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Final

# Remedial Investigation Report

## Area of Concern (AOC) J

Former Naval Ammunition Support Detachment,  
Vieques, Puerto Rico



Prepared for  
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# Acronyms and Abbreviations

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AB	Ambient Blank
ABS <sub>dermal</sub>	Dermal Absorption Factor
ABS <sub>GI</sub>	Gastrointestinal Absorption
AD	Average Daily Intake
AOC	Area of Concern
ASTM	American Society for Testing and Materials
atm-m <sup>3</sup> /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
CSF	Cancer Slope Factors
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
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 Rinse 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

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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	Not Collected
NCEA	National Center for Environmental Assessment
ND	Not Detected
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	Oxidative-Redox 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
RfC	Reference Concentration Value
RfD	Reference Dose Value
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
SOP	Standard Operating Procedures

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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

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Area of Concern (AOC) J 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 April 2004, the Draft Remedial Investigation (RI) Report for AOC J 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 2006), refined as applicable in accordance with regulatory agency comments.

In order to efficiently focus resources to achieve timely removal of the waste at AOC J 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:

- All agency comments are presented in Appendix M.
- Because the risk assessments for AOC J 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).

- 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.

AOC J is approximately 2 miles west of the entrance to the former Navy property and approximately 50 feet south of Vieques Passage. The site is in a partially cleared wooded area next to an ephemeral stream. The site elevation ranges from approximately sea level to 10 feet above mean sea level (msl) and is accessed by a dirt road extending north from Highway 200 to the site. Historical waste disposal activities occurred in an area of approximately 1.2 acres along the ephemeral stream that extends through the east side of the site. From 1965 to 1973, AOC J was used as a solid waste disposal site for construction staging activities. After 1973, some of the solid waste was removed from the site and placed in a municipal landfill off base. No records were kept indicating the size or location of the waste disposal site or the specific types of waste discarded and later removed from the site. No munitions and explosives of concern (MEC) were identified at the site.

The ephemeral stream is the only surface water body on the site. During periods of heavy and prolonged rainfall or ocean surge action, this ephemeral stream periodically opens into Vieques Passage to the north.

Previous environmental site investigations completed at AOC J included an Environmental Baseline Survey (EBS) and an Expanded Preliminary Assessment/Site Investigation (PA/SI). The results of both of these investigations have been incorporated into this RI report. The sampling for this RI is described in a work plan (CH2M HILL, 2003b) reviewed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Technical Committee (CTC). 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.

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 the site-related contaminants pose an unacceptable risk to human health and the environment.

## Remedial Investigation Activities

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

- Performance of geophysical surveys to delineate the extent of waste disposed at the site and to confirm that no MEC are present at sampling locations. A visual search for MEC was also conducted.
- Completion of five subsurface soil borings and the collection of five surface soil and five subsurface soil samples to characterize the site geology and provide samples for laboratory analysis. The analyses of these samples supplement the analyses of 10 soil samples collected for the Expanded PA/SI and 2 soil samples collected from the EBS.
- Installation of four monitoring wells (to supplement data from four monitoring wells installed during the Expanded PA/SI) to characterize the groundwater flow conditions and provide groundwater samples for analyses.
- Collection of groundwater elevation data and groundwater samples from eight monitoring wells to assess the groundwater flow conditions and groundwater quality impacts.
- Collection of five surface water and five sediment samples to assess the potential environmental impacts to the ephemeral stream at AOC J. These samples supplement the data from five surface water samples and five sediment samples previously collected at the site.
- Completion of laboratory analysis of the collected soil samples, groundwater samples, sediment samples, and surface water samples for metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and explosives.
- Collection of site-specific background samples of groundwater, sediment, and surface water for comparison with concentrations of inorganic chemicals detected in these media at AOC J. For soils, previously established background inorganic chemical values were used for comparison.

The RI was completed in accordance with the provisions of CERCLA and followed the Environmental Protection Agency (EPA) interim final *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). The analytical data were compared to EPA Region 9 Preliminary Remediation Goals (PRGs) and ecological screening criteria to assess whether detailed risk assessment is required.

## Nature and Extent of Contamination

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.

The analytical results of the 10 surface soil samples show that iron, lead, manganese, thallium, and zinc exceeded background levels and human health and/or ecological screening criteria. None of the surface soil samples indicated levels of VOCs, SVOCs, pesticides, PCBs, or explosives above screening criteria.

The analytical results of the 10 subsurface soil samples showed that none of the detected chemicals were above the screening criteria and background levels. This information suggests that the waste disposal activities have not likely had an impact on the site subsurface soils. None of the subsurface soil samples contained detectable levels of VOCs, SVOCs, pesticides, PCBs, or explosives above leachability screening criteria.

The analytical results of the 12 unfiltered groundwater samples show that concentrations of 10 metals (aluminum, arsenic, barium, cadmium, chromium, iron, lead, manganese, selenium, and vanadium) exceeded background levels and PRGs at one or more downgradient wells. The higher concentration of total metals within the groundwater compared with the dissolved metals concentrations indicates that suspended solids in the groundwater are contributing to the elevated metals concentrations. The dissolved metals analyses showed that nine metals exceeded PRGs and background levels.

Perchlorate was detected in 1 of 12 groundwater samples. The one detection of perchlorate occurred during the 2000 sampling in well NDAJMW01, but it was not detected in 2003 sampling of the same well. None of the other munitions/explosives-group chemicals analyzed for 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 yields false positive results, especially at low concentrations (<4 ug/L), as well as when used for analysis of other matrixes 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.

TCE was detected in 1 of 12 samples at NDAJMW05 in the 2003 sampling. This well was sampled again in 2004, and TCE was not detected during this resampling. A human health risk assessment (HHRA) was completed to evaluate whether these constituents pose an unacceptable risk to human health and the environment. None of the groundwater samples contained detectable levels of VOCs (including TCE), SVOCs, pesticides, PCBs, or explosives above PRGs.

The analytical results of the surface water samples showed that barium in one sample and beryllium in one sample exceeded both ecological screening criteria and background levels. The sediment data show that barium exceeded background levels and ecological screening criteria. Barium exceeded its basewide sediment background concentration at 1 of the 10 sediment sample locations. The chemical p,p'-DDT also

exceeded ecological screening criteria at one sediment sample location. No background data were collected for this chemical.

In summary, the analytical results indicate that the site may have contributed to elevated levels of a few metals in the soils, groundwater, and sediments. The absence of VOCs, SVOCs, pesticides (except DDT at one location), PCBs, and explosives above PRGs or ecological screening values indicates that these constituents are not likely potential contaminants of concern at this site. However, to assess whether any of these constituents pose an unacceptable risk to human health and the environment, an HHRA and an ecological risk assessment (ERA) were completed using all the detected chemicals.

## **Fate and Transport Summary**

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.

A fate and transport evaluation was performed for potential contaminants at AOC J. The primary migration pathways for transport of contaminants from the disposal area are rainwater leaching from surface to subsurface, and surface soil runoff into the ephemeral stream. Surface runoff to the ephemeral stream is not a likely pathway for AOC J, as the berm separating the site and the ephemeral stream acts as a partial barrier; thus runoff contribution to the ephemeral stream is likely to be minimal. The co-located subsurface soil samples did not have metals above criteria and do not indicate significant leaching from surface soil to subsurface soil, likely making this an unimportant contaminant migration pathway at AOC J. Metals were ubiquitous in groundwater. However, corresponding metals were not identified as a leachability concern for soils and thus are not likely from soil contaminants leaching to groundwater.

Based on the fate and transport evaluation, the soil to groundwater migration pathway does not appear to be significant at AOC J. Site wells indicate higher salinity concentrations than the background well, which may explain the difference in concentration between some of the dissolved solids and minerals in these site wells and background. Overall, the past debris disposal activities at AOC J do not seem to have had an observable effect on site groundwater.

Groundwater at AOC J has elevated dissolved (filtered) metals concentrations, particularly of manganese and iron. The levels of dissolved arsenic also were elevated in the same wells where iron and manganese were noted. Elevated concentrations of manganese in the filtered samples suggest that manganese reduction is likely a predominant electron-accepting process in the shallow aquifer. In this natural process,

soil bacteria use naturally available soil organic matter as an electron donor and manganese present in mineral form as an electron acceptor, causing increases in soluble manganese (+2 valence). This process often occurs in aquifers with organic-rich soil and depleted oxygen under reducing conditions, or low oxygen-reduction potential (ORP). Other metals that are sensitive to low ORP and may be elevated under these conditions include iron, arsenic, and selenium. Their presence in dissolved form may be due to the above-described site-specific geochemical conditions.

