyclohexane)	NDW07MW08	09/06/03	0.01	U	-	
Dieldrin	NDW07MW08	09/06/03	0.02	U	-	
Endosulfan Sulfate	NDW07MW08	09/06/03	0.02	U	-	
Endrin	NDW07MW08	09/06/03	0.02	UJ	-	
Endrin Aldehyde	NDW07MW08	09/06/03	0.02	U	-	
Endrin Ketone	NDW07MW08	09/06/03	0.02	U	-	
Gamma BHC (Lindane)	NDW07MW08	09/06/03	0.01	U	-	
Gamma-Chlordane	NDW07MW08	09/06/03	0.01	U	-	
Heptachlor	NDW07MW08	09/06/03	0.01	U	-	
Heptachlor Epoxide	NDW07MW08	09/06/03	0.01	U	-	
Methoxychlor	NDW07MW08	09/06/03	0.1	U	-	
P,P'-DDD	NDW07MW08	09/06/03	0.02	U	-	
p,p'-DDE	NDW07MW08	09/06/03	0.02	U	-	
p,p'-DDT	NDW07MW08	09/06/03	0.02	U	-	
Toxaphene	NDW07MW08	09/06/03	0.05	U	-	

U indicates that the chemical was not detected. The reported value is the minimum detection limit (MDL, inorganics) or the reporting limit (RL, organics).
UJ indicates that the chemical was not detected and the quantitation limit may be inaccurate or imprecise.
J indicates that the chemical was detected. The reported value is estimated.
= indicates that the chemical was detected. The reported value is the measured concentration.
- indicates that the chemical was not sampled or analyzed for in the dissolved sample.

TABLE 4-2
ESSENTIAL NUTRIENTS IN SURFACE SOIL
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Maximum Concentration in Surface Soil (mg/Kg)	Background Concentration[1] (mg/Kg)	Daily Soil Intake [2] (kg/day)		Daily Nutrient Intake from Soil [3] (mg/day)		Recommended Daily Nutrient Intake [4] (mg/day)		Percent of Recommended Daily Nutrient Intake from Soil Consumption	
			Child	Adult	Child	Adult	Child	Adult	Child	Adult
Calcium	9,330	210,000	0.0002	0.0001	1.87	0.93	600	1000	0.31%	0.09%
Magnesium	8,300	12,834	0.0002	0.0001	1.66	0.83	105	300	1.58%	0.28%
Potassium	1,550	1,700	0.0002	0.0001	0.31	0.16	1,050	2,000	0.03%	0.01%
Sodium	449	6,300	0.0002	0.0001	0.090	0.04	260	500	0.03%	0.01%

[1] Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002b).
[2] Soil intake is 200 mg/day for a child and 100 mg/day for an adult.
[3] Calculated value.
[4] Median value from the Recommended Dietary Allowances, 10th Edition, National Academy of Sciences, National Research Council, Food and Nutrition Board, 1989.

TABLE 4-3
DETECTED ORGANIC CHEMICALS ABOVE SCREENING CRITERIA AND INORGANIC CHEMICALS ABOVE BACKGROUND AND SCREENING CRITERIA IN SURFACE SOIL

SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Sample Date	Result	Qualifier	Region 9 PRG[1]	Ecological Criteria [2]	SSL (DAF= 20)[3]	Screening Criteria Exceedances		
								PRG	Ecological	SSL
				Metals (mg/Kg)						
Arsenic	NDW07SS03	04/18/00	6.6	=	0.39	10	29	yes	no	no
	NDW07SS14	08/26/03	2.41	=				yes	no	no
Cadmium	NDW07SS16	08/25/03	6.75	=	3.7	4	8	yes	yes	no
Chromium, Total	NDW07SS01	04/18/00	91.9	=	211	0.4	38	no	yes	yes
	NDW07SS17	08/25/03	80.6	J				no	yes	yes
	NDW07SS02	04/18/00	75.7	=				no	yes	yes
Cobalt	NDW07SD02	04/18/00	42.4	J	903	20	NA	no	yes	na
	NDW07SS01	04/18/00	30.8	=				no	yes	na
	NDW07SD01	04/18/00	30.3	J				no	yes	na
	NDW07SS20	08/27/03	30	=				no	yes	na
	NDW07SS17	08/25/03	28.5	=				no	yes	na
Copper	NDW07SS01	04/18/00	1250	=	313	50	NA	yes	yes	na
Iron	NDW07SS14	08/26/03	59200	J	2350	200	NA	yes	yes	na
	NDW07SS03	04/18/00	51500	=				yes	yes	na
	NDW07SS05	04/18/00	42700	=				yes	yes	na
Lead	NDW07SS14	08/26/03	293	=	400	50	NA	no	yes	na
	NDW07SS05	04/18/00	98.7	=				no	yes	na
Manganese	NDW07SS20	08/27/03	1190	=	176	100	NA	yes	yes	na
Nickel	NDW07SS01	04/18/00	42.7	=	156	30	130	no	yes	no
	NDW07SS17	08/25/03	40.6	=				no	yes	no
Thallium	NDW07SS03	04/18/00	2	J	0.516	1	NA	yes	yes	na
	NDW07SS01	04/18/00	1.3	J				yes	yes	na
	NDW07SS05	04/18/00	1	J				yes	no	na
	NDW07SS02	04/18/00	0.99	J				yes	no	na
	NDW07SD03	04/18/00	0.83	J				yes	no	na
	NDW07SS13	08/27/03	0.757	J				yes	no	na
	NDW07SS21	08/27/03	0.7	J				yes	no	na
	NDW07SD01	04/18/00	0.68	J				yes	no	na
Zinc	NDW07SS02	04/18/00	419	=	2350	50	12000	no	yes	no
	NDW07SS04	04/18/00	274	=				no	yes	no
	NDW07SS05	04/18/00	200	=				no	yes	no
	NDW07SS06	04/18/00	197	=				no	yes	no
	NDW07SS14	08/26/03	134	=				no	yes	no
	NDW07SS03	04/18/00	124	=				no	yes	no
	NDW07SS16	08/25/03	123	=				no	yes	no
	NDW07SS01	04/18/00	104	=				no	yes	no
	NDW07SS09	08/26/03	78.5	=				no	yes	no

TABLE 4-3
DETECTED ORGANIC CHEMICALS ABOVE SCREENING CRITERIA AND INORGANIC CHEMICALS ABOVE BACKGROUND AND SCREENING CRITERIA IN SURFACE SOIL

SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Sample Date	Result	Qualifier	Region 9 PRG[1]	Ecological Criteria [2]	SSL (DAF= 20)[3]	Screening Criteria Exceedances		
								PRG	Ecological	SSL
Pesticides (mg/Kg)										
p,p'-DDE	NDW07SS04	04/18/00	0.0099	J	1.72	0.0025	54	no	yes	no
p,p'-DDT	NDW07SS04	04/18/00	0.023	J	1.72	0.0025	32	no	yes	no
	NDW07SS05	04/18/00	0.016	J				no	yes	no
	NDW07SS06	04/18/00	0.0036	J				no	yes	no
Semivolatile Organic Compounds (mg/Kg)										
Benzo(a) pyrene	NDW07SS05	04/18/00	0.337	J	0.0621	0.1	8	yes	yes	no
	NDW07SS03	04/18/00	0.215	J				yes	yes	no
	NDW07SS04	04/18/00	0.073	J				yes	no	no
Pyrene	NDW07SS05	04/18/00	0.626	J	232	0.1	4200	no	yes	no
	NDW07SS03	04/18/00	0.255	J				no	yes	no
	NDW07SS04	04/18/00	0.128	J				no	yes	no
Volatile Organic Compounds (mg/Kg)										
No VOCs were above criteria										

Note: See Appendix I for more detailed comparison table of Site Detected Concentrations against Screening Criteria.

[1] EPA Region 9 PRG (2002) based on a hazard index (HI) of 0.1 for noncarcinogens.
[2] The lower of the toxicological benchmarks invertebrates and heterotrophs (Efroymson, 1997a) or terrestrial plants (Efroymson, 1997b).
[3] EPA Region 9 PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 20.
[a] Anthracene used as surrogate (isometric).
J indicates that the chemical was detected. The reported value is estimated.

TABLE 4-4
DETECTED CHEMICALS ABOVE SCREENING CRITERIA AND BACKGROUND IN SUBSURFACE SOIL
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Sample Date	Result	Qualifier	SSL (DAF=20)[1]	Exceedances of SSL
Metals (mg/Kg)						
Chromium, Total	NDW07SB17	08/25/03	82.9	J	38	yes
Munitions/Perchlorate (mg/Kg)						
No Chemicals in this category were above criteria						
Pesticides (mg/Kg)						
No Pesticides were above criteria						
Semivolatile Organic Compounds (mg/Kg)						
No SVOCs were above criteria						

[1] EPA Region 9 PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 20.
J indicates that the chemical was detected. The reported value is estimated.

TABLE 4-5
DETECTED INORGANIC CHEMICALS ABOVE BACKGROUND AND SCREENING CRITERIA AND ORGANIC CHEMICALS ABOVE CRITERIA IN GROUNDWATER
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Station ID	Sample Date	Concentration (ug/L)					Region 9 PRG Exceedances	
			Total	Qualifier	Dissolved	Qualifier	PRG [1]	Total	Dissolved
Aluminum	NDW07MW03R	05/02/00	4090	=	ND		3650	yes	no
Antimony	NDW07MW01	05/02/00	1.5	J	ND		1.46	yes	no
Arsenic	NDW07MW06	09/03/03	37.1	J	ND		0.0448	yes	no
	NDW07MW01	05/02/00	27.2	=	8.4	J		yes	yes
Chromium, Total	NDW07MW01	05/02/00	29.4	=	0.69	J	11	yes	no
Iron	NDW07MW01	05/02/00	7320	J	944	J	1090	yes	no
	NDW07MW03R	05/02/00	4170	J	ND			yes	no
	NDW07MW02R	05/02/00	1460	J	70.5	J		yes	no
Lead	NDW07MW06	09/03/03	25.1	J	ND		15	yes	no
Manganese	NDW07MW02R	09/07/03	1740	J	1670	=	87.6	yes	yes
	NDW07MW01	05/02/00	1270	=	1090	=		yes	yes
	NDW07MW03R	09/08/03	785	J	692	=		yes	yes
	NDW07MW03R	05/02/00	148	=	31.1	=		yes	no
Vanadium	NDW07MW05	09/07/03	58	=	59.8	=	25.5	yes	yes
	NDW07MW03R	05/02/00	46.2	J	35.5	J		yes	yes
	NDW07MW04	09/07/03	29.2	J	26.8	J		yes	yes
	NDW07MW07	09/09/03	28.2	J	27.2	J		yes	yes
	NDW07MW03R	09/08/03	27.3	J	29	J		yes	yes
Zinc	NDW07MW01	05/02/00	2950	=	10	J	1090	yes	no
Explosives/Perchlorate (ug/L)									
N*o explosives/ perchlorate were detected above criteria*									
Volatile Organic Compounds (ug/L)									
No VOCs were detected above criteria									

[1] EPA Region 9 tap water PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.
ND indicates that the chemical was not detected.
J indicates that the chemical was detected. The reported value is estimated.
= indicates that the chemical was detected. The reported value is the measured concentration.

TABLE 4-6
DETECTED CHEMICALS IN OFFSITE SEDIMENT SAMPLES FROM VIEQUES PASSAGE
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	**Station ID**	**Sample Date**	**Result (mg/Kg)**	**Qualifier**	**Ecological Screening Criteria [1]**	**Exceedances of Ecological Criteria**
Barium	NDW07SD05	08/27/03	50.7	=	20	Yes
	NDW07SD04	08/27/03	25.1	J		Yes
Copper	NDW07SD05	08/27/03	20.9	=	18.7	yes

Note: No organic chemicals were detected above detection limits
[1] The lower of the screening criteria for marine and estuarine sediments (Long, 1995) or the EPA guidance on Ecological Risk Assessment (EPA, 2000).
J indicates that the chemical was detected. The reported value is estimated.
= Indicates that the chemical was detected. The reported value is the measured concentration.

TABLE 4-7
SUMMARY OF SURFACE SOIL EXCEEDANCES OF SCREENING CRITERIA
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (mg/Kg)	Minimum Detect (mg/Kg)	Mean Concentration[1] (mg/Kg)	Residential PRG[2]	Ecologic Screening Value[3]	Leaching Screening Value[4]	Background Concentration[5] (mg/Kg)
Aluminum	24	24	22000	5840	14500	7610	50	NA	29000
Arsenic	24	21	6.6	0.286	0.915	0.39	10	29	2.2
Cadmium	24	10	6.75	0.0214	0.394	3.7	4.0	8	0.04
Cobalt	24	24	42.4	8.19	18.9	903	20	NA	25
Chromium, Total	24	24	91.9	9.62	50.6	211	1	38	74
Copper	24	24	1250	15.5	89	313	50	NA	68
Iron	24	24	59200	16200	29300	2350	200	NA	37531
Manganese	21	21	1190	220	701	176	100	NA	1167
Nickel	24	24	42.7	4.48	23.4	156	30	130	40
Lead	24	24	293	1.7	25.1	400	50	NA	6.9
Thallium	24	16	2	0.124	0.513	0.516	1	NA	0.67
Vanadium	24	24	130	55.7	94.7	54.7	2	6000	130
Zinc	24	24	419	16.8	91.5	2350	50	12000	65
P,P'-DDE	24	5	0.0099	0.00031	0.00211	1.72	0.0025	54	NA
P,P'-DDT	24	6	0.023	0.00043	0.00335	1.72	0.0025	32	NA
Benzo(a) pyrene	24	5	0.337	0.0255	0.196	0.0621	0.1	8	NA
Pyrene	24	5	0.626	0.035	0.213	232	0.1	4200	NA

[1] Mean concentration is based on 1/2 the detection limit for non-detects.
[2] EPA Region 9 PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.
[3] The lower of the toxicological benchmarks terrestrial plants, (Efroymson, 1997a) or invertebrates and heterotrophs (Efroymson, 1997b).
[4] EPA Region 9 PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 20.
[5] Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002b).
NA indicates that the information is not available or not applicable.
Exceedances are highlighted.

TABLE 4-8
SUMMARY OF SUBSURFACE SOIL EXCEEDANCES OF SCREENING CRITERIA
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (mg/Kg)	Minimum Detect (mg/Kg)	Mean Concentration[1] (mg/Kg)	Leaching Screening Value [2]	Background Concentration[3] (mg/Kg)
Chromium, Total	11	11	82.9	31.3	53	38	74

[1] Mean concentration is based on 1/2 the detection limit for non-detects.
[2] EPA Region 9 PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 20.
[3] Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M HILL, 2002b).
Exceedances are highlighted.

TABLE 4-9
SUMMARY OF GROUNDWATER EXCEEDANCES OF SCREENING CRITERIA
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (ug/L)	Minimum Detect (ug/L)	Mean Concentration[1] (ug/L)	Tap Water [2] PRG	Background Concentrations Site-Specific[3] (ug/L)
Aluminum, Dissolved	9	1	53.1	0	6.6	365.0	61.3
Arsenic, Dissolved	9	1	8.4	8.4	3.01	0.0448	2.04 UJ
Manganese, Dissolved	9	8	1670	17.4	403	87.6	21.7
Lead, Dissolved	9	1	1.7	1.7	1.78	15	1.76 UJ
Vanadium, Dissolved	9	9	59.8	3.5	25.8	25.5	8.67
Zinc, Dissolved	9	9	20.7	2.51	7.69	1090	0.492
Aluminum	9	8	4090	53.2	858	3650	102
Arsenic	9	2	37.1	27.2	8.09	0.0448	2.04 UJ
Chromium, Total	9	8	29.4	1.31	7.13	11	13.6
Manganese	9	9	1740	8.9	462	87.6	23.4
Lead	9	3	25.1	1.4	4.55	15	1.76 UJ
Antimony	9	1	1.5	1.5	2.41	1.46	2.5 U
Vanadium	9	9	58	11	27.9	25.5	8.64
Zinc	9	9	2950	3.43	334	1090	2.67
Perchlorate	9	1	2.4	2.4	7.02	0.365	NA

[1] Mean concentration is based on 1/2 the detection limit for non-detects.
[2] EPA Region 9 tap water PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.
[3] Site-specific background sample from well NDW07MW08.
[4] Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M HILL, 2002b).
NA indicates that the information is not available or not applicable.
U indicates that the chemical was not detected. The reported value is the minimum detection limit (MDL, inorganics) or the reporting limit (RL, organics).
UJ indicates that the chemical was not detected and the quantitation limit may be inaccurate or imprecise.
As 1 filtration exceed in MW01 in 00, but not when resampled
Mn 3 filtration exceed 02R, 01, 3R--103, 100, 103
V 5 filtration exceed 05 3R 4 07 3R--’03 ’00 ’03 ’03 ’03
Exceedances are highlighted.

TABLE 4-10
SUMMARY OF SEDIMENT EXCEEDANCES OF SCREENING CRITERIA
SWMU 7, Former NASD, Vieques, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (mg/Kg)	Minimum Detect (mg/Kg)	Mean Concentration[1] (mg/Kg)	Ecologic Screening Value[2]	Base-Wide Background[3] (mg/Kg)
Barium	2	2	50.7	25.1	37.9	20	69
Copper	2	2	20.9	16.6	18.8	18.7	26

[1] Mean concentration is based on 1/2 the detection limit for non-detects.
[2] The lower of the screening criteria for marine and estuarine sediments (Long, 1995) or the EPA guidance on Ecological Risk Assessment (EPA, 2000).
[3] Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002b).
Exceedances are highlighted.

NOTE: Original figure created in color

Data for locations labeled in blue were collected in 2000

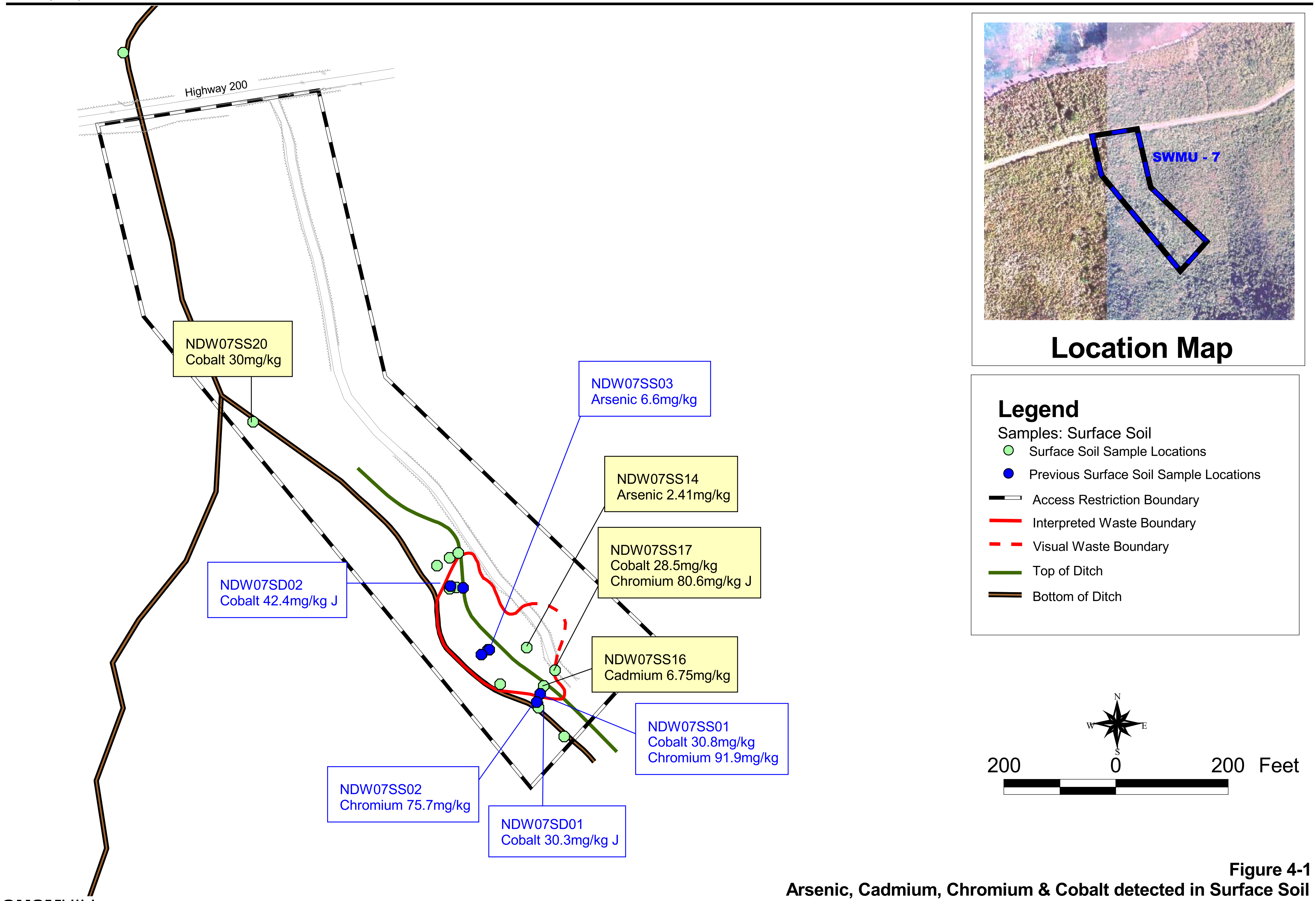

Figure 4-1
Arsenic, Cadmium, Chromium & Cobalt detected in Surface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

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NOTE: Original figure created in color

Data for locations labeled in blue were collected in 2000

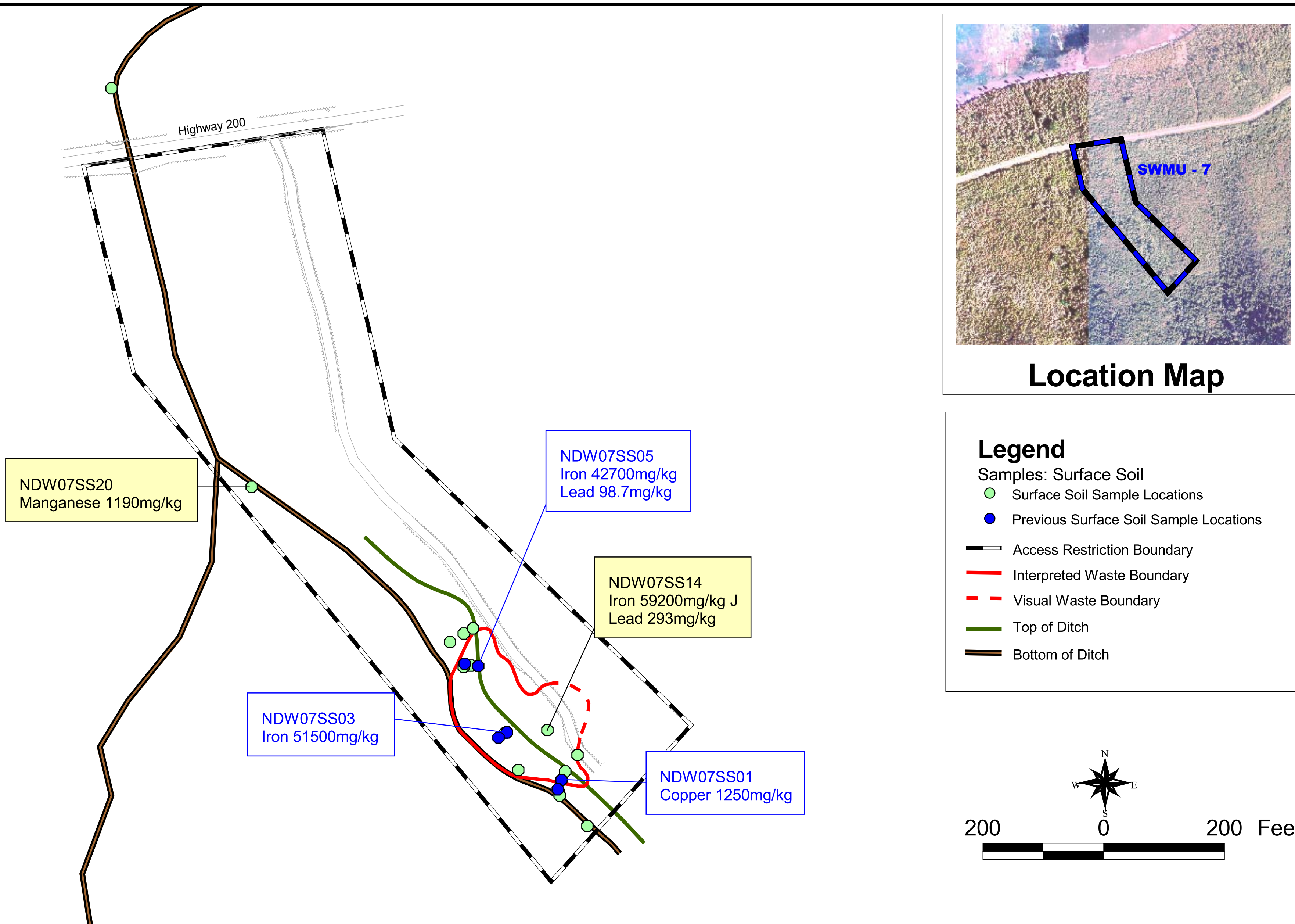

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Figure 4-2
Copper, Iron, Lead & Manganese detected in Surface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

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NOTE: Original figure created in color

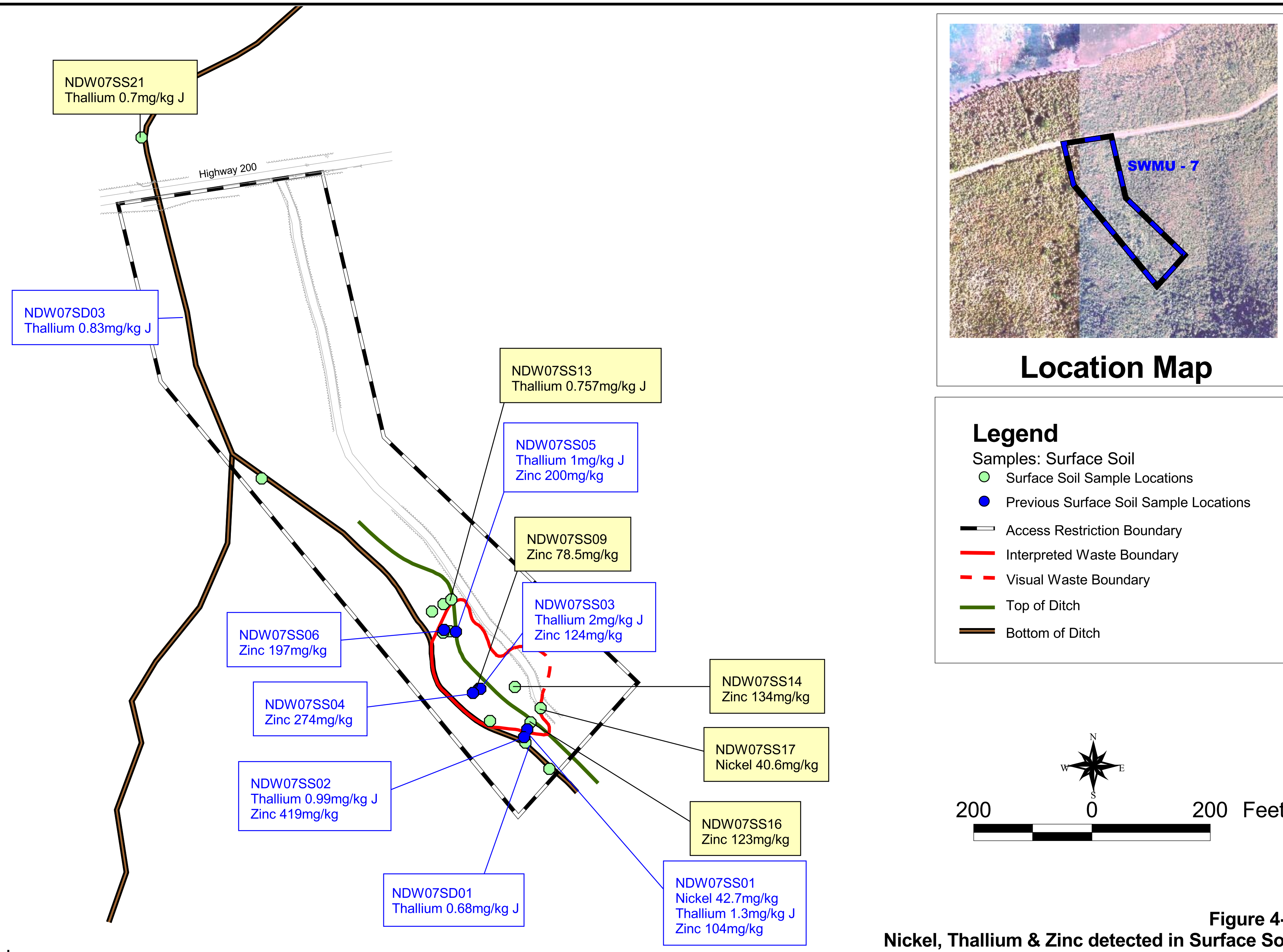

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Figure 4-3
Nickel, Thallium & Zinc detected in Surface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