## Human Health Risk Assessment

The discussion below is a summary of the HHRA conducted for AOC J, 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. To provide a conservative assessment of risk and meet the guidelines of EPA Region 2, the risk assessment includes COPCs exceeding PRGs but below background levels. In addition, the maximum detected chemical concentrations were compared against the applicable screening criteria. The sampling data collected at AOC J from the Expanded PA/SI and this RI were used to select the COPCs. Surface soil, subsurface soil, groundwater, sediment, and surface water data were included in the evaluation.

The chemicals identified as COPCs for the various media included several inorganic chemicals in soils and sediments; one VOC and several inorganic chemicals in surface water; and one SVOC, three VOCs, and several inorganic chemicals in groundwater.

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 risks and Hazard Index (HI) for the various receptors from potential exposure to soils, groundwater, sediment, and surface water were evaluated.

A major conclusion from the risk assessment was that for the existing and anticipated land use (recreational) potential risks from human exposures to the site conditions are within EPA's target risk range. It was also concluded that exposures of maintenance workers and construction workers to the site soils are within the target cancer risk range.

The risk assessment for residential land use at the site shows that potential risks from human exposure to the soils exceeded the target risk range, primarily due to the

presence of iron and vanadium in the soils. However, these chemicals were detected within the range of background levels.

The potential risks from exposure to groundwater through potable use for industrial and residential users exceeded the target cancer risk range due to the presence of arsenic. The HI to the industrial worker and the residential adult and child from groundwater potable use were also above the target value of 1.0 due to aluminum, arsenic, iron, manganese, and vanadium. Concentrations of each of these metals, except aluminum, in groundwater are significantly influenced by oxidation-reduction potential (ORP) conditions in the aquifer. The high concentrations of dissolved manganese in groundwater at the site likely indicate that manganese reduction, a natural biogeochemical process, is occurring to a significant degree. Additionally, the groundwater at the site is not suitable for potable use due to the high salinity. Puerto Rico regulations require that groundwater with TDS less than 10,000 mg/L be considered potable. All of the groundwater samples collected at SWMU 6 had salinity concentrations greater than 11,500 mg/L.

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 with respect to soil is uncertain because soil 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 AOC J, 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.

AOC J currently supports a diverse vegetative community of trees, shrubs, and vines, along with associated birds, reptiles, and some mammals. The ephemeral stream likely supports a variety of benthic invertebrates and fish. The exposure pathways evaluated in the ERA included direct exposure to contaminants in the soil, surface water, and sediment, as well as contaminants potentially accumulating in onsite food webs from these media. Metals were detected in most samples, while organic chemicals were infrequently detected.

The ERA concluded that chemicals in surface soil, surface water, and sediment do not likely pose unacceptable risk to directly exposed soil organisms, nor do chemicals in these media likely pose a risk to upper trophic level wildlife feeding on various terrestrial and aquatic prey items at the site. Concentrations of many of the metals detected onsite were, on average, comparable to background. Average concentrations of

the other 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 and the anticipated land use of the site, the site conditions at AOC J do not likely pose an unacceptable risk to human health or ecological receptors. As a result, no remedial actions would be recommended based on the results of the risk assessments. 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

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El Área de Preocupación (AOC, por sus siglas en inglés) fue utilizado como vertedero de desechos sólidos en el Antiguo Destacamento Naval de Apoyo de Municiones (NASD, por sus siglas en inglés) en el oeste de la Isla de Vieques, Puerto Rico. En Abril del 2004, se sometió a las agencias reguladoras el Borrador al Reporte de Investigación de Remediación (RI) para el AOC J. Se recolectaron muestras principalmente adyacentes a la pila de desechos en vez de directamente de la pila de desechos (por motivos de seguridad), desechos y se llegó a la conclusión de que el área no presenta un riesgo inaceptable a la salud humana ó al ambiente. Mientras que la incertidumbre es inherente (y aceptable, hasta cierto punto) en todos los hallazgos, conclusiones, y decisiones que se toman en investigaciones ambientales, y en el proceso de remediación, la Marina y las agencias reguladoras concurrieron que la incertidumbre asociada con desechos que representan fuentes de contaminación potenciales (y los riesgos potenciales asociados) es inaceptable.

En el año 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 (JCA) de Puerto Rico concurrieron que una acción de remoción de desechos, en conjunto con un plan robusto de caracterización de desechos y un protocolo de confirmación de muestreo, atenderá la incertidumbre asociada con desechos que representen fuentes potenciales de contaminación futura, y asegurar que las concentraciones residuales protegen la salud humana y el ambiente. Antes de iniciar la acción de remoción desechos, se colectaran muestras de suelo a través del área de disposición (incluyendo áreas dentro de las pilas de desechos) para determinar las alternativas de disposición apropiadas.

Una vez concluida la acción de remoción, se recolectarán muestras confirmatorias dentro del área excavada, y se conducirá una evaluación de riesgo para re-asegurar que las concentraciones residuales protegen la salud humana y el ambiente. La evaluación de riesgo considerará la información presentada en el Plan de Conservación Comprensivo 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 realizará de acuerdo a los protocolos para la salud humana y evaluación de riesgo ecológico del Plan Maestro para el Proyecto de Control de Calidad (CH2M HILL, Mayo 2006), revisado de acuerdo a los comentarios provistos por la agencia reguladora.

Para enfocar los recursos mas eficientemente y lograr la disposición a tiempo de desechos en el AOC J, y confirmar que las concentraciones residuales protegen la salud

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humana y el ambiente, éste reporte se ha finalizado tal como se presentó el borrador original con las siguientes modificaciones:

- Todos los comentarios provistos por las agencias están incluidos en el Apéndice M.
- Debido a que las evaluaciones de riesgo para el AOC J serán hechos de nuevo usando la data confirmatoria obtenido durante la acción de remoción, la evaluación de riesgo ecológico y a la salud humana se ha movido al Apéndice L con el fin de enfatizar que éste será obsoleto una vez que se concluya la acción de remoción, y el hecho de que estos hallazgos no son la base para conducir la acción de remoción., (es decir, la remoción se está implementando para atender la incertidumbre de que los desechos puedan ser fuentes de contaminación en un futuro).
- En vez de atender los comentarios de las agencias individualmente, los temas substanciales de los comentarios (es decir, incertidumbres asociadas con la localización de la muestras, conclusiones en referencia a riesgo potencial, etc.), son tomados en cuenta por medio de inserciones en el texto (y algunas cancelaciones de textos) a través del reporte final del RI para demostrar que las agencias reguladoras no necesariamente están de acuerdo con los resultados/conclusiones de la Marina en el borrador del reporte, y que las incertidumbres asociadas con las pilas de desechos serán atendidas durante la acción de remoción.

El AOC J se encuentra aproximadamente a 2 millas al oeste de la antigua propiedad de la Marina, y aproximadamente a 50 pies al sur del Pasaje de Vieques. El sitio se encuentra en un bosque parcialmente despejado, junto a una corriente efímera. La elevación del sitio varía aproximadamente entre el nivel del mar y 10 pies sobre el nivel del mar, y se llega a través de una carretera sin asfaltar que se extiende desde el norte de la carretera 200 hasta el sitio. Actividades históricas relacionadas con la disposición de desechos se realizaron en un área de aproximadamente 1.2 acres a lo largo de la corriente que se extiende al este del sitio. Entre 1965 y 1973, el AOC J fue usado como vertedero de desechos sólidos relacionados con actividades de construcción. Después del año 1973, se removieron parte de los desechos y fueron trasladados a un vertedero municipal fuera de la base. No se documentó el área ó localización del vertedero, la naturaleza de los desechos que se dispusieron y luego removidos del sitio. No se identificaron municiones ó explosivos de preocupación (MEC, por sus siglas en inglés) en el área.

La corriente efímera es la única corriente de agua superficial en el sitio. Durante periodos prolongados de lluvia fuerte u oleaje, la corriente efímera se abre hacia el Pasaje de Vieques, que se encuentra hacia el norte.