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NOTE: Original figure created in color

Data for locations labeled in blue were collected in 2000

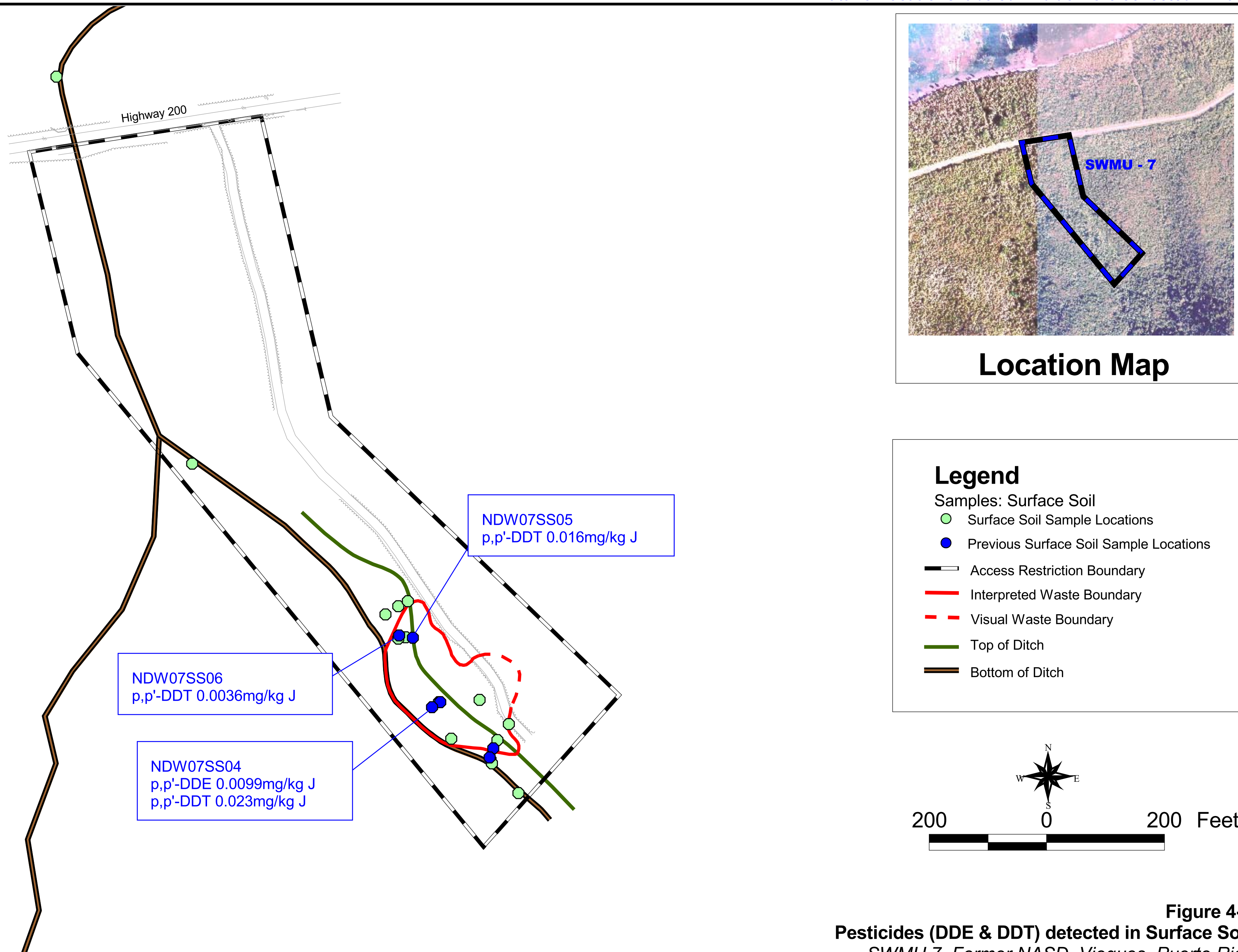

Figure 4-4
Pesticides (DDE & DDT) detected in Surface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

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NOTE: Original figure created in color

Data for locations labeled in blue were collected in 2000

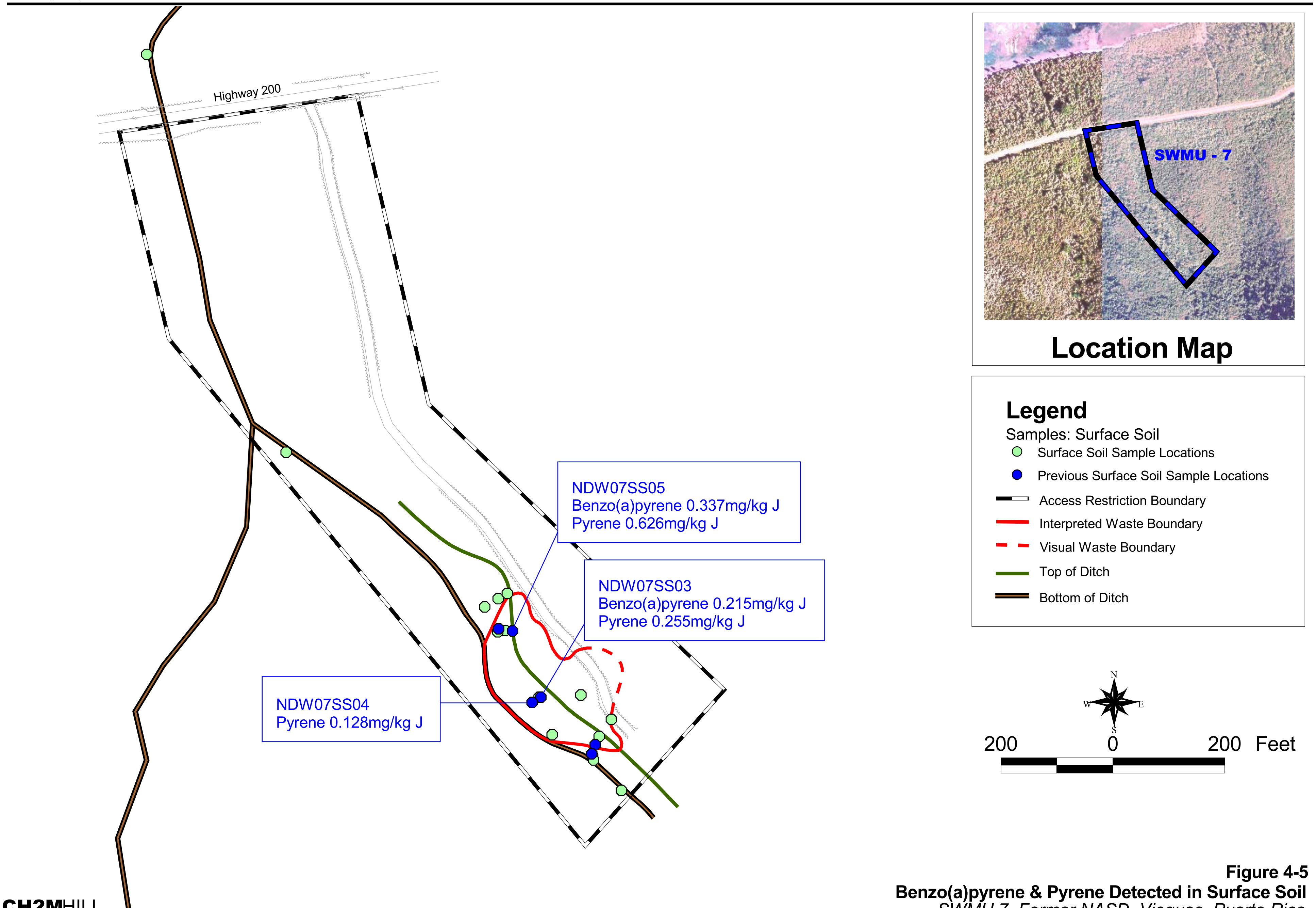

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Figure 4-5
Benzo(a)pyrene & Pyrene Detected in Surface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

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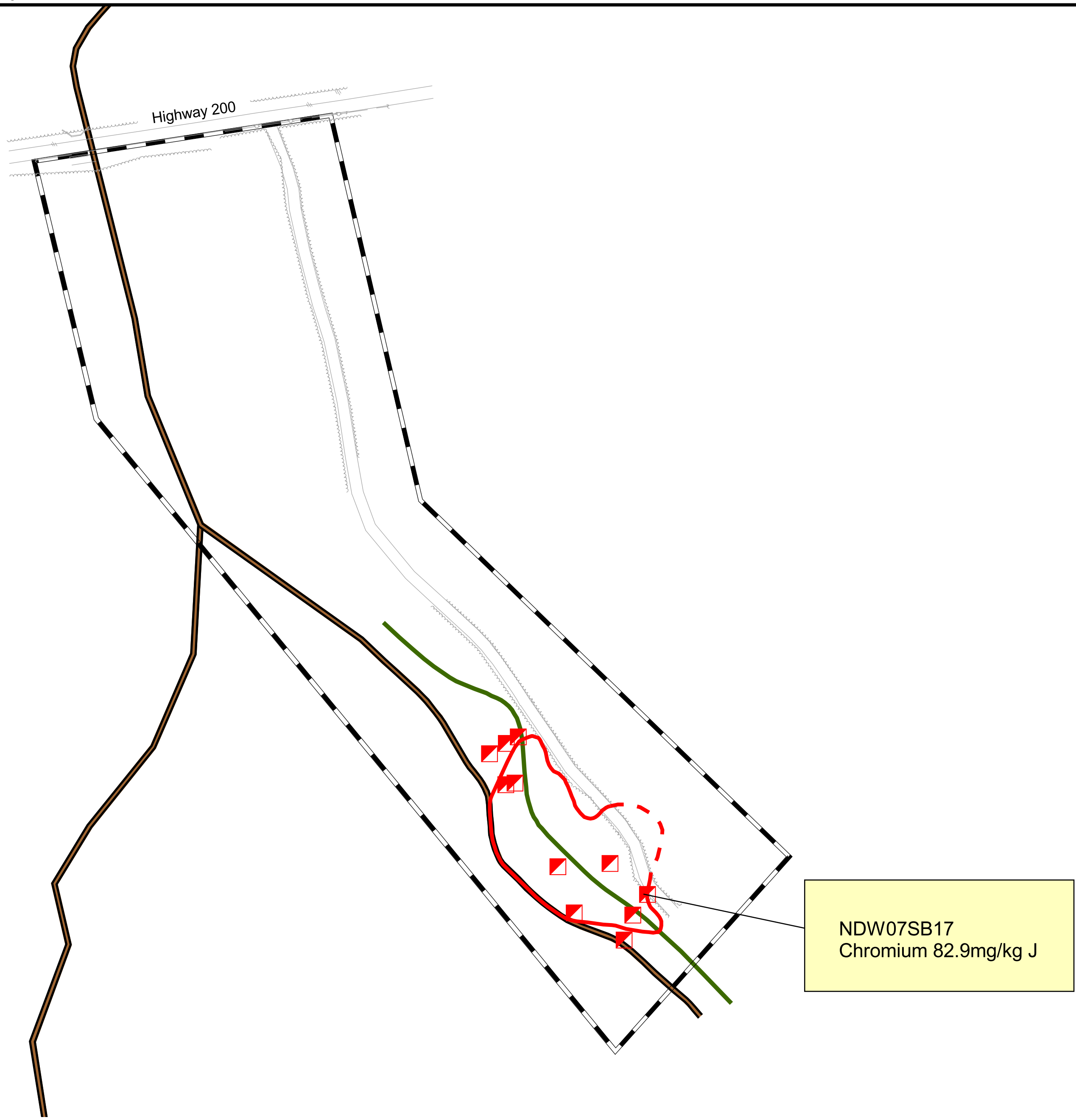
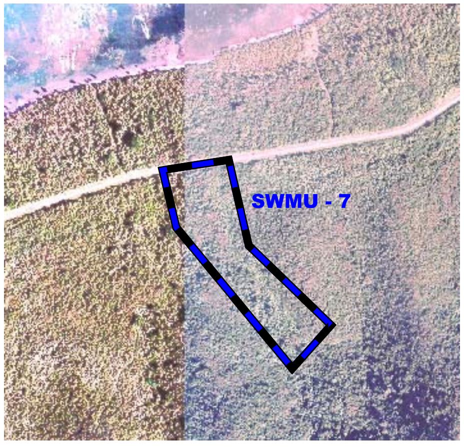
NOTE: Original figure created in color





Location Map

Legend

Samples: Surface Soil

- Soil Boring Locations
- Access Restriction Boundary
- Interpreted Waste Boundary
- Visual Waste Boundary
- Top of Ditch
- Bottom of Ditch

200 0 200 Feet

Figure 4-6
Chromium detected in Subsurface Soil
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

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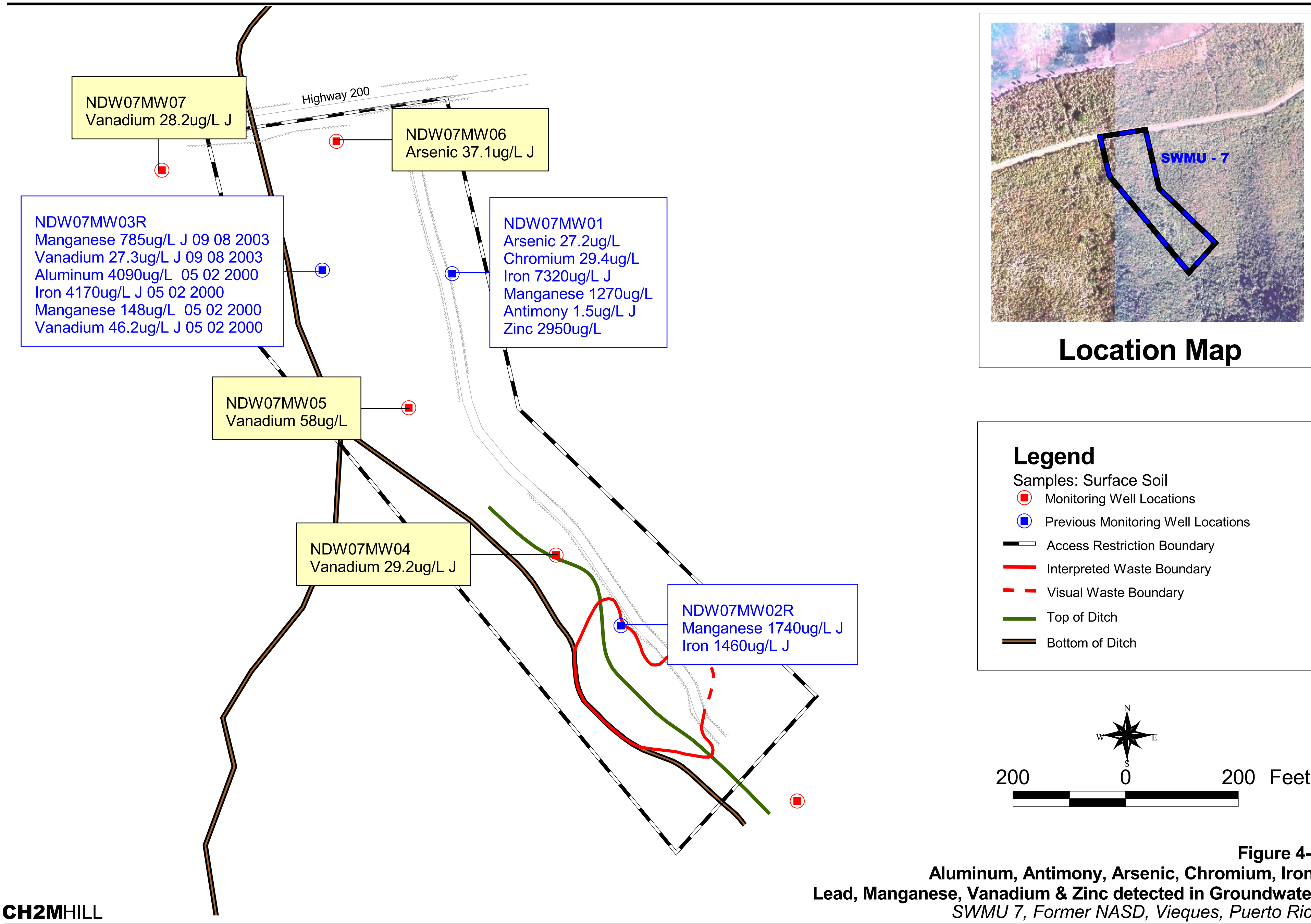
NOTE: Original figure created in color

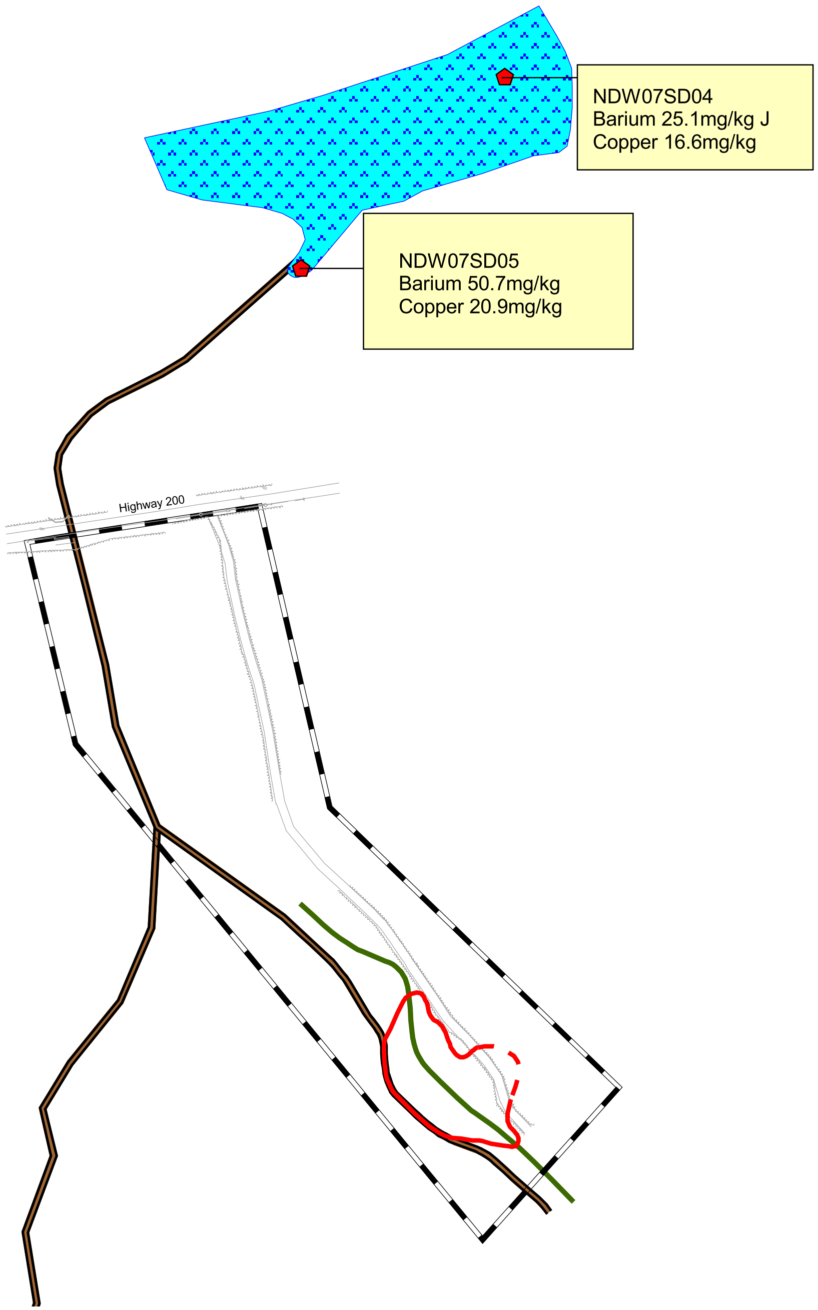


CH2MHILL

Figure 4-7
Aluminum, Antimony, Arsenic, Chromium, Iron,
Lead, Manganese, Vanadium & Zinc detected in Groundwater
SWMU 7, Former NASD, Vieques, Puerto Rico

File Path: t:\environmental\navy clean ii_vieques_ pr\former nasd\gis\report-figures\swmu-7-figures.apr, Date: 17 Mar 2004 10:27, User: JRIVERA1, SWMU7-Figure-4-7-Groundwater

NOTE: Original figure created in color



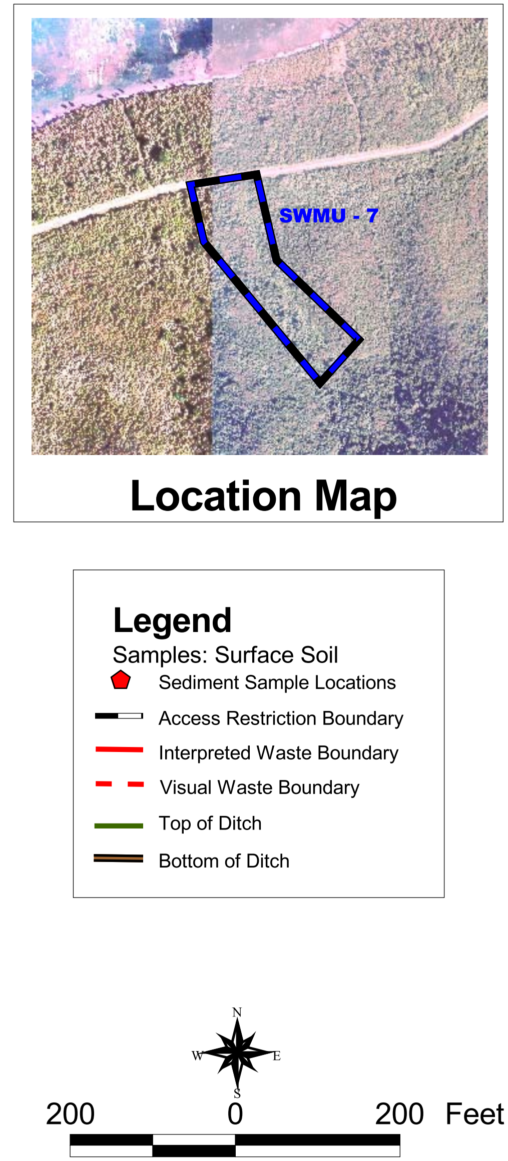


Figure 4-8
Barium and Copper Detected in offsite Sediment
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL

File Path: t:\environmental\navy clean ii_vieques_ pr\former nasd\gis\report-figures\swmu-7-figures.apr, Date: 17 Mar 2004 10:32, User: JRIVERA1, SWMU7-Firgure-4-8-Sediment

SECTION 5

Contaminant Fate and Transport

This section presents a discussion of contaminant migration potentials at SWMU 7 through an environmental contaminant fate and transport evaluation. The site physical characteristics, source characteristics, and extent of detected chemicals as presented in Sections 2, 3, and 4 were combined to form the basis of this section.

The conceptual site model (CSM) is also presented in this section and introduces the potential exposure pathways associated with the site. Factors that affect contaminant migration and chemical persistence are described. Finally, an assessment of contaminant migration patterns at the site is presented.

5.1 Potential Sources for Contamination

The discussion below is a summary of the fate and transport of constituents, primarily those identified as contaminants, based on the sample distribution from the Expanded PA/SI and RI. It is recognized that there is uncertainty associated with constituents identified as contaminants and their associated concentrations because soil samples were not collected directly through the waste piles. It is possible that additional contaminants or contaminants at higher concentrations would have been identified under those circumstances. However, the general discussion of fate and transport is appropriate based on the data collected. Further, the removal action will address the contamination present in the waste, which will address the uncertainty associated with contaminant types and levels and their associated fate and transport.

SWMU 7 was used by the former NASD for solid waste disposal between the early 1960s and late 1970s. Based on site observations, material discarded at the site includes old tires, sheet metal, empty containers such as drums, cans, and bottles, used batteries, and construction rubble. An MEC avoidance survey was conducted at this site as part of the Expanded PA/SI prior to conducting sampling. No live OE were identified at SWMU 7 during this survey.

A geophysical survey was conducted at SWMU 7 to determine the extent of metallic waste, as described in Section 3. Based on survey results, the waste boundary is delineated on all sides except for a small lobe in the southeast. There is some metal material that extends across the dirt road to the east.

5.2 Conceptual Site Model

The CSM qualitatively defines the various contaminant sources, release mechanisms, relative rates of migration and persistence of contaminants, and migration pathways for contaminants at the site. Based on the available site information, a flow chart of the potential migration pathways, exposure pathways, potential human receptors, and ecological receptors was identified for the site (Figure 5-1). No human receptors currently are located at the site. The ecological survey identified this area as a thriving ecological community.

A graphical representation of the CSM for SWMU 7 is presented as Figure 5-2. SWMU 7 consists of a vegetated hillside that slopes gently to the north and steeply to the west into an ephemeral stream. The upland area is covered by shrub and tree canopy layers that provide nearly 100 percent cover. The ephemeral stream width varies from 20 to 30 feet, and the stream has embankments 10 to 20 feet deep. During past operations, the Navy noted evidence of waste disposal from the hillside into the ephemeral stream. The waste is scattered along the slope and in the bottom of the streambed. There was no evidence that waste disposal at the SWMU 7 site has had an impact on the wildlife or its habitat.

The lithology at SWMU 7 consists of silty sand that is underlain by a weathered granodiorite, or saprolite (Figure 2-5). Analyzed as oxides, granodiorite and quartz diorite typically range from about 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 (ATSDR, 2001). Chemicals identified in site soil that exceed screening criteria include inorganics, two pesticides, and two SVOCs. It is noted that because soil samples were not collected directly through the waste piles, there may be other chemicals present that exceed screening criteria. However, this uncertainty will be addressed by the removal action and associated confirmatory sampling protocol and residual risk assessment.

During rain events, surface water from the upland area flows as runoff toward an ephemeral stream. Water flows in the streambed only in the event of a rainstorm; thus, the ephemeral stream remains dry most of the year. Distinct scouring marks along the creek banks indicate rapid flows during storm events. The ephemeral stream drains to the north through a culvert under Highway 200 to Vieques Passage. The site does not have aquatic habitat.

The Resolución Valley aquifer does not occur under this site. Groundwater at SWMU 7 exists under potentially semiconfined conditions in the saprolite at a depth of 33 to 71 feet bls. The groundwater flow direction follows the topography, generally northerly toward the sea (Figure 2-6).

A summary of field parameters measured in groundwater monitoring wells at SWMU 7 during the 2003 sampling is presented in Table 5-1. The data indicate that the groundwater has moderate levels of total dissolved solids (approximately 1,000 to 1,400 mg/L), with the TDS in well NDW07MW06 being somewhat higher than the others (approximately 5,200 mg/L). Dissolved oxygen ranged from 1 to 8 mg/L, suggesting an oxic groundwater. However, some aeration of the samples could have occurred during the pumping of the groundwater to land surface; thus the actual dissolved oxygen levels in site groundwater may be somewhat lower than the values measured at land surface. The presence of a hydrogen sulfide odor in some of the wells suggests that although the groundwater may be generally oxic, the ORP environment is spatially variable, with some sulfate reduction occurring in portions of the aquifer. The lower ORP may allow for certain ORP-sensitive metals (such as iron, manganese, arsenic, and vanadium) to occur naturally at elevated levels in dissolved form in site groundwater.

5.3 Potential Routes of Migration

One mechanism for contaminant transport from the source areas at SWMU 7 may be surface runoff because of the steep incline on which this site is located. No surface water is present at the site except during extreme rain events; therefore, the site has no sediment or aquatic habitat. Chemicals in soil and buried waste materials may also leach through the vadose zone and be transported into the groundwater system. Surface soil may also be released to the air by wind erosion.

5.3.1 Soil to Atmosphere Pathway

Wind erosion is considered a potential mechanism for release of site contaminants to the atmosphere from soil because inorganics constitute most contaminants identified at the site. Inorganics and many pesticides and SVOCs tend to bind to the soil and can be released to the atmosphere as dust during windy conditions. However, the potential for release of contaminants to the atmosphere at SWMU 7 is likely minimal because the site is heavily vegetated.

Volatilization, the primary mechanism for releasing volatile contaminants from soil to the atmosphere, is not considered a significant migration pathway at the site. No VOCs were identified as exceeding screening criteria in surface soil or subsurface soil at the site. Therefore the volatization pathway is not likely a significant part of potential contaminant release at this site.