Investigaciones ambientales previas en el AOC J incluyeron un Estudio Medioambiental de Reconocimiento Inicial (EBS, por sus siglas en Inglés) y un Estudio Preliminar Extendido/Investigación de Sitio (PA/SI, por sus siglas en inglés). Los resultados de ambas s investigaciones se han incorporado en el reporte RI. El muestreo para éste RI se

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describe en el plan de trabajo (CH2M HILL 2003b), revisado por el Comité Técnico (CTC, por sus siglas en inglés) de la Ley de Respuesta Ambiental, Responsabilidad y Compensación Comprensiva (CERCLA, por sus siglas en inglés). Por preocupaciones de seguridad, se tomaron muestras de desechos adyacentes a las pilas de desechos, en vez de a través de las pilas de desechos. Es posible que se pudiesen identificar componentes adicionales o componentes con concentraciones más altas si se hubiesen colectado las muestras a través de la pila de desechos. Por lo tanto, existe cierta incertidumbre si es que las conclusiones a las que se llegaron en el borrador del reporte con respecto al riesgo ecológico y a la salud humana serían iguales si se hubiese obtenido data dentro y debajo de las pilas de desechos, y se hubiese incluido la data en el estudio. Ésta incertidumbre será atendida por medio de la acción de remoción, el muestreo de caracterización y confirmación, y la evaluación de riesgo sobre las concentraciones residuales. La evaluación de riesgo a la salud humana y ecológica será conducida usando la data de muestreo confirmatorio luego de la remoción.

Éste RI fue conducido para suplementar investigaciones previas para (1) caracterizar la naturaleza y extensión de la contaminación ambiental asociada al sitio, y (2) evaluar si la contaminación relacionada al sitio posee un riesgo inaceptable para la salud humana y el ambiente.

### Actividades de Investigación Remediadoras

Para alcanzar los objetivos del RI, se completó un número de tareas, incluyendo lo siguiente:

- Monitoreo geofísico para delinear la extensión de los desechos dispuestos en el área de desechos y confirmar que no existe MEC en localizaciones de muestreo. También se efectuó una inspección ocular para detectar MEC.
- Se completaron cinco evaluaciones con excavaciones en el subsuelo; se tomaron 5 muestras de la superficie del suelo y 5 muestras del subsuelo para caracterizar la geología del sitio y proveer muestras para ser analizadas en el laboratorio. El análisis de éstas muestras suplementan el análisis de 10 muestras de suelo tomadas durante el PA/SI, y 2 muestras de suelo tomadas durante el EBS.
- Instalación de cuatro pozos de monitoreo (para suplementar data de cuatro pozos de monitoreo instalados durante el PA/SI) para caracterizar las condiciones de flujo de agua subterránea y proveer muestras de agua subterránea para ser analizadas.
- Recolección de data del nivel de agua subterránea y muestreo de aguas subterráneas de ocho pozos de monitoreo para evaluar las condiciones de flujo de agua subterránea e impactos en la calidad del agua subterránea.
- Recolección de cinco muestras de agua de superficie y cinco muestras de sedimentos para evaluar impactos ambientales potenciales en la corriente efímera en

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el AOC J. Éstas muestras suplementan la data obtenida de cinco muestras de agua de superficie y cinco muestras de sedimento previamente obtenidas.

- Se completaron los análisis de laboratorio de las muestras de suelo recolectadas de agua subterránea, sedimentos, y agua de superficie para análisis de metales, compuestos orgánicos volátiles (VOCs, por sus siglas en Inglés), compuestos orgánicos semi-volátiles (SVOCs, por sus siglas en Inglés), pesticidas, bifenilos policlorinados (PCBs, por sus siglas en Inglés), y explosivos.
- Recolección de muestras de trasfondo para sitio específico de aguas subterráneas, sedimentos y aguas de superficie para ser comparados con las concentraciones de químicos inorgánicos detectados en éstos medios en el AOC J. En el caso de suelos, se usaron valores previamente establecidos de químicos de trasfondo inorgánicos para comparación.

El RI se completó de acuerdo a las guías establecidas en CERCLA, y el documento interino final de la Agencia de Protección Ambiental (EPA, por sus siglas en Inglés) titulado *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). La data analítica se comparó con la Metas de Remediación Preliminares, EPA Región 9 (PRG, por sus siglas en inglés), y los criterios ecológicos de la evaluación para determinar si se requiere una evaluación de riesgo detallada.

## Naturaleza y Extensión de la Contaminación

La discusión que se presenta a continuación es un resumen de la naturaleza y extensión de la contaminación, basado en la distribución de muestras tomadas durante el PA/SI. Debe de tomarse en cuenta que la representación de la naturaleza y extensión de la contaminación no incluye data obtenida directamente a través de las pilas de desechos, existiendo la posibilidad de que se haya podido detectar componentes adicionales o componentes en concentraciones mas altas dentro de ó directamente debajo de las pilas de desechos. Ésta incertidumbre será tratada durante la acción de remoción junto con el muestreo de caracterización y confirmación, los resultados de los cuales se presentarán en el reporte de la acción de remoción.

Los resultados analíticos de las 10 muestras de suelo demuestran que hierro, plomo, manganeso, talio y cinc exceden los niveles de criterio de trasfondo, al igual que el criterio de salud humano y/ó ecológico. Ninguna de las muestras de suelos de superficie excedieron los niveles de criterio para VOCs, SVOCs, pesticidas, PCBs, ó explosivos.

Los resultados analíticos de las 10 muestras del subsuelo indican que ninguno de los químicos detectados exceden los niveles de criterio ó los niveles de trasfondo. Ésta información sugiere que las actividades de disposición de desechos probablemente no han impactado el subsuelo del sitio. Ninguna de las muestras tomadas del subsuelo

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contiene niveles detectables de VOCs, SVOCs, pesticidas, PCBs, ó explosivos sobre los criterios de lixiviación en el subsuelo.

Los resultados analíticos de las 12 muestras de aguas subterráneas (no filtradas) indican que las concentraciones de 10 metales (aluminio, arsénico, bario, cadmio, cromo, hierro, plomo, manganeso, selenio, y vanadio) exceden los niveles base y PRGs por lo menos en uno de los pozos vertiente abajo. La concentración mayor de metales totales dentro de aguas subterráneas, comparada con las concentraciones de metales disueltos indica que los sólidos suspendidos en las aguas subterráneas contribuyen a elevar las concentraciones. Resultados analíticos de metales disueltos indican que nueve metales exceden los niveles de trasfondo y el PRG.

Perclorato fue detectado en 1 de las 12 muestras de agua subterránea. La única detección de perclorato ocurrió en la muestra que se tomó del pozo NDAJMW01 en el año 2000; sin embargo, perclorato no fue detectado en la muestra que se tomó en ése mismo pozo en el año 2003. Ninguna de las otras sustancias químicas dentro del grupo municiones/explosivos analizadas fueron detectadas en ninguna otra muestra de agua subterránea ó muestras de suelo. La concentración de perclorato detectada fue en una muestra de agua subterránea analizada siguiendo el Método 314.0 del EPA. Éste método no es de confianza a bajos niveles de detección (<4 µg/L) ó cuando se usa para analizar otros medios (por ejemplo, suelos) y se recomienda verificar cualquier detección siguiendo un método alternativo (DoD, 2004), ya que el perclorato se encuentra en muchos detergentes comunes usados en los laboratorios (correo electrónico interno del laboratorio analítico STL, 2003, ver el Apéndice J). Debido a que el perclorato no fue detectado en la última ronda de muestreo, verificación de los resultados siguiendo otro método alternativo no fue necesario. Por lo tanto, se puede concluir que la presencia de perclorato en el sitio es poco probable.

TCE fue detectado en 1 de las 12 muestras tomadas en el año 2003 del pozo NDAJMW05. Este pozo fue muestreado nuevamente en el año 2004, y no se detectó ningún TCE. Se completó una evaluación de riesgo a la salud humana (HHRA, por sus siglas en inglés) para evaluar si estos componentes presentan un riesgo inaceptable a la salud humana y al ambiente. Ninguna de las muestras de agua subterránea indicaron concentraciones detectables de VOCs, (incluyendo TCE), SVOCs, pesticidas, PCBs, ó explosivos sobre los niveles de PRGs.

Los resultados analíticos de las muestras de aguas de superficie indicaron concentraciones de bario en una muestra y berilio en otra muestra a niveles más altos de los criterios ecológicos de investigación y niveles de trasfondo. Los resultados analíticos de las muestras de sedimentos indican que concentraciones de bario exceden los niveles de trasfondo y el criterio ecológico de investigación. El bario excedió las concentraciones de nivel de trasfondo en sedimentos en 1 de las 10 muestras. La sustancia química p,p'-DDT también excedió los criterios ecológicos de la investigación en una muestra. No se ha tomado muestras de trasfondo para ésta sustancia química.

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En resumen, los resultados analíticos indican que el sitio puede haber contribuido a las concentraciones elevadas de algunos metales en el suelo, el agua subterránea, y sedimentos. Debido a que las concentraciones de VOCs, SVOCs, pesticidas (con la excepción de DDT en una muestra), PCBs, y explosivos no exceden los niveles del PRG ó los niveles de criterio ecológico, indican que éstas sustancias químicas probablemente no son potenciales contaminantes de interés relacionados con el sitio. Sin embargo, para evaluar si alguna de éstas sustancias químicas presenta un riesgo inaceptable a la salud humana ó al ambiente, se completó un HHRA y monitoreo de riesgo ecológico (ERA, por sus siglas en Inglés) incluyendo todas las sustancias químicas detectadas.

## Resumen de Destino y Transportación

A continuación se presenta un resumen del destino y transportación de los componentes , principalmente aquellas que han sido identificadas como contaminantes, basado en la distribución de muestras tomadas durante el PA/SI y el RI. Se reconoce que hay cierta incertidumbre asociada con los componentes identificados como contaminantes y las concentraciones asociadas debido a que las muestras de suelo no se tomaron directamente a través de las pilas de desechos. Es posible que otros contaminantes ó concentraciones más altas se hayan podido detectar bajo éstas circunstancias. Sin embargo, la discusión general sobre el destino y transportación es apropiada basada en los datos obtenidos. Más aun, la acción de remoción atenderá la incertidumbre asociada con los tipos y niveles de contaminantes y el destino y transportación relacionados. Se llevó a cabo una evaluación del destino y transporte de los contaminantes potenciales en el AOC J. Las principales medios de transporte de los contaminantes en el área donde los desechos fueron dispuestos es por medio de infiltración de lluvia hacia al subsuelo, y por medio de las agüas de escorrentía hacia la corriente efímera. Aguas de escorrentía hacia la corriente efímera no es muy probable ya que la berma que separa el sitio y la corriente efímera sirve como barrera parcial; por lo tanto, se especula que la contribución de las aguas de escorrentía a la corriente efímera es mínima. Las concentraciones de metales en las muestras co-localizadas no exceden el criterio e indicaron que la infiltración de la superficie hacia el subsuelo no es significativa, haciendo éste un medio de poca importancia en el transporte de contaminantes en AOC J. Metales ocurren naturalmente en aguas subterráneas. Sin embargo, infiltración de los metales correspondientes en el suelo no es de preocupación, y es poco probable que los contaminantes presentes en el suelo se estén infiltrando hacia el agua subterránea.

Basados en la evaluación del destino y transporte, infiltración de contaminantes hacia el agua subterránea parece ser de poca importancia en AOC J. Pozos de agua en el sitio indican concentraciones de salinidad más elevados que las concentraciones en los pozos de trasfondo , que a su vez pueden explicar la diferencia en concentraciones entre algunos de los sólidos disueltos y minerales en los pozos de agua en el sitio y los pozos de agua de trasfondo. En general, las actividades de disposición de desechos en AOC J no parecen haber tenido mayor efecto en el agüa subterránea.

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El agua subterránea en AOC J contiene concentraciones elevadas de metales (filtrados), particularmente manganeso y hierro. Niveles elevados de arsénico también existen en los mismos pozos de agua donde existen concentraciones elevadas de hierro y manganeso. Concentraciones elevadas de manganeso en las muestras filtradas indican la probabilidad que el principal proceso de reducción es a través del manganeso, quien actúa como receptor de electrones en el área superficial del acuífero. Dentro de este proceso natural, la bacteria presente en el suelo utiliza la materia orgánica natural como donante de electrones y el manganeso en forma mineral como receptor de electrones, resultando en el aumento de concentraciones de manganeso disuelto (valencia +2). Este proceso ocurre con frecuencia en acuíferos ricos en materia orgánica y agotados en oxígeno bajo condiciones reducidas, ó bajos niveles del potencial de reducción del oxígeno (ORP, por sus siglas en Inglés). Otros metales que son sensibles a bajos niveles de ORP, y bajo estas condiciones pueden encontrarse en concentraciones elevadas incluyen hierro, arsénico, y selenio. Su presencia en estado disuelto puede ser el resultado de las condiciones geoquímicas del sitio.

## Evaluación de Riesgo a la Salud Humana

La información que se presenta a continuación es un resumen del HHRA preparado para el AOC J, basado en la distribución de muestras previamente discutidas. Debe de 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 Químicos de Preocupación Potencial (COPCs, por sus siglas en Inglés) identificadas y las conclusiones en la evaluación de riesgo basados en dichos COPCs. Sin embargo, ésta es una incertidumbre que será atendida durante la acción de remoción, junto con el protocolo de muestreo de caracterización y confirmación.

El HHRA se hizo para evaluar si las concentraciones de COPCs que exceden el PRG presentan un riesgo inaceptable a la salud humana. Con el fin de proveer una evaluación de riesgo conservador y cumplir con las guías de la Región II de la EPA, la evaluación de riesgo incluye COPCs que exceden los niveles del PRG, y que a su vez se encuentran a concentraciones más bajas que los niveles De trasfondo. Además, las concentraciones máximas de las sustancias químicas fueron comparadas con los debidos criterios. Los COPCs fueron seleccionados basados en la data obtenida de las muestras tomadas en AOC J durante el PA/SI y éste RI. La evaluación incluyó data de suelos superficiales, subsuelo, aguas subterráneas, sedimentos, y agua de superficie.

Las sustancias químicas identificadas como COPCs en los diferentes medios incluyeron varios químicos inorgánicos en el suelo y sedimentos; un VOC, y varios químicos inorgánicos en aguas de superficie; un SVOC, tres VOCs, y varios químicos inorgánicos en aguas subterráneas.

Basados en el uso anticipado del sitio, las siguientes poblaciones potencialmente expuestas fueron evaluadas:

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

El índice de peligrosidad (HI, por sus siglas en inglés) para los varios receptores fue evaluado por exposición al suelo, aguas subterráneas, sedimentos, y aguas de superficie.

Una conclusión principal del estudio de riesgo fue que, dado el uso actual y anticipado del área (uso recreacional), el riesgo potencial que resulta al exponer seres humanos a las condiciones del sitio se encuentran dentro del criterio de riesgo del EPA. También se concluyó que el riesgo de exponer trabajadores de mantenimiento y construcción al suelo, se encuentra dentro del criterio de riesgo para el cáncer.

La evaluación de riesgo para uso residencial indica que el riesgo potencial de exponer seres humanos al suelo excede el criterio de riesgo, debido principalmente a la existencia de hierro y vanadio en el suelo. Sin embargo, estos elementos químicos fueron detectados en concentraciones dentro de los niveles de trasfondo.

Los riesgos potenciales para usuarios residenciales e industriales por exposición a agua subterránea a través del uso de agua potable excede el criterio de riesgo de cáncer debido a la existencia de arsénico. El HI para el trabajador industrial, tal como el adulto y el niño en un ambiente residencial, debido al uso de agua potable excede el criterio de 1.0 debido a la existencia de aluminio, arsénico, hierro, manganeso, y vanadio. Las concentraciones de cada uno de estos metales en agua subterránea, con la excepción de aluminio, son influenciadas significativamente por las condiciones del ORP en el acuífero. Las concentraciones elevadas de manganeso disuelto en agua subterránea en el sitio probablemente indican que la reducción de manganeso, que es un proceso bioquímico natural, es significativa. Además, el agua subterránea del sitio no es apta para consumo potable debido a la alta salinidad. Las leyes de Puerto Rico dictan que aguas subterráneas con sólidos disueltos totales (TDS por sus siglas en inglés) en concentraciones a menos de 10,000 mg/L son consideradas agua potable. Todas las muestras de agua subterránea tomadas en el SWMU 6 tienen concentraciones de cloruro en exceso de 27,000 mg/L.

Basados en los resultados del HHRA, las sustancias químicas relacionadas con el sitio probablemente no presentan un riesgo inaceptable para el uso actual y anticipado del sitio, pero se reconoce que ésta conclusión con respecto al suelo es incierta debido a que las muestras de suelo fueron tomadas junto a la pila 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 de convertirse en una fuente de contaminación en un futuro, las agencias han concurrido implementar una acción de

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remoción para despejar ésta 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 AOC J, basados en la data de la distribución de muestras previamente discutido. Debe de considerarse que la evaluación de riesgo ecológico no incluye la posibilidad de tener concentraciones más altas 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 basados en dichos COPCs. Sin embargo, ésta es una incertidumbre que será tratada durante la acción de remoción, junto con el protocolo de muestreo de caracterización y confirmación.