5.3.2 Surface Runoff Pathway

Chemicals in the site soil may be transported by stormwater runoff to surface soil in the ephemeral stream. Surface drainage at the site is directed along the steep slope to the bottom of the ephemeral stream. Chemicals may be transported by surface runoff either in the dissolved phase or as suspended particulates. Surface water in the ephemeral stream is only present under rainstorm conditions. Therefore, runoff to surface water is short-lived, and mobilized soil particles are redeposited as soil downstream. Free-standing water is not present, and thus the site does not have sediment. Further, the planned removal action will eliminate the waste and associated contaminated soil in order to address this potential contaminant migration pathway.

The degree to which surface soil can be eroded and contribute to the runoff pathway at a particular location depends on a variety of site-specific factors including topography, soil type, climate, and nature of surface cover, such as pavement or vegetation. The presence of vegetative cover or pavement over contaminated soil reduces the potential for runoff to cause migration of contaminated soil and reduces the amount of soil transported offsite in runoff. Even where no vegetative cover is present, soil particulates may not be readily detached from the bulk soil matrix. The rainfall impact intensity or surface water velocity must be great enough to detach individual soil particles from the bulk soil. Forces resisting particle detachment are related to such factors as grain size, the angle of friction with surrounding grains, and the cohesive forces with which each grain adheres to the soil mass.

Climatological factors and precipitation patterns are also important in determining the degree to which surface soil contributes sediment to runoff. Not all rainfall events release sufficient precipitation to cause surface runoff. A significant portion of total precipitation does not become runoff; most precipitation is returned to the atmosphere via evaporation or evapotranspiration, and some infiltrates into groundwater. Typically, for unpaved areas, surface water runoff is expected to be on the order of 10 to 20 percent of total precipitation. Areas with flat topography or more permeable soils are in the low end of this range. When a storm event does provide adequate rainfall to cause surface runoff, suspended soil particles that are mobilized into the runoff are also subject to sedimentation forces, and some of the suspended soil particles may redeposit in the soil prior to migrating offsite.

5.3.3 Soil to Groundwater Pathway

Chemicals detected in soils may migrate through the soil column to the underlying shallow groundwater. Recharge to the groundwater aquifer primarily occurs through infiltration of rainfall. The movement of water through the unsaturated soil and buried waste can dissolve chemicals and leach them from waste materials, then transport them to the underlying groundwater. Some of the factors that influence this process include the mobility of the detected chemical, the nature of the soils, rainfall and other climatological factors, and depth to groundwater. The planned removal action will eliminate the waste and associated contaminated soil in order to address this potential contaminant migration pathway.

Chemicals identified in groundwater that exceed screening criteria include inorganics that occur naturally in the environment and were measured in background samples. Therefore, the contribution from the background occurrence of these chemicals and presence of high turbidity in the unfiltered groundwater samples need to be assessed when interpreting these data. No SVOCs or pesticides were detected in groundwater. Acetone was the only VOC detected in groundwater, but at a concentration below the screening criteria. Acetone is a common lab contaminant. Therefore, organic contaminants in site soil appear to be immobile or attenuating before reaching groundwater.

5.4 Contaminant Persistence

The mobility and persistence of the potential contaminants at the site are determined by their physical, chemical, and biological interaction with the environment. Mobility is the potential for a chemical to migrate from a site, and persistence is a measure of how long a chemical will remain in the environment.

5.4.1 Physical and Chemical Properties of Contaminant Groups

Various basic physical and chemical properties affect the transport of chemicals in the environment at the site. In general, chemicals that are soluble, volatile, or leachable tend to be mobile. Mobile chemicals are likely to be released and transported from the source and are not likely persistent, while persistent chemicals tend to remain localized in the source area and are generally resistant to chemical and biological degradation reactions. Sorption, volatilization, degradation, transformation, and bioaccumulation are considered the most important properties affecting transport.

5.4.1.1 Sorption

Sorption is the tendency for chemicals to adsorb to and desorb from materials in the media through which the contaminants are being transported. The subsurface materials likely to sorb chemicals typically are clays and organic material. In addition, inorganic chemicals adsorb onto iron, manganese, and aluminum oxyhydroxide or oxide coatings on soil and sediment grains. The conventional measure of sorption for a chemical is the soil-water distribution coefficient K_d. The K_d for organic chemicals is the product of a partition coefficient (K_{oc}) and the fraction of organic carbon (f_{oc}). In general, chemicals with a K_{oc} greater than 10,000 ml/g (e.g., many SVOCs) have high degrees of adsorption and consequentially low mobility, while chemicals with a K_{oc} lower than 1,000 ml/g (e.g., many VOCs) have lower degrees of adsorption and consequentially higher mobility.

5.4.1.2 Volatilization

Volatilization is the tendency for some chemicals, particularly VOCs, to change from a liquid or adsorbed state to a gas. A conventional measure of volatility is Henry's Law constant (H). Compounds with H values higher than 10^{-3} atmosphere-cubic meter per mole (atm-m^3/M) are expected to volatilize readily from water to air, whereas those with H values lower than 10^{-5} atm-m^3/M are relatively nonvolatile. Most inorganic chemicals are not volatile under normal temperature and pressure conditions.

5.4.1.3 Degradation

Degradation is the transformation of one chemical to another by such processes as hydrolysis, photolysis, and biodegradation. Hydrolysis is the reaction of a chemical with water, and photolysis is the result of exposing the chemical to light. Degradation is commonly expressed as a half-life that combines the degradation by whatever processes may be operating.

5.4.1.4 Transformation

Transformation occurs when metals are increased or reduced in valence state by oxidation or reduction, respectively. Transformation may have a significant effect on the mobility of a metal, either increasing or decreasing it. Transformation can be caused by Eh and pH changes and by microbial or nonmicrobial (abiotic) processes.

5.4.1.5 Bioaccumulation

Bioaccumulation is the extent to which a chemical will partition from water into the lipophilic parts (i.e., fat) of an organism. Bioaccumulation commonly is estimated by the octanol-water partition coefficient, K_{ow}. Chemicals with high values of K_{ow} tend to avoid the aqueous phase and remain in soil longer or bioaccumulate in the lipid tissue of exposed organisms. Accumulation of a chemical in the tissue of the organism can be quantified by a bioconcentration factor (BCF), which is the ratio of the concentration of the chemical in the tissue to the concentration in the water. BCFs are both contaminant-specific and species-specific. Inorganic chemicals and SVOCs tend to have higher K_{ow} values, so they tend to bioaccumulate more extensively than VOCs.

5.4.2 Fate and Transport of Contaminant Groups

Table 5-2 summarizes some of the relevant physical and chemical parameters for potential contaminants at SWMU 7. The fate and transport of COPCs are discussed as groups (VOCs, SVOCs, pesticides, and inorganics) in the subsections below. It is recognized that there is uncertainty associated with the number and type of chemicals exceeding screening criteria in soil because soil samples were not collected directly through the waste piles. It is possible that additional contaminants or contaminants at higher concentrations would have been identified under those circumstances. However, as noted previously, this uncertainty will be addressed by the removal action and its robust characterization and confirmatory sampling protocol and residual risk assessments.

5.4.2.1 Volatile Organic Compounds

VOCs are characterized by relatively high vapor pressures, Henry's Law constants, and solubility in water. VOCs have a tendency to partition to the vapor phase (air) from either the sorbed (soil) or dissolved (aqueous) phases and could be released through volatilization from VOC-contaminated soil. No VOCs were identified as exceeding screening criteria in any media samples at SWMU 7.

5.4.2.2 Semivolatile Organic Compounds

Two SVOCs were identified as exceeding leachability criteria in surface soil at SWMU 7. These SVOCs are benzo(a)pyrene and pyrene in the surface soil. Some SVOCs were detected in subsurface soil but were not above screening criteria. SVOCs were not detected in groundwater. The PAH properties are discussed below.

5.4.2.2.1 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs), which include benzo(a)pyrene and pyrene, are a group of chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances. Particulate emissions to ambient air can result from adsorption onto soot particles that can be carried on wind currents and then returned to the surface (dry deposition). High-molecular-weight PAHs are more likely to be transported via particulate emissions, while low-molecular-weight PAHs have a greater tendency to volatilize (Agency for Toxic Substances and Disease Registry [ATSDR], 1995). Ten PAHs are identified as COPCs in surface soil at SWMU 7; most are of higher molecular weight.

Solubility, volatility, biodegradability, and toxicity vary widely across this class of compounds (ATSDR, 1995). PAHs at SWMU 7 have a high sorption coefficient, low water solubility, and low Henry's Law constant. These PAHs are most likely to sorb tightly to soil or other organic matter. A primary fate and transport mechanism is migration of adsorbed PAHs with surface soil and sediment. However, the low solubility of adsorbed PAHs indicates that they would not partition significantly to water.

Photolysis and biodegradation are two common attenuation mechanisms for PAH compounds (Howard, 1991). Although all PAHs transform in the presence of light via photolysis, their rates vary. Photolysis may reduce concentrations of these chemicals in surface waters or surface soils, but it is not relevant for deeper media. Biodegradation of PAHs in soils also varies widely across the chemical class. Generally, the PAHs with three or fewer rings will biodegrade more readily than PAHs of higher molecular weight. Factors that affect the rate of biodegradation in soil include the types of microorganisms present, the availability of nutrients, the presence of oxygen, and the chemical concentration. The extent to which chemicals may biodegrade also can be affected by their presence in mixtures. If both stable and mobile PAHs are present in a mixture, the less readily degradable materials may be co-metabolized at a rate similar to or higher than those of the more readily degradable compounds (Howard, 1991).

Animals and microorganisms can metabolize PAHs to products that ultimately reach complete degradation. PAHs in soil may be assimilated by plants, degraded by soil microorganisms, or accumulated to relatively high levels in the soils. High PAH concentrations in soil can lead to increased populations of soil microorganisms that are capable of degrading the compounds. PAHs can be taken into the mammalian body by inhalation, skin contact, or ingestion but are poorly absorbed from the gastrointestinal tract. Specific enzymes present in mammals metabolize PAHs, thus making the PAHs water-soluble and available for excretion. Although metabolic pathways detoxify PAHs, some metabolic intermediates may be toxic, mutagenic, or carcinogenic to the host.

5.4.2.3 Chlorinated Pesticides

Two chlorinated pesticides, DDE and DDT, were identified as exceeding ecological screening criteria in surface soil. DDE and DDD enter the environment as a contaminant or breakdown product of DDT. These pesticides were used in the past for pest control but have not been used since the 1960s. Their presence in soils could be from historical use. They were not detected in subsurface soil or groundwater.

In general, these chlorinated pesticides have low Henry’s Law constants and are not expected to volatilize significantly. However, they will volatilize to a small extent from soil surfaces, depending on the temperature and humidity. These compounds have a low water solubility and very high K_{oc} values, indicating that they are more likely to sorb to soil and are not likely to leach to groundwater if organic matter is present. The most likely migration pathways for pesticides are transport in particulate emissions and transport of sorbed materials in surface runoff.

These compounds may undergo biotic and abiotic transformations. DDE will not hydrolyze under normal environmental conditions and probably will not significantly biodegrade. These pesticides have a high K_{ow}, suggesting a high potential for bioaccumulation and biomagnification in the food web.

5.4.2.4 Metals

Metals have been detected in all media at SWMU 7. Metals identified as exceeding screening criteria include: aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, thallium, vanadium, and zinc. All of these metals commonly occur and were detected in background samples. Their reported presence may or may not indicate a contaminant release. In many groundwaters, metals occur at concentrations above EPA drinking water standards (ERG, 2003). However, these metals were also detected in background samples. A comparison with background levels is included at the end of Section 6.

The potential release and migration of metals in the subsurface environment is a complicated process. Because metals are typically not volatile, emissions to ambient air are usually in the form of particulate emissions. The mobility of metals depends on factors such as the overall groundwater composition, pH, metal complex formation, valence state of the metal, and cation-ion exchange capacity. Changes in the oxidation-reduction potential (ORP) in soil or groundwater can affect the chemical species that is present. Metals can occur in the environment as a free ion or as a complexed species, which is composed of positively charged cation and negatively charged anion or neutral molecule. Complexing generally increases the solubility and mobility of metals in groundwater. Additionally, the type of complex a metal forms depends on whether the species is hard (strongly held electron field) or soft (deformable electron field). Hard species form stronger bonds than soft species.

The distribution between soil and water for metals is much more difficult to estimate than for organic compounds. Since the sorption of metals depends on pH, the metal concentration, the species present, and the type of complex formation, a single distribution coefficient or isotherm equation cannot be used to predict metal adsorption. Literature values for K_d can vary by more than two orders of magnitude (ERG, 2003). Generally metal adsorption increases with pH. Inorganics most often sorb to clay minerals, organic matter, and iron and manganese oxyhydroxides. The surface charge of organic matter and oxyhydroxides is strongly pH dependent, becoming more negative as pH increases and more positive as pH decreases. Metals may be sorbed on the surface of the soil or fixed to the interior of the soil, where they are unavailable for release to water. After available sorption sites are filled, most metals are incorporated into the structures of major mineral precipitates, as coprecipitates. At very high concentrations, they may be precipitated into pure metal phases.

The solubility of metals also depends on several factors. The solubility of cations decreases as pH increases. For a few cations (Be^{+2}, Zn^{+2}, Al^{+3}, and Fe^{+2}), metal solubility increases again at alkaline pH values. The solubility of metals may decrease depending on the complex formation. Some cations may complex with oxygen and hydroxide, forming insoluble oxyhydroxides, or may complex with phosphate, sulfate, and carbonate to form insoluble mineral precipitates. Metal sulfide complexes, which form in reducing environments, are extremely insoluble, and their formation will tend to reduce the total metals concentrations. Metals may be removed from the water phase through mechanisms such as precipitation and irreversible sorption (EPA, 1979).

Metal concentrations are usually reported as total metal concentrations. However, metal toxicity is a function of the concentrations of specific metal species, not the total concentration. Furthermore, in the water phase, the total metal concentration includes the dissolved metal concentration and the suspended metal concentration, which is sorbed to colloidal particles. As a result, the groundwater data may reflect metals concentrations that are associated with a significant percentage of colloidal material. Although the groundwater samples at SWMU 7 were filtered with a 0.45 micron filter, studies indicated that the most mobile particles were in the range of 0.1 to 0.55 microns and contributed as much as 40 percent of the total mobile metals (EPA, 1979). Therefore, elevated metals concentrations in groundwater may be due to the suspended load and not just from the dissolved aqueous forms.

The total concentration of metals in soils is generally not a reliable guide to the extent of total metal uptake by plants. The free metals ion activity in the soil solution has been shown to be a better indicator of bioavailability and toxic response than is the total soil metal content (ERG, 2003). It is assumed that for a metal to be taken up by a plant or to exert an effect on plant growth, it must be present in solution. Therefore, factors that influence the speciation and solubility of heavy metals in soils also affect bioconcentration. The pH of soils can also impact the amount of plant uptake of certain elements.

The fate and transport properties of selected metals are discussed in more detail below.

5.4.2.4.1 Aluminum and Barium

Aluminum and barium naturally occur in the environment as a result of the weathering of rocks and minerals. Both metals are hard cations and are least soluble when combined with hydroxide, sulfate, carbonate, and phosphate species. The maximum Al^{+3} concentration is generally limited by the solubility of aluminum oxyhydroxide solids. Barium is most often found in inorganic complexes and is likely to precipitate out of solution as an insoluble salt. The maximum concentration of barium on groundwater is often limited by the solubility of the mineral barite (ERG, August 2003).

Aluminum does not bioaccumulate to a significant extent, and aluminum concentrations toxic to plants are generally only found in acidic soils. Barium may bioaccumulate in some plants and aquatic organisms.

5.4.2.4.2 Cadmium, Cobalt, Nickel, Lead, and Zinc

Cadmium, cobalt, nickel, lead, and zinc are naturally present in the earth's crust and may be released from weathering processes and from anthropogenic sources. These elements are borderline hard/soft cations that will form insoluble metal sulfides in anaerobic environments. These metals tend to sorb and will be transported in water primarily with suspended colloidal particles (ERG, 2003). The concentrations of cadmium, nickel, and zinc in groundwater are usually controlled by the adsorption or coprecipitation of these metals with iron, manganese, and aluminum. However, cadmium and zinc carbonates are relatively soluble at pH below 8.

Lead is relatively immobile in all matrices due to its strong tendency to be sorbed by iron and manganese oxides and the insolubility of many lead minerals. Lead is effectively removed from water by adsorption to organic matter and clay minerals, precipitation as insoluble salt, and the reaction with hydrous iron and manganese oxide.

Cadmium taken up by plants may bioaccumulate in the animals that eat those plants. Lead and zinc will likely bioaccumluate in plants and animals but may not biomagnify in the food web. Cobalt and nickel do not significantly bioaccumulate or biomagnify in the food web.

5.4.2.4.3 Iron and Manganese

Iron and manganese are naturally occurring elements that are ubiquitous in the environment. Manganese is a hard cation that is often precipitated in soils to manganese minerals. Iron is a hard cation in the Fe^{+3} oxidation state and a borderline cation in the Fe^{+2} oxidation state. The transport of these elements is dependent on their species and the pH and ORP of the soil or water environment. Both iron oxyhydroxides and manganese oxides are relatively insoluble in oxidizing environments and are strong sorbants of other metals. These oxyhydroxides and oxides can be used by microorganisms as electron acceptors under reducing conditions and are reduced to more soluble forms in a process known as bioreduction or reductive dissolution.

Manganese can be released from the burning of fossil fuels, incineration of wastes, or cement production. Manganese is a natural component of most foods. It may significantly bioconcentrate at lower trophic levels in water. Iron bioaccumulates in organisms; however, its bioavailability is dependent on its chemical form of occurrence.

5.4.2.4.4 Copper

Copper is naturally present in the environment and is distributed throughout the environment by both natural and anthropogenic processes. Copper is a soft cation that is highly insoluble in reduced environments, where it precipitates as a metal sulfide. They are both strongly adsorbed by organic matter, iron and manganese oxides, and clays, but complexing of these metals to ligands can increase its solubility and thus mobility. Copper is insoluble above a pH of 7 to 8 and in the presence of abundant carbonate. There is little evidence of copper bioaccumulating, even at the lowest levels of the food web (ATSDR, 2002).

5.4.2.4.5 Thallium

Thallium is primarily released to the atmosphere from anthropogenic processes such as the burning of coal and smelting. The mobility of thallium in water is limited by the low solubility of thallium oxides, and it is only soluble in highly reduced environments, in the charged ionic form. Thallium is strongly adsorbed by montmorillonite clays and manganese oxides. Thallium tends to bioaccumulate in plants and animals.

5.4.2.4.6 Arsenic, Chromium, and Vanadium

Arsenic, chromium, and vanadium are inorganics that occur naturally in the earth's crust and are released to soil and groundwater from natural and anthropogenic sources. These metals can be transported from soil by wind erosion or runoff, or they may leach into the subsurface.

In oxidizing environments, these compounds primarily exist as oxyanions (hard anions that contain oxygen) and are relatively mobile. However, they can be adsorbed by clays, iron oxyhydroxides and oxides, aluminum hydroxides, manganese compounds, and organic material at acidic and neutral pHs. Arsenic, chromium, and vanadium can be reduced from higher to lower valance states by organic matter, divalent metals, and dissolved sulfide.

Under reducing conditions, insoluble arsenic sulfides are precipitated. However, vanadium and chromium are less likely to form these complexes. Chromium exists as Cr^{+3} in reduced environments and can combine with aqueous hydroxide ions to form insoluble chromium hydroxide or be sorbed by manganese oxides and oxidized to Cr^{+6}.

Arsenic and chromium bioaccumulate in aquatic organisms and can pass through the food web. However, biomagnification of arsenic and chromium in aquatic food webs has not been documented. Vanadium does not appear to bioconcentrate significantly in plants or aquatic organisms.

5.5 Contaminant Migration

Thirteen metals, two pesticides, and two SVOCs were detected above screening criteria in the 24 surface soil samples collected along the hillside and the bed of the ephemeral stream. The disposal area lies approximately 300 feet along the southeastern side of the ephemeral stream, parallel to the dirt access road in the area. The 24 surface soil samples were collected at locations within the waste disposal area, around its perimeter, and downgradient to characterize the source area and surrounding area. However, soil samples were not collected directly through the waste piles due to safety concerns. Most of the metals are at concentrations consistent with background levels. A few metals, such as lead, cadmium, thallium, and zinc, showed sporadic detections in samples within the general waste disposal area at concentrations above background and at least one of the screening criteria. However, no high-concentration source areas (i.e., ones that would be considered a principal threat waste) were identified. It is recognized that soil samples were not collected through the waste piles, which may have resulted in an underestimation of contaminant levels in soil. The mean concentrations of a few metals in surface soil, such as lead, copper, and zinc, are greater than the background value, but the concentrations of those metals are below levels that would likely pose an unacceptable risk to human or ecological receptors.

One of the most significant potential migration pathways for SWMU 7 is the transport of site soil by stormwater runoff to downgradient locations. The closest downgradient surface soil sample to the disposal site is NDW07SS20, approximately 315 feet from the disposal area. At this location, all inorganics were below the established background concentrations except for cobalt and manganese, which only slightly exceeded them. Two organic compounds, bis(2-ethylhexyl)phthalate and acetone, were detected in this sample. However, these two chemicals are recognized as common laboratory contaminants, and their isolated detections in this sample and lack of detections at significant concentrations in other soil samples collected at SWMU 7 make their presence suspect. At downgradient surface soil sample ND07SD03, concentrations of inorganic COPCs were all below the surface soil background levels except thallium, which only slightly exceeded the background level (0.83 mg/kg compared to 0.67 mg/kg). No organic compounds were detected in this sample. The surface runoff flowing through the ephemeral stream does not appear to have caused significant migration of contamination from SWMU 7.

Another potential contaminant pathway is the migration of contaminants from surface soil into the subsurface. Infiltration of rainfall may have leached some contaminants into subsurface soil and subsequently the groundwater system. However, only chromium was detected above its SSL, and this SSL was based on the chromium being present in the hexavalent form, which is unlikely. No evidence of significant leaching of chemicals to the subsurface was found in the RI. Any uncertainty associated with surface soil-to-subsurface soil potential contaminant migration pathway will be addressed by the planned removal action.

Groundwater flows in a generally northerly direction toward the sea. Eight metals and perchlorate exceeded their respective tap-water PRG and background concentrations in at least one groundwater sample. Because of the presence of turbidity in the unfiltered samples, which is caused by inorganic particles that contribute metals, the unfiltered samples do not provide a reliable basis for assessing the extent of dissolved metals in groundwater. Metals leaching into groundwater from soil at SWMU 7 would be in the dissolved form. Thus, the filtered metals results provide a more reliable basis for assessing potential migration of metals in groundwater from SWMU 7.

Of the filtered metals results for groundwater, only three metals exceeded their tap-water PRGs in a few samples: arsenic, manganese, and vanadium. Arsenic was detected above its tap-water PRG in one filtered groundwater sample, collected from well NDW07MW01 during the 2000 sampling. However, this well could not be sampled during the 2003 field effort since it was dry. Overall, the data do not suggest that the arsenic detection in this sample above its tap-water PRG is related to a release from SWMU 7.

Manganese was detected above its tap-water PRG in three filtered groundwater samples, from wells NDW07MW01, NDW07MW02R, and NDW07MW03R. Manganese is a naturally occurring metal that often is present at elevated concentrations in groundwater. Its presence in the dissolved form in groundwater is typically due to naturally low ORP conditions. Manganese in soil is used by native soil bacteria as a terminal electron acceptor, and such natural microbiological processes result in elevated dissolved manganese in groundwater. Only one of the wells in which manganese was detected above its PRG in the filtered samples (NDW07MW02R) is located in the area of SWMU 7 where waste disposal occurred. The other two wells are located 500 to 600 feet downgradient of this area. Another well located between well NDW07MW02R and wells NDW07MW01 and NDW07MW03R did not have manganese detected above its tap-water PRG in the filtered sample. Overall, the data do not indicate that elevated manganese concentrations in groundwater have been caused by a release from SWMU 7.

Vanadium was detected above its tap-water PRG in five filtered groundwater samples, from wells NDW07MW03R, NDW07MW04, NDW07MW05, and NDW07MW07. One of these wells, NDW07MW04, is located in the area of SWMU 7 where waste disposal occurred. The other wells are between 300 to 1,000 feet downgradient of this well. There are no indications that elevated vanadium concentrations in groundwater are due to a release from SWMU 7. The SSL for vanadium to assess its potential leachability is 6,000 mg/kg. Soil concentrations of vanadium in surface soils ranged from 56 to 130 mg/kg and thus do not have significant leaching potential. Similarly, vanadium concentrations in subsurface soil ranged from 68 to 139 mg/kg and do not have significant leaching potential. Thus, the source of elevated vanadium concentrations in groundwater is likely from background conditions.

Monitoring well NDW07MW08, located in the southeastern portion of the site, is considered the background well for the site. All of the metals detected in groundwater above screening criteria at the site were detected in this well, except for arsenic and lead.

Perchlorate was detected in groundwater at NDW07MW03R during the 2000 sampling. However, perchlorate was not detected during resampling in 2003. Therefore, its presence in well NDW07MW03R is suspect and is likely a false positive. Perchlorate was not detected in any other wells. In addition, no other MEC were detected.

Overall, the site data do not indicate that significant contaminant migration from SWMU 7 has occurred.

TABLE 5-1
SUMMARY OF FIELD PARAMETERS MEASURED IN MONITORING WELLS
SWMU 7, Former NASD, Vieques, Puerto Rico

Well	Specific Conductance, umhos/cm	Estimated Total Dissolved Solids*, mg/L	Dissolved Oxygen, mg/L	Turbidity, NTU	Comments by sampling team
NDW07MW02	2300	1350	1.84 - 1.93	2.5	Slight H2S odor
NDW07MW3R	1750	1030	2.8 - 7.7	4.4	
NDW07MW04	1879	1110	2.3 - 3.1	1	Slight H2S odor
NDW07MW05	1660	980	5.0 - 5.5	2	Slight H2S odor
NDW07MW06	8800	5200	1.0 - 1.2	7	
NDW07MW07	1930	1140	6.5 - 8	4.8	
NDW07MW08	1717	1010	1.2 - 4.4	7.4	

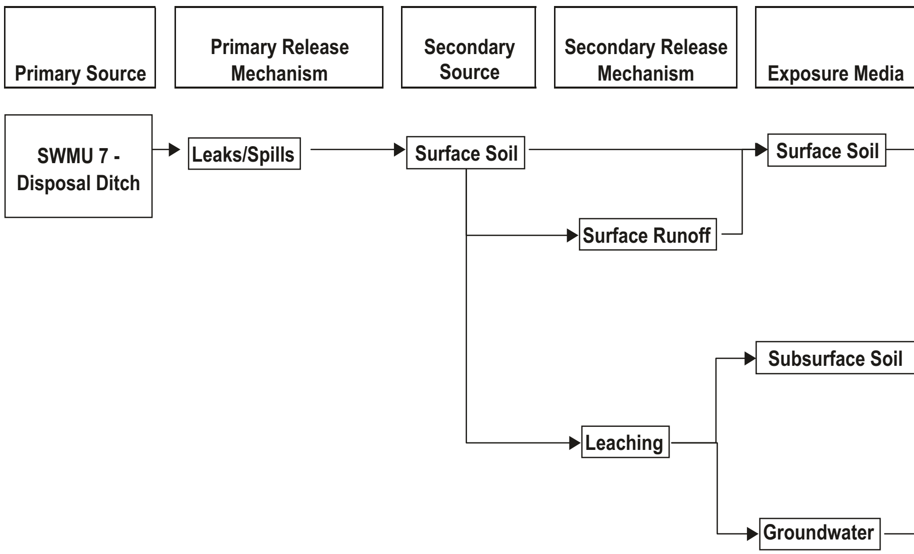
* TDS is estimated based on relationship (presented by Mem, 1985) of TDS (mg/L) = specific conductance (microseiemiens/cm) multiplied by 0.59 (Mem, 1985).