El AOC J sostiene una comunidad de vegetación diversificada que incluye árboles, arbustos y viñas, además de pájaros, reptiles, y ciertos mamíferos. Es probable que la corriente efímera sostenga una variedad de animales invertebrados rastreros y pescados. Las vías de exposición evaluadas en el ERA incluyen exposición directa a los contaminantes presentes en el suelo, agua de superficie, y sedimentos, así como contaminantes que potencialmente se estén acumulando dentro de cada uno de éstos medios. Se detectaron metales en la mayoría de las muestras, mientras que sustancias químicas orgánicas fueron detectadas con menor frecuencia.

El ERA concluye que no es probable que las sustancias químicas presentes en el suelo superficial, , agua de superficie y sedimentos presenten un riesgo inaceptable a los organismos que se encuentran en el suelo; así mismo, las sustancias químicas en éstos medios no parecen presentar un riesgo a la comunidad trófica superior que se alimentan por medio de sus presas acuáticas y terrestres. Las concentraciones de varios metales detectadas en el sitio se encuentran dentro del promedio de los niveles de trasfondo. Las concentraciones promedio de los otros metales, y algunos de los compuestos orgánicos detectados, se encuentran por debajo de los valores ecotóxicos ó excedieron levemente los valores ecotóxicos. 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 concurren 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.

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## Recomendaciones

Basados en los resultados del RI, y el uso anticipado del sitio, las condiciones de sitio en el AOC J no parecen presentar un riesgo inaceptable a la salud humana ó receptores ecológicos. Basados en los resultados de las evaluaciones de riesgo, no se recomienda implementar acciones de remediación. Sin embargo, debido a que hay cierta incertidumbre asociada con las conclusiones del estudio de riesgo y una incertidumbre inaceptable asociada con los desechos como fuentes potenciales de contaminación en un futuro, las agencias han concurrido 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

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This Remedial Investigation (RI) report presents the results of previous investigations and the RI conducted during 2003 at Area of Concern (AOC) J of the former Naval Ammunition Support Detachment (NASD), Vieques Island, Puerto Rico.

In April 2004, the Draft RI Report for AOC J 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 2006), refined as applicable in accordance with regulatory agency comments.

In order to efficiently focus resources to achieve timely removal of the waste at AOC J 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:

- All agency comments are presented in Appendix M
- Because the risk assessments for AOC J 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).

- 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 by the Naval Facilities Engineering Command (NAVFACENGCOM) Atlantic Division (LANTDIV) and CH2M HILL under Navy Contract N62470-02-D-3052, Navy Comprehensive Long-Term Environmental Action Navy (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 sources onsite so that recommendations for remedial actions, if any, could be evaluated from site data. To achieve this, two 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, groundwater, surface water, and sediments).
2. Determine the current and potential future risks to human health and the environment based on analytical results from site media and the planned future land use for the site.

To meet these objectives, 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 environmental activities completed within AOC J to evaluate and establish a baseline of the physical characteristics, subsurface soil profiles, groundwater interfaces, and subsurface and groundwater quality within the study area.
- Collection and interpretation of data on groundwater levels to establish baseline static groundwater levels and observe any tidal influence within the vicinity of the AOC J study area.
- Collection of surface soil samples for laboratory analysis and reporting.
- Installation of subsurface soil borings to further classify the subsurface geologic profile and to collect environmental samples for laboratory analysis and reporting.
- Installation of monitoring wells to supplement the existing monitoring well network constructed during the site characterization (SC) and Expanded PA/SI completed at AOC J in 2000.

- Collection of groundwater samples from existing and newly installed monitoring wells for laboratory analysis and reporting.
- Collection of sediment and surface water samples 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 CERCLA guidance (EPA,1988).

As indicated above, the main objective of the AOC J 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 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.

## 1.2 Report Organization

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 AOC J, such as its former uses, climate, topography, and natural and cultural resources, as well as a discussion on 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 AOC J and the approach, methods, and operational procedures employed to perform these tasks. This section also presents the data management and quality control measures used during collection of AOC J-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 AOC J and screening of sampling data against conservative criteria.

*Section 5. Contaminant Fate and Transport* presents a conceptual site model (CSM) that builds on results of the previous sections and information on site physical characteristics, contaminant source characteristics, and extent of contamination to formulate conclusions on contaminant fate and transport.

*Section 6. RI Conclusions and Recommendations* presents the conclusions and recommendations from the RI program 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 AOC J, 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 late 2006, the DOI issued the Draft 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 AOC J 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 2006), refined as applicable in accordance with regulatory agency comments. 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

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This section presents the site setting, history, and previous environmental investigations conducted at the AOC J area. This section also contains brief descriptions of the natural and cultural resources within the former NASD and results of previous environmental investigations that led to the RI.

## 2.1 AOC J 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.

AOC J is approximately 2 miles west of the entrance to the former Navy property. It is north of Highway 200 and approximately 50 feet south of Vieques Passage at the coordinates of 18° 07' 07" N latitude and 065° 33' 05" W longitude. The site is in a wooded area next to an ephemeral stream. The site elevation ranges from approximately sea level to 10 feet above mean sea level (msl) and is accessed by a dirt road extending north from Highway 200 to the disposal site. The historical disposal activities were concentrated in an area approximately 1.2 acres in size along the ephemeral stream that extends through the site. Figure 2-2 shows the location of AOC J within the former NASD property and its present land use.

## 2.2 Site History

The AOC J site encompasses an area of approximately 1.2 acres and was used from 1965 to 1973 as a solid waste disposal site for construction staging activities (ERM, 2000). After 1973, some of the unidentified solid waste was removed from the site and placed in a municipal landfill off base. No records were kept indicating the location of the landfill. The types of waste taken from the site are unknown.

As part of the Expanded PA/SI in 2000, a CH2M HILL inspection with a munitions and explosives of concern (MEC) avoidance survey team identified two 106-millimeter (mm) shell casings, one flash tube, one 106 mm cartridge base, and six cartridge canisters (CH2M HILL, 2000d). An MEC avoidance survey also was conducted in 2003 prior to soil boring and groundwater well installations at this site (see Appendix A). No unexploded ordnance (UXO)/ordnance and explosives (OE) items were found in either survey.

The U.S. Navy ceased facility-wide operations on the former NASD on April 30, 2001, when the land was transferred to the DOI, MOV, and Conservation Trust. AOC J is located on DOI property that has been designated as a wildlife refuge.

## 2.3 Physical Setting

### 2.3.1 Weather and Climate

The climate of Vieques is tropical-marine. Temperatures are nearly constant, with 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 through 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 area slopes gradually from the center to the coast, with the exception of steep slopes in the vicinity of Mount Pirata.

Topography at AOC J is characterized by a generally flat area with an ephemeral stream extending through the eastern portion of the site. This ephemeral stream drains to the north to Vieques Passage (CH2M HILL, 2000d). Figure 2-3 is an aerial photograph of AOC J that shows the ephemeral stream and densely overgrown conditions along the ephemeral stream. The ephemeral stream varies from 20 to 40 feet wide and an average of 3 to 6 feet deep. Most of the solid waste is located adjacent to the west side of the ephemeral stream, and some debris piles are located up to 100 feet west of the ephemeral stream. The site elevation is 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).

AOC J is in a thorn scrub forest near the coast. Historically, parts of this site were cleared, but clearings have been discontinued long enough for the plant community to become reestablished within the lowland area. This plant community consists of four species: mesquite, gumbo limbo, black cabbage bark, and yellow pickle. The shrub stratum was represented by Christmas tree, broomstick, and bisselet. Along the ocean, coconut palm trees were observed. There were a few species of herbs, but no grasses were present in the lowest stratum. The plant community is representative of the coastal scrub forest and did not differ significantly from the reference site. The tree canopy layers provide nearly 100 percent cover in some areas. No vegetation stresses were observed at AOC J. The ephemeral stream is also heavily vegetated with mature trees established on the banks and ephemeral stream bottom.

## 2.3.4 Geology

### 2.3.4.1 Regional 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).

### 2.3.4.2 Local Geology

A geologic cross-section for AOC J was developed through the evaluation of soil boring logs and is illustrated in Figure 2-5. Soil samples collected during the installation of soil borings and monitoring wells associated with the Expanded PA/SI completed in 2000 and this RI indicate that the soils encountered beneath AOC J consist of a mixture of clay and organic soil from ground surface to a depth of between 10 and 14 feet below land surface (bls), underlain by a sandy clay to a maximum depth investigated of 23 feet bls. Highly organic soils, common in the northern portion of the site, are a result of stagnant tidewater retained by sand dunes blocking the mouth of the ephemeral stream extending south to north on the east site boundary. Iron oxide staining is prevalent on subsurface soils at a depth of 6 to 7 feet bls. Soil colors ranged from primarily dark brown in the clay to a reddish brown in the deeper sandy clay. Silt layers were encountered at three locations (NDAJMW06, NDAJMW07, and NDAJMW08) at depths ranging from 6 to 14 feet. The materials in the clay surficial zone generally exhibit low plasticity when moist, are medium stiff when dry, and are easily crumbled under hand pressure. The materials in the lower sandy clay zone also exhibit low plasticity when moist, are generally stiff, and can be easily crumbled under hand pressure.

The AOC J area does not appear to lie within the Resolución Valley aquifer and does not contain the 30-foot-thick sediment in the Mount Pirata area units described in the USGS (1989) study. The water-bearing sediments (the silty sand) described in the USGS study are not found at AOC J. The water-bearing zone at AOC J appears to be within the clay and sandy clay zones. The water-bearing zone within the clay layers is between 3 and 9 feet bls as seen in the nine monitoring wells onsite.

## 2.3.5 Hydrology

### 2.3.5.1 Surface Water

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 rains. These streams are located throughout the former NASD, generally flowing in a northerly direction.

An ephemeral stream is located just east of the disposal site and is typically stagnant. During periods of heavy and prolonged rainfall or ocean surge action, the mouth of the stream periodically opens to Vieques Passage to the north.

### 2.3.5.2 Groundwater

AOC J is underlain by a potentially semiconfined groundwater system composed of alluvial deposits made up of clay and sandy clay. Groundwater was encountered at the site at depths of 5 feet bls near the northern end of the site to 11 feet bls slightly upland (wells NDAJMW03 and NDAJMW07). The site does not appear to lie within the Resolución Valley aquifer system, as a sandy layer was not encountered at the site. General groundwater flow is to the north in the direction of Vieques Passage. At AOC J, the local groundwater flow is easterly, toward the ephemeral stream, to northeasterly. Figure 2-6 illustrates the groundwater flow direction at the site.

Salinity measurements for groundwater samples collected during the Expanded PA/SI indicated that the groundwater at AOC J is brackish to saline, with salinity readings ranging from 11.6 parts per thousand (ppt) in well NDAJMW03 to 37.3 ppt in well NDAJMW01. By comparison, the salinity of seawater generally ranges from 32 to 37 ppt. These salinity readings are not unexpected, given the site's low elevation and location close to Vieques Passage and indicate that groundwater is affected by and intermixed with saltwater. The high salinity renders the groundwater at AOC J unsuitable for potable water use without desalinization.

## 2.4 Wildlife

During the wildlife survey, woody debris piles along the edges of the site were observed to attract large numbers of lizards and to provide perches for birds. A mature green iguana was observed on the opposite side of the creek to the east of the site. Land crab was the only invertebrate observed at the northern end of the site, as evidenced by the presence of multiple burrows. The bare ground and small, isolated patch of shrubs and trees provided limited habitat for birds. Species observed on site included Caribbean elaenia, Adelaide's warbler, greater Antillean grackle, and gray kingbird.

No federally protected species or preferred habitat were observed on the site. Two brown pelicans were observed flying over adjacent habitat toward the north. Although cobana negra has been found at NASD (on the boundary between black mangrove communities, salt flats, and the upland communities), the habitat at AOC J was primarily upland thorn scrub (Geo-Marine, 2000). In September 2005, Geo-Marine conducted another flora and fauna survey during which two specimens of the protected species *stahlia monosperma* were observed along the ephemeral stream at AOC J.

## 2.5 Cultural Resources

A number of resources on the former NASD property are of interest from a cultural perspective, including conservation zones 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<sup>th</sup> century and early 20<sup>th</sup> 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 during the records search associated with the Western Training Area OE investigation (CH2M HILL, 2001b). None of these 12 archeological sites occurs within the AOC J area. No cultural resources are expected to be encountered at AOC J based on its recent history and lack of documented evidence of such resources.

## 2.6 Summary of Previous Investigations

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

This section includes a summary of the detailed information included in the Expanded PA/SI Report.

### 2.6.1 Environmental Baseline Survey

As part of the EBS, two soil samples were collected at 3 to 4 feet bls adjacent to the visible remains of the disposal site from a backhoe-excavated pit. The samples were analyzed for VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), and metals. Analytical results showed no elevated levels of any constituent of concern for this site (ERM, 2000).

### 2.6.2 Ecological Survey

An ecological survey was conducted in August 2000 by Geo-Marine Inc. The survey concluded that no endangered or threatened species were present at this site. However, during another survey conducted in September 2005, two specimens of the protected species *stahlia monosperma* were observed along the ephemeral stream at AOC J.

### 2.6.3 Expanded PA/SI

A field investigation for the Expanded PA/SI was conducted by CH2M HILL (2000d). During this study, a barbed-wire fence was installed to delineate the site and keep visitors away from the site. Five surface soil, five surface water, five sediment, and four groundwater samples were collected and analyzed for metals, VOCs, SVOCs, pesticides, PCBs, and explosives. The samples were compared against EPA Region 9 screening criteria

and ecological screening values for sediment. One monitoring well was installed upgradient and three were installed downgradient of the site. Groundwater samples were collected from each monitoring well. One upstream surface water/sediment sample was collected in the adjacent ephemeral stream, and four other surface water/sediment samples were collected at equally spaced locations downstream of the site toward Vieques Passage (Figure 3-4). An MEC avoidance survey was conducted before any intrusive activities were performed.

From the laboratory analysis, total concentrations of aluminum, arsenic, barium, cadmium, iron, lead, manganese, and vanadium in groundwater samples exceeded the maximum contaminant levels (MCLs) and/or tap-water preliminary remediation goals (PRGs). Dissolved concentrations of aluminum, cadmium, iron, lead, and vanadium were either not detected or below PRGs. Dissolved concentrations of arsenic, barium, and manganese were above PRGs. Perchlorate was detected in one well, NDAJMW01, in groundwater above the tap-water PRG. This well was resampled in 2003, and perchlorate was not detected in the more recent sample. Pesticides, PCBs, SVOCs, and VOCs were either not detected or detected at concentrations below applicable screening criteria.

Surface-water exceedances included copper and mercury. The detected concentration of copper was below background levels. Mercury values were reported at or near the method detection limit (MDL) and are likely a false positive. Explosives, pesticides, PCBs, SVOCs, and VOCs were either not detected or detected at concentrations below applicable screening criteria.

Chemicals in surface soil samples detected above residential PRGs were aluminum, arsenic, iron, manganese, and vanadium. For subsurface soil and sediment samples, no exceedances of screening criteria were recorded for any of the target chemicals.

## 2.7 Regulatory Status

The investigations of AOC J 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, since AOC J 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.