TABLE 5-2
FATE AND TRANSPORT PARAMETERS FOR SELECTED COPCS
SWMU 7, Former NASD, Vieques, Puerto Rico

Compound	Chemical Group	Organic Carbon Partition Coefficient/ Koc (L/kg)		Soil Distribution Coefficient/ Kd (L/kg)		Water Solubility (mg/L)		Henry's Law Constant/H (atm-m3/M)		Octanol Water Partition Coefficient/ Koc (L/kg)	
Antimony	Inorganic			4.50E+01	a						
Arsenic	Inorganic			2.90E+01	a						
Barium	Inorganic			4.10E+01	a						
Cadmium	Inorganic			7.50E+01	a						
Chromium, Total	Inorganic			1.90E+01	a						
Cobalt	Inorganic			1.26E+02	c						
Copper	Inorganic			5.01E+02	c						
Iron	Inorganic			NA							
Lead	Inorganic			1.58E+04	c						
Manganese	Inorganic			NA							
Mercury	Inorganic			5.20E+01	a			1.14E-02	a		
Nickel	Inorganic			6.50E+01	a						
Thallium	Inorganic			7.10E+01	a						
Vanadium	Inorganic			1.00E+03	a						
Zinc	Inorganic			6.20E+01	a						
p,p'-DDE	Pesticide	4.47E+06	a			1.20E-01	a	2.10E-05	a	3.24E+06	b
p,p'-DDT	Pesticide	2.63E+06	a			2.50E-02	a	8.10E-06	a	1.05E+06	b
Benzo(a)pyrene	SVOC	1.02E+06	a			1.62E-03	a	1.13E-06	a	1.15E+06	b
Pyrene	SVOC	1.05E+05	a			1.35E-01	a	1.10E-05	a	3.80E+06	b

Notes:
1. The soil distribution parameter for metals assumes a typical soil pH of 6.8.
2. Transport properties for inorganics are high variable dependent the chemical species and the site-specific environment. Therefore, the solubility, H, and Kow were not listed for metals.
3. No chemical properties could be located for perchlorate.

Sources:
a. EPA, 1996e
b. ATSDR. Toxicological Profiles: http://www.atsdr.cdc.gov/toxpro2.html#Final
c. HydroGeoLogic Inc., 1999
d. Spectrum Laboratory. Chemical Fact Sheets: http://www.speclab.com/compound
e. Mackay et al., 2000
atm-m^3/M = atmosphere times cubic meters per mole
L/kg = liters per kilogram
mg/L = milligrams per liter
NA = a value not available



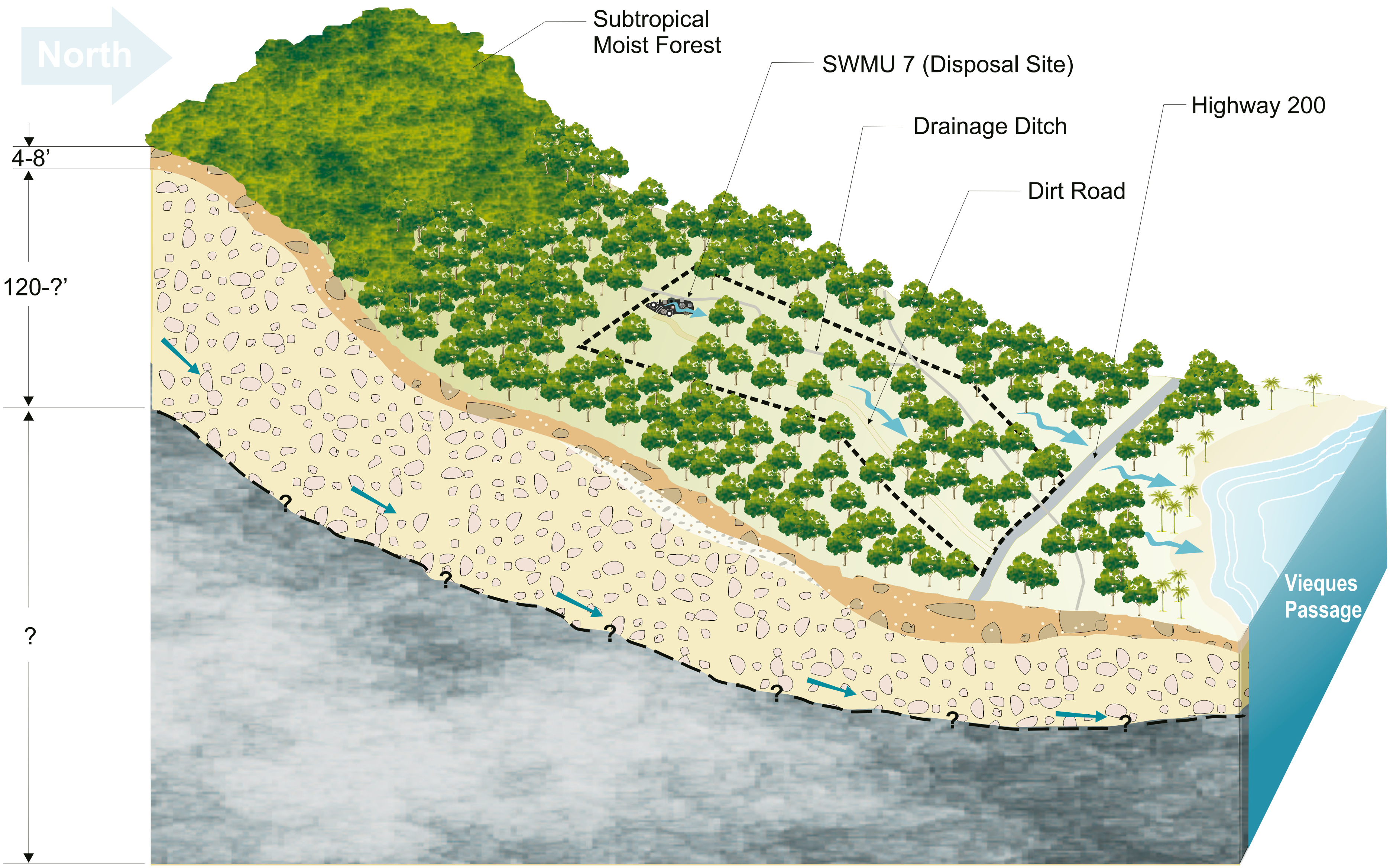
Exposure Media	Exposure Route	Potential Human Receptors: Maintenance Worker	Industrial Worker	Construction Worker	Residential: Adult	Residential: Child	Recreational: Adult	Recreational: Child	Recreational: Youth	Potential Ecological Receptors – Terrestial: Plants	Terrestial: Animals
Surface Soil	Ingestion	X	X		?	?	X	X	X		X
	Dermal Contact	X	X		?	?	X	X	X		X
	Inhalation	X	X		?	?	X	X	X		X
	Root Uptake									X	
Subsurface Soil	Ingestion			X	?	?					
	Dermal Contact			X	?	?					
Groundwater	Ingestion	?	?	?	X	X					
	Dermal Contact	?	?	?	X	X					

LEGEND
X = Potentially complete exposure pathways identified
? = Questionabe pathway; however included in the risk assessment for comparison purpose.

Note: *Surface water only intermittently present at the site during heavy rain events.*
Since there is no constant standing water, there is no sediment.

Figure 5-1
Conceptual Site Model for Disposal Site
SWMU 7, Former NASD, Vieques, Puerto Rico

CH2MHILL



LEGEND

Granite
Saprolite
SS Silty Sand
SGS Silty Gravel with Sand
Surface Water Flow
Groundwater Flow
Inferred Contact
Access Restriction Boundary

Figure 5-2
Conceptual Site Model
SWMU 7, Former NASD, Vieques Island, Puerto Rico

CH2MHILL

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SECTION 6

Remedial Investigation Conclusions and Recommendations

This section presents the conclusions and recommendations of the SWMU 7 RI.

6.1 Conclusions

SWMU 7 is a former solid waste disposal site on the former NASD in the western portion of Vieques Island, Puerto Rico. In March 2004, the Draft RI Report for SWMU 7 was submitted for regulatory agency review. Soil samples were collected primarily adjacent to waste piles rather than directly through the waste piles (due to safety concerns), and the conclusions drawn based on those data were that the site does not pose an unacceptable risk to human health or the environment. While uncertainty is inherent (and at some level, acceptable) in all findings, conclusions, and decisions made in the environmental investigation and remediation process, the Navy and regulatory agencies have concurred that the uncertainty associated with the waste representing a potential future source of contamination (and associated potential risks) is unacceptable.

In 2005, the Navy, USEPA, and the PREQB concurred that a waste removal action, coupled with a robust waste characterization and confirmatory sampling protocol, will address the uncertainties associated with the findings and conclusions of the RI Report and ensure residual media concentrations are protective of human health and the environment. Prior to the removal action, soil samples will be collected across the disposal area (including within the waste piles) to determine the appropriate disposal alternative(s).

Following the removal action, confirmatory samples will be collected from the excavated area and a risk assessment will be performed to ensure residual media concentrations are protective of human health and the environment. The risk assessment will take into consideration the information presented in the Comprehensive Conservation Plan provided by the DOI. Additionally, the risk assessment will be performed in accordance with the human health and ecological risk assessment protocols in the Master Quality Assurance Project Plan (CH2M HILL, May 2007).

6.1.1 Site Investigations

SWMU 7 was sampled twice, once during the Expanded PA/SI (CH2M HILL, 2000d) and again during the RI. The sampling for the RI was described in a work plan reviewed (CH2M HILL, 2003) and approved by the CERCLA Technical Committee (CTC). The sampling activities conducted at SWMU 7 during the Expanded PA/SI and RI fieldwork of 2000 through 2003 consisted of surface and subsurface soil sampling, groundwater sampling from permanent wells, and sampling of ephemeral stream bottom soils, referred to as sediment samples during the Expanded PA/SI. Because the ephemeral stream does not have standing water, these samples are treated as surface soils during the data screening and risk assessment.

Two sediment samples were also collected from a location farther downstream near Vieques Passage. These two samples are not representative of site conditions and therefore were not included in the site nature and extent and risk assessments. However, results of the sampling and analysis were presented in Section 4. These samples had only inorganic chemicals, which occur commonly in sediments and likely represent background levels for this area.

The geophysical investigation indicated that the fill boundary at SWMU 7 appears to be delineated on all sides with the exception of a small lobe in the southeast. The waste boundary on the southeast could not be defined due to the thick vegetation preventing equipment access. However, a visual waste definition is presented in figures of earlier sections. Both conductivity and in-phase data indicate that some metal material extends across the road to the east. Data collected along the transects in the southwest do not indicate that any debris extends westward of the bottom of the ephemeral stream.

6.1.2 Nature and Extent Determination

The discussion below is a summary of the nature and extent of contamination, based on the sample distribution from the Expanded PA/SI and RI. It should be noted that the representation of the nature and extent does not include data from directly through the waste piles, so it is possible that higher levels of constituents would have been detected within or directly beneath the waste piles. However, this is an uncertainty that will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol and residual risk assessment.

6.1.2.1 Surface Soil

A total of six surface soil sample locations and three ephemeral stream bottom soils, originally called sediments, were sampled during the Expanded PA/SI. Additionally, 15 surface soil samples were collected at SWMU 7 during the RI. Thus a total of 24 surface soil samples were collected to characterize the site conditions.

6.1.2.1.1 Inorganic Chemicals

A total of 23 inorganic analytes were detected in surface soil samples at SWMU 7. Thirteen inorganic analytes were detected above screening criteria in at least one surface soil sample. Nine metals (aluminum, arsenic, cadmium, copper, iron, lead, manganese, thallium, and vanadium) exceeded their respective EPA Region 9 residential PRGs (HI = 0.1). Human health-based screening criteria were not available for calcium, magnesium, potassium, and sodium. These essential human nutrients were not identified as COPCs in accordance with EPA RAGS Part A guidance (EPA, 1989).

Twelve metals (aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, thallium, vanadium, and zinc) exceeded their respective ecological screening criteria in at least one surface soil sample.

6.1.2.1.2 Organic Chemicals

Pesticides: Three pesticides were detected in nine surface soil sample locations. None were found at concentrations above their respective residential PRGs.

Two pesticides, DDE and DDT, exceeded their respective ecological screening criteria. Ecological screening criteria were not available for heptachlor. Based on these results, DDE, DDT, and heptachlor are identified as ecological chemicals of potential concern (ECOPCs).

SVOCs: Sixteen SVOCs were detected in 18 of the 24 surface soil sample locations. The SVOCs detected consisted of 11 PAHs, three phthalates, and carbazole. Of the detected SVOCs, only benzo(a)pyrene was detected at a concentration that exceeded its residential PRG. It exceeded its human health-based screening criteria in three samples. The phthalates are also common laboratory contaminants.

Two SVOCs, benzo(a)pyrene and pyrene, exceeded their respective ecological screening criteria. Benzo(a)pyrene exceeded screening criteria in two samples, and pyrene exceeded screening criteria in three samples.

VOCs: VOCs were detected in 13 of the 24 samples during the RI; acetone was included in the TAL in 17 samples. Five VOCs were detected in the surface soil during the RI. VOCs were not detected above available human health-based screening criteria, ecological screening criteria, or SSLs in surface soil.

Several of the inorganic chemicals detected in surface soils, though they could be related to presence in background soils, were carried through human health and ecological risk assessments. Some of the SVOCs were also selected for risk analysis, while VOCs detected did not exceed the screening criteria thus were not COPCs for risk assessment.

6.1.2.2 Subsurface Soil

Eleven subsurface soil samples were collected during the RI and none were collected in the earlier studies at SWMU 7. The subsurface soil samples were analyzed for TCL organic chemicals, VOCs, SVOCs, pesticides, explosives, and perchlorate and TAL inorganic chemicals.

6.1.2.2.1 Inorganic Chemicals

A total of 23 inorganic analytes were detected in subsurface soil samples at SWMU 7. Of these, one inorganic analyte, chromium, was detected above its SSL in 10 subsurface soil samples. One sample contained chromium above its background concentration of 74 mg/kg (CH2M HILL, 2002).

Perchlorate: Perchlorate was detected in one of 11 subsurface soil samples collected at SWMU 7. An SSL was not available for comparison. The detected concentration is estimated and near the detection limit as indicated by the "J" qualifier. The perchlorate analytical method is prone to false positives (DoD, 2004), and none of the other explosives-related chemicals were detected in the samples. Thus, detected perchlorate is not considered a true detection at the site.

6.1.2.2.2 Organic Chemicals

Pesticides: Two pesticides were detected at two subsurface soil sampling locations. The detected concentrations did not exceed their respective SSLs.

SVOCs: The detected SVOCs consisted of five PAHs and two phthalates. Detected SVOCs were below the leachaility based screening criteria.

VOCs: Two VOCs, 2-hexanone and methylene chloride were detected above detection limits. Methylene chloride was detected below its SSL in the one sample where it was detected. A SSL was not available for 2-hexanone. It was detected in three subsurface soil samples at concentrations ranging from 0.0023 J mg/kg to 0.0035 J mg/kg. The detected concentrations are all estimated and near the detection limit as indicated by the "J" qualifier.

All the chemicals detected in soils were evaluated through human health and ecological risk assessments.