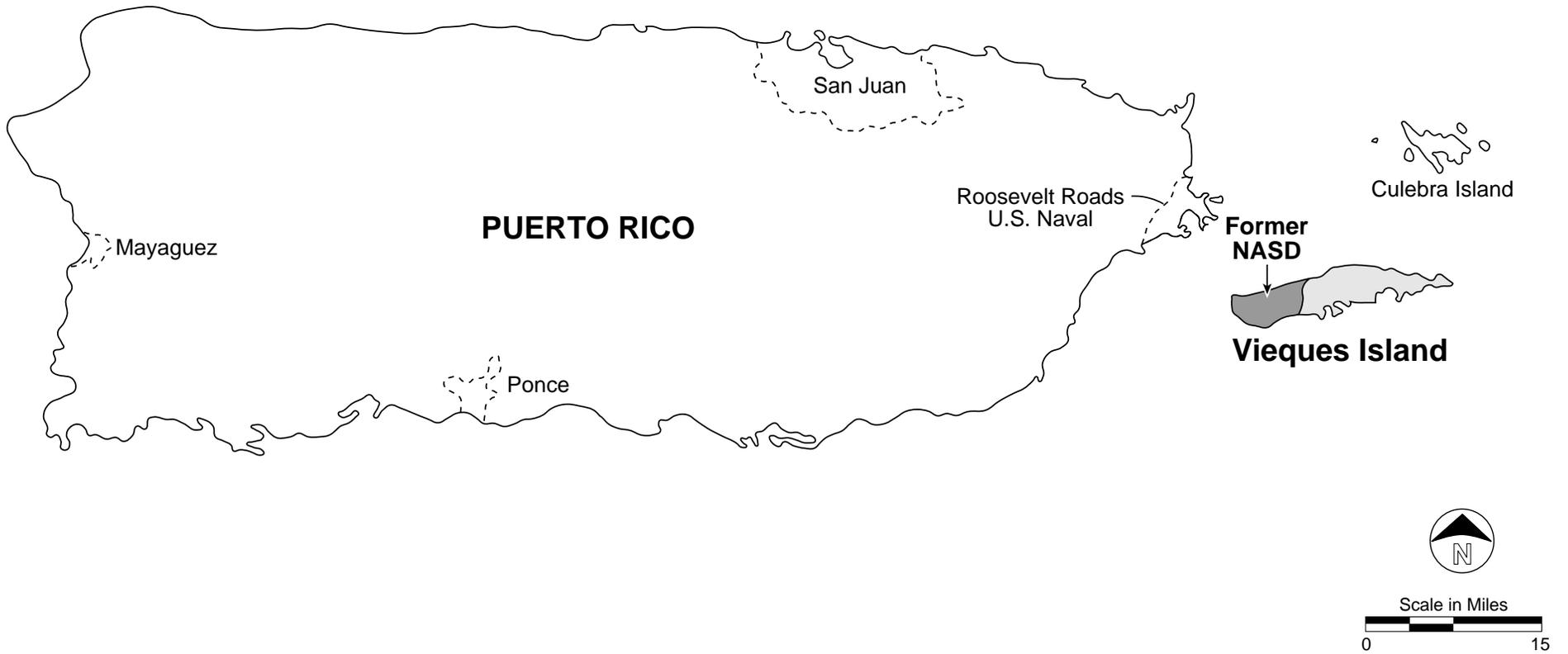
AOC J was originally identified as a potential release location and addressed under the EBS (ERM, 2000) and in the Expanded PA/SI report (CH2M HILL, 2000d). EPA Region 2 has reviewed the Expanded PA/SI and has provided comments on both reports. These comments were incorporated in the RI Work Plan and included recommendations for additional sampling of soils, groundwater, and sediments. 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 AOC J. Additional data were collected during 2003 as part of this RI to further characterize the site and define the nature and extent of contamination in site media.

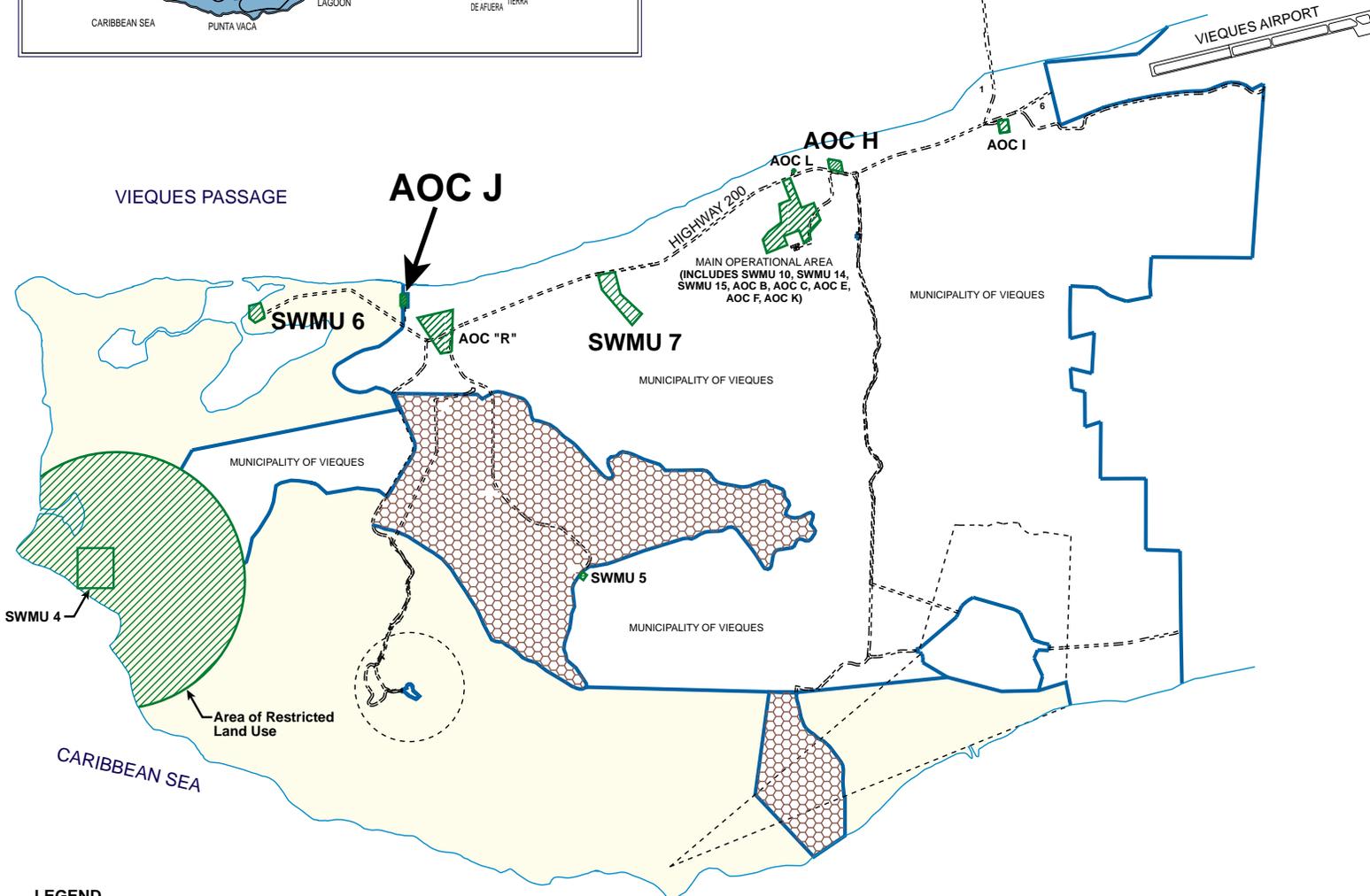
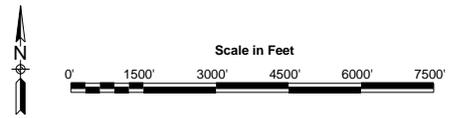
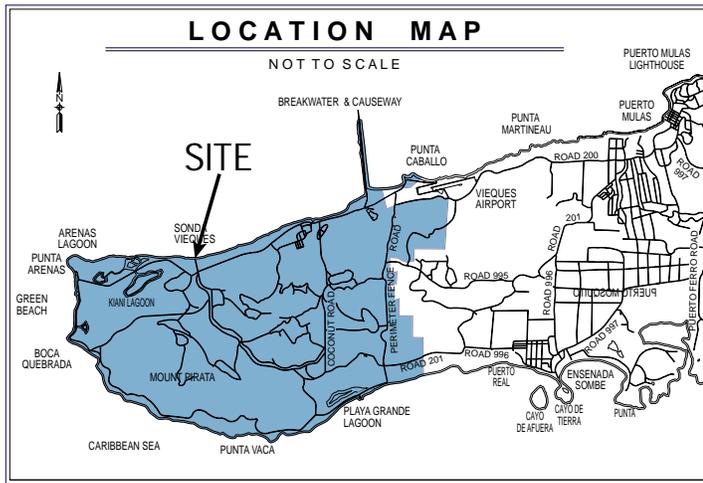
**TABLE 2-1**

Previous Sampling/Investigations at AOC J as Reported in Expanded PA/SI Report  
AOC J, Former NASD, Vieques, Puerto Rico

<b>Event/Activity</b>	<b>Samples</b>	<b>Purpose</b>	<b>Findings</b>
Environmental Baseline Survey (EBS) by ERM (2000)	Two subsurface soil samples from 3 to 4 feet bls, using a backhoe	To determine presence of wastes from past operations	No detections of any of the full scan analysis results above criteria.
Ecological Survey	Plant and animal survey	Characterize ecology, identify any federally protected species present, conduct qualitative impact analysis	Two specimens of <i>stahlia monosperma</i> were identified in 2005
MEC Avoidance Survey	Magnetometer assisted surface sweep	Ensure no MEC is present at the site	No UXO/OE items were found; however, empty shell casings were found.
Expanded PA/SI Sampling	4 new monitoring wells 5 surface soil 5 subsurface soil 5 surface water 5 sediment	Determine if RI/FS is required or NFA	Groundwater had metals and perchlorate above criteria.  Metals in surface soils and surface water were above criteria.  No chemicals above criteria in subsurface soils.



**FIGURE 2-1**  
**Regional Location Map**  
*Vieques, Puerto Rico* **CH2MHILL**



**LEGEND**

- PROPERTY LINE
- EASEMENT LINE
- APPROXIMATE EDGE OF WATER
- UNITED STATES GOVERNMENT DEPARTMENT OF THE INTERIOR
- PUERTO RICO CONSERVATION TRUST
- AREA OF RESTRICTED LAND USE AT SWMUs AND AOCs

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

**Figure 2-2**  
**AOC J and Other IR Sites Location Map**  
 Former NASD, West Vieques Island, Puerto Rico **CH2MHILL**



**Legend**

 Access Restriction Boundary

Source: 1994 Aerial Photograph

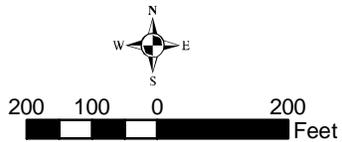
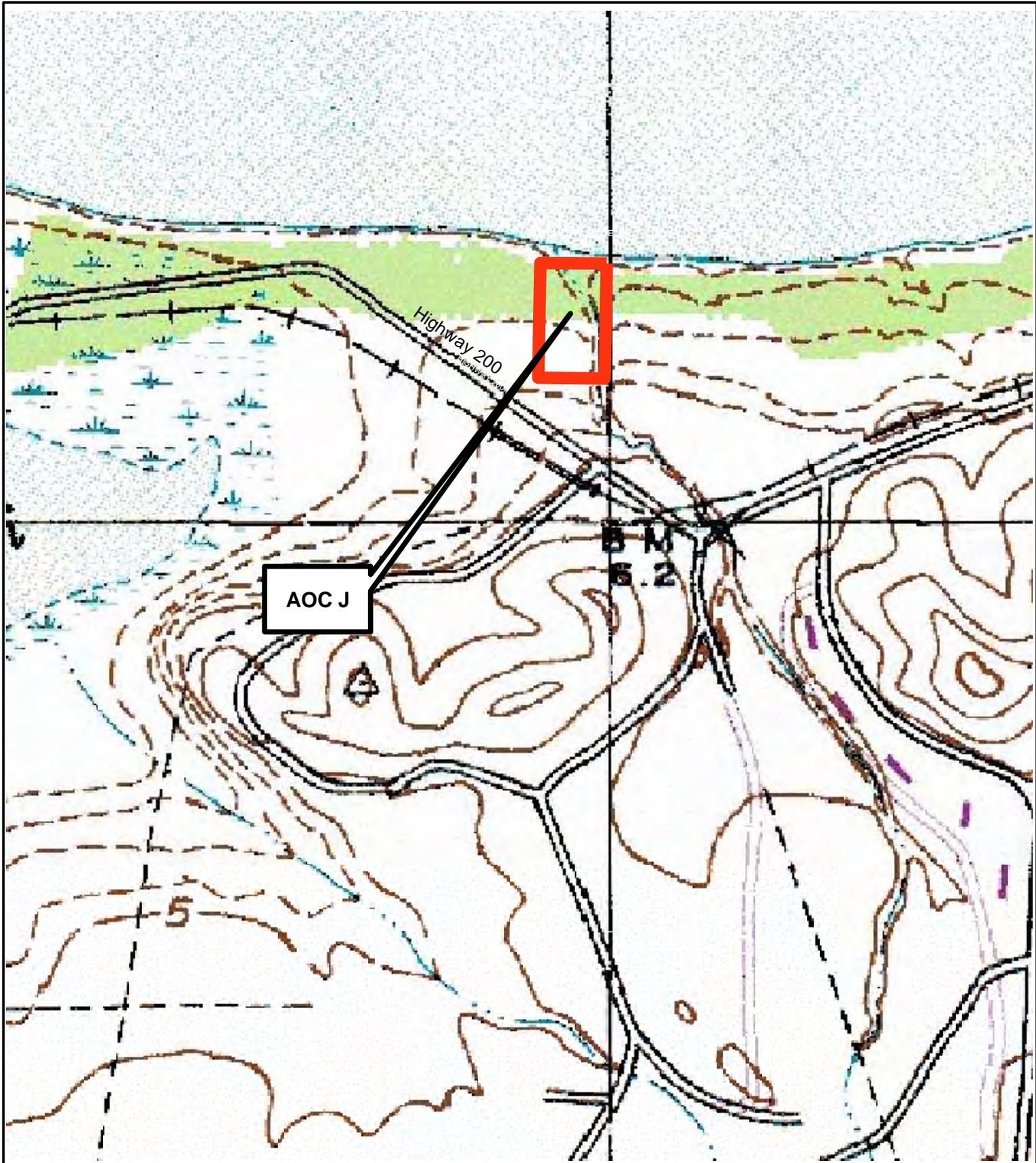


Figure 2-3  
Aerial Photograph  
AOC J, Former NASD, Vieques, Puerto Rico

**CH2MHILL**



## Legend

 Access Restriction Boundary

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



190 0 190 Feet

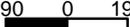
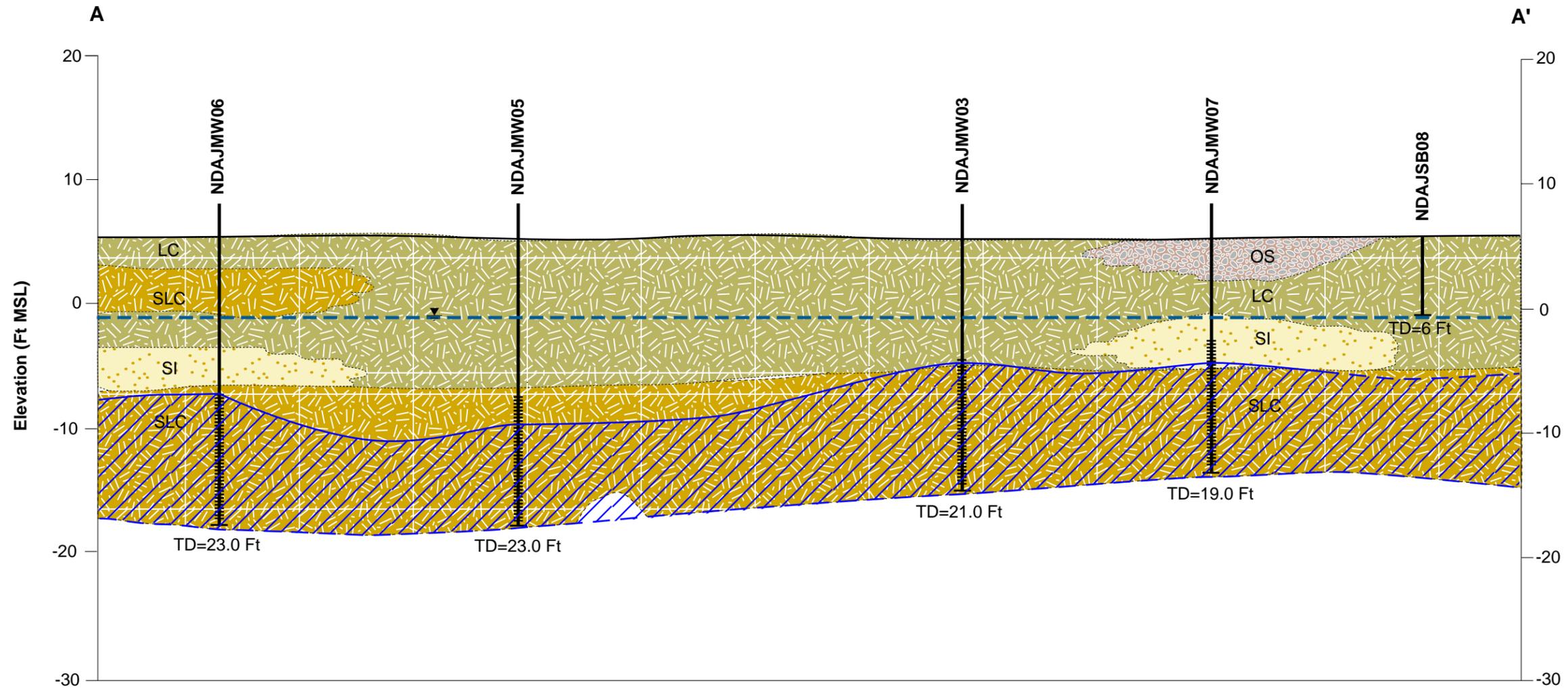