6.1.2.3 Groundwater

The Resolución Valley aquifer is not present at SWMU 7. This site is underlain by a potentially semiconfined groundwater system, which is composed of alluvial deposits made up of silty sands and weathered granodiorite. Groundwater at the site is encountered at depths of approximately 33 to 71 feet bls. The local groundwater flow direction is generally toward Vieques Passage.

Three monitoring wells were installed and sampled as part of the 1988 CS. During the Expanded PA/SI, two of these wells could not be located and were subsequently replaced. All three monitoring wells were sampled during the PA/SI. The samples were analyzed for dissolved and TAL metals, VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate. Tables 4-5 and 4-9 present the detected concentrations, screening criteria, and exceedances of each chemical in SWMU 7 groundwater samples.

6.1.2.3.1 Inorganic Chemicals

A total of 20 inorganic analytes were detected in unfiltered (total) groundwater samples. Twenty-one inorganic analytes were detected in filtered samples. Six analytes (aluminum, antimony, arsenic, manganese, vanadium, and zinc) were detected above their respective EPA Region 9 tap-water PRGs in unfiltered samples. Three analytes were detected above screening criteria in filtered samples; these were arsenic, manganese, and vanadium.

Perchlorate: Perchlorate was detected in one of nine groundwater samples collected from SWMU 7. It was detected at an estimated concentration of 2.4 J ug/L in the sample collected in 2000. It was not detected in the resampled groundwater collected in 2003 from the same well.

6.1.2.3.2 Organic Chemicals

VOCs: No VOCs were detected above screening criteria in the groundwater samples collected from SWMU 7. Acetone was the only VOC detected, and it was detected below screening criteria in a single sample collected in 2000.

SVOCs/Pesticides: None were detected.

All of the detected inorganic and organic chemicals were included for human health risk assessment. No direct exposure is expected to ecological receptors, and thus these were not included for ecological risk assessment.

6.1.3 Chemical Fate and Transport

Some of the detected chemicals were identified as exceeding the screening criteria. The fate and transport of these chemicals in each medium was evaluated to determine their long term potential to remain in the environmental media and the potential for them to transfer across media.

Soil samples had inorganic chemicals and some SVOCs detected in surface soil along the hillside and at the bottom of the ephemeral stream. The disposal area lies approximately 300 feet along the dirt access road on the eastern side of the steep banks of the ephemeral stream. The most significant potential migration pathways is the transport of site soil by stormwater runoff to downgradient locations.

The downgradient surface soil sample collected north of the State Road 200, NDW07SS20, is approximately 315 feet from the disposal area. At this location, all inorganic chemicals were below the established background concentrations except for cobalt and manganese, which only slightly exceeded them. Two organic compounds, bis(2-ethylhexyl)phthalate and acetone, were detected in one soil sample, indicating that runoff or wind erosion may have transported contaminated soil to this distance. Both of these chemicals are also common laboratory contaminants, thus may not be specific to the site, particularly because they were not detected above criteria in site samples from within waste area. At downgradient surface soil sample ND07SD03, concentrations of inorganic COPCs were all below the surface soil background levels except thallium, which only slightly exceeded the background level (0.83 mg/kg compared to 0.67 mg/kg). No organic compounds were detected in this sample. Surface runoff flowing through the ephemeral stream does not appear to have caused significant migration of contamination from SWMU 7.

Another potential contaminant pathway is the migration of contaminants from surface soil into the subsurface. Infiltration of rainfall may have leached some contaminants into subsurface soil and subsequently the groundwater system. However, only chromium was detected above its SSL. The selected SSL for chromium was based on the chromium being present in the hexavalent forms, which is a conservative assumption. Chromium was not identified as a COPC in site groundwater. Thus, no evidence of significant leaching of chemicals to the subsurface were found in the RI.

As noted previously, groundwater at SWMU 7 flows generally northward toward the sea. Typically, contaminants will not move as rapidly as the groundwater because of adsorption of the contaminant on the soil. Retardation of metals is a complex process and is affected by sorption, iron exchange, speciation, precipitation, colloid formation, biofixation, natural organic matter interactions, anion exclusion, pH, ORP, salinity, competing ions, surface area, and densities (ERG, 2002). Generally, clayey soils have high adsorption, thus less migration through clayey soils is expected.

NDW07MW08, located in the southeastern portion of the site, is the upgradient background well for the site. All of the groundwater COPCs detected in site groundwater were also detected in this well, except for arsenic, lead, and antimony. Manganese, vanadium, and zinc were detected in the background below screening criteria; however, they were detected above the screening criteria in other wells at the site. Their occurrence is similar among site wells.

Because inorganics occur naturally and turbidity in groundwater can strongly affect results, it is difficult to determine whether metal concentrations detected in downgradient groundwater can be attributed to the disposal area. Perchlorate was detected in groundwater at NDW07MW03R during the 2000 sampling. However, perchlorate was not detected during resampling of this well. Its presence in well NDW07MW03R is questionable, particularly considering the detection method is prone to false positive detections. Perchlorate was not detected in any source area wells at the site. Overall, the fate and transport analysis did not identify significant evidence that migration of contaminants from SWMU 7 was occurring.

6.1.4 Human Health Risk Assessment

The discussion below is a summary of the human health risk assessment conducted for SWMU 7, based on the data from the sample distribution discussed previously. It should be noted that the assessment of risk does not account for potentially higher soil constituent concentrations within and beneath the waste piles, so there is uncertainty associated with the COPCs identified and the risk assessment conclusions drawn based on those COPCs. However, this is an uncertainty that will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol and residual risk assessment.

Site exposure media evaluated were the surface and subsurface soil and groundwater. All the detected chemicals in the Expanded PA/SI and the RI were included for COPC selection. The maximum detected chemical concentration was compared against the screening criteria presented in the RAGS Part D tables in Appendix L.

All the inorganic chemicals were screened against criteria for COPC selection. The only chemicals identified as COPCs were inorganic chemicals, one PAH in soils, and perchlorate in groundwater based on a single low-level detection. The inorganic chemicals are also detected in background samples and are likely part of the natural soil mineralogy. All these chemicals were also found at concentrations similar to those in the background soils of the former NASD.

Based on anticipated future land use considerations, the following potentially exposed populations were identified:

- Maintenance workers
- Construction workers
- Industrial workers
- Recreational receptors (adult, youth, and child)
- Residential receptors (adult and child)

Other potentially exposed populations could exist, though their exposures would likely be lower than exposures to the populations listed above.

The risk assessment evaluated the exposure of potential receptor populations such as maintenance workers, industrial workers, construction workers, recreational receptors, and residential receptors. The estimated cancer risks from soils were within the target risk range for all the receptors except the resident child scenario. The HI for soils was slightly above the target HI = 1.0 for the residential adult and child scenarios due to the presence of iron and vanadium in soils. Also, the risks and HI from groundwater exposure through potable use were above acceptable limits due to the total arsenic, iron, and vanadium levels in groundwater. However, arsenic and iron were not elevated in the filtered sample, indicating that the detection in the unfiltered sample is likely due to particulates in the samples. Vanadium levels were within basewide background levels and thus are not specific to SWMU 7.

The PAH in soil does not present significant risks or hazards. The inorganic chemicals in surface soil are not present at concentrations above background levels; thus risks to human health and the environment are comparable to the background levels. The hazard index from iron detected above background at three of the locations does not present significant risk (iron HI = 1.4). The perchlorate was likely a false positive (DoD, 2004), as it was not detected in groundwater during resampling.

Due to the absence of site-specific risks above background levels, the site-specific human health risk is within acceptable limits, and no remedial actions are proposed to protect public health at SWMU 7 under CERCLA. No additional sampling or monitoring of the soil is necessary because the conditions at the site are protective of human health and the environment. However, because of the uncertainty associated with the risk conclusions and the uncertainty of the debris being a potential future source of contamination, the agencies have concurred that in order to address the uncertainty and ensure the residual media concentrations at the site are protective of human health, a removal action will be performed.

6.1.5 Ecological Risk Assessment Summary

The discussion below is a summary of the ecological risk assessment (ERA) conducted for SWMU 7, based on the data from the sample distribution discussed previously. It should be noted that the assessment of risk does not account for potentially higher soil constituent concentrations within and beneath the waste piles, so there is uncertainty associated with the COPCs identified and the risk assessment conclusions drawn based on those COPCs. However, this is an uncertainty that will be addressed via the removal action and its associated waste characterization and confirmatory sampling protocol, including a residual risk assessment.

The conclusion of the screening **problem formulation** includes the selection of ecological endpoints and risk hypotheses, which are based upon the preliminary conceptual model. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process (EPA, 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint.

Exposure Estimation: Maximum concentrations were used in the screening portion of the ERA to conservatively estimate potential chemical exposures for the ecological receptors selected to represent the assessment endpoints at SWMU 7. Food web exposures for upper trophic level receptor species were determined by estimating the chemical-specific concentrations in each dietary component using uptake and food web models. Incidental ingestion of soil or sediment was also included when calculating the total level of exposure. Maximum sediment or surface soil concentrations were used in all screening food web calculations to provide a conservative assessment.

For conservatism, the maximum reporting limit for chemicals analyzed for but not detected was also compared to medium-specific screening values and (where applicable) used for food web exposure modeling. This was done to determine if reporting limits were less than or equal to chemical concentrations at which potential adverse effects to ecological receptors may occur.

The **effects evaluation** step established the chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. The direct exposure to surface soil is the only potentially complete pathway at SWMU 7. When multiple sources for these values were available, the lowest screening value from these three sources was selected for screening as a conservative risk estimation measure.

In the **screening risk calculation,** the maximum exposure concentrations (abiotic media) or exposure doses (upper trophic level receptor species) are compared with the corresponding screening values to derive screening risk estimates. The outcome of this step is a list of COPCs for each medium-pathway-receptor combination evaluated or a conclusion of acceptable risk.

In the refinement step a list of COCs are finalized as summarized below. Ten metals (aluminum, chromium, cobalt, copper, iron, lead, manganese, thallium, vanadium, and zinc) were identified as PCOCs in surface soils from SWMU 7. Onsite surface soil concentrations for these metals were compared to background surface soil concentrations.

Maximum and average concentrations of aluminum and vanadium were below background. Although HQs were above 1.0 in all comparisons to screening values, these metals are consistent with background soil concentrations.

The average site concentrations of chromium, cobalt, iron, manganese, and thallium did not exceed background. Sample-specific comparisons to background indicate infrequent exceedances of background for these metals; exceedances of background for these metals were as follows:

- chromium – 3 of 24 samples
- cobalt – 5 of 24 samples
- iron – 3 of 24 samples
- manganese – 1 of 21 samples
- thallium – 8 of 24 samples

Thus, on an area-wide basis (the site is approximately 1 acre in size), the risk associated with these five metals is likely to be low.

The mean HQ for lead was less than 1.0, and lead concentrations compared to the alternate screening value resulted in HQs of less than 1.0 for maximum and average concentrations.

The mean HQs for copper (1.8) and zinc (1.8) were low, indicating a low potential for ecological effects. Comparisons of mean concentrations of these metals to less conservative criteria resulted in HQs less than 1.0.

Pesticides DDE and DDT and the PAHs benzo(a)pyrene, fluoranthene, and pyrene were detected in 20 to 25 percent of soil samples. Average concentrations of these organic chemicals were low, with mean HQs ranging from 0.8 to 2.1. Concentrations of all detections were below the secondary, less conservative screening values. These chemicals are not widespread across this small site; detections generally occurred in two isolated locations within the center of the SWMU. These chemicals, therefore, are localized and have not migrated from the primary source (solid waste landfill).

SWMU 7 has been undisturbed since the late 1970s and currently supports a diverse vegetative community consisting of various trees, shrubs, and vines, along with associated birds, reptiles, and some mammals. There is no permanent aquatic habitat onsite. The exposure pathways evaluated in the ERA included direct exposure of wildlife to contaminants in the soil, as well as soil contaminants potentially accumulating in the onsite food web. Chemical data from 24 soil sampling locations within SWMU 7 were used in the ERA. Metals were detected in most samples, while organic chemicals were infrequently detected.

Based on the results of the ERA, it was concluded that soil chemicals do not pose unacceptable risk to directly exposed soil organisms, and chemicals in the surface soil do not pose a risk to upper trophic level wildlife feeding on various prey items at the site. Many of the metals detected onsite were generally comparable to background. Average concentrations of remaining soil metals and the few detected organic chemicals were either below screening ecotoxicity values or had a low magnitude of exceedance. Given the low risk estimates for site-related chemicals, no additional ecological studies or sampling are recommended for SWMU 7 based upon the results of this ERA. The ERA concluded that there are sufficient data available on which to base a conclusion of no unacceptable risk within acceptable uncertainty at SWMU 7. It is recognized, however, that this conclusion with respect to soil is uncertain because soil samples were collected adjacent to the waste piles, rather than directly within/beneath them. As with the human health risk assessment conclusions, because of the uncertainty associated with the ecological risk conclusions and the uncertainty of the debris being a potential future source of contamination, the agencies have concurred that in order to address the uncertainty and ensure the residual media concentrations at the site are protective of the environment, a removal action will be performed.

6.1.6 Rare, Threatened, or Endangered Species

Fourteen federally listed species are known to occur or have the potential to occur on the former NASD Vieques. Prior to conducting the fieldwork, a literature search was performed for each federally protected species. During the May 15-19, 2000, surveys, biologists walked transects through each site, identified any federally protected species seen, and noted the presence or absence of preferred habitat for the species.

No federally protected species or preferred habitats were observed at SWMU 7. A terrestrial forested plant community that is not preferred habitat for any of the species dominated SWMU 7. During the surveys, endangered brown pelicans were observed flying over the adjacent marine habitat, but not at SWMU 7. The brown pelican would not occur at this fully terrestrial site.

6.1.7 Cultural Resources

No cultural resources are expected to be encountered at SWMU 7 based on its recent operational history and lack of documented evidence of such resources to date.

6.1.8 Solid Waste

Solid waste disposal was discontinued in the 1970s. No hazardous waste release from the remaining items was observed during site visits or in the RI analyses. Thus no chemical hazards are anticipated from the solid waste present at the site. Much of the waste is more than 40 years old, and no additional hazardous impacts are anticipated in the future.

6.2 Recommendations

Because of the uncertainty associated with the conclusions drawn based on the data collected during the RI and the uncertainty associated with the debris being a potential future source of contamination, the agencies have concurred that in order to address the uncertainty and ensure residual media concentrations at the site are protective of human health and the environment, a removal action will be performed.

SECTION 7

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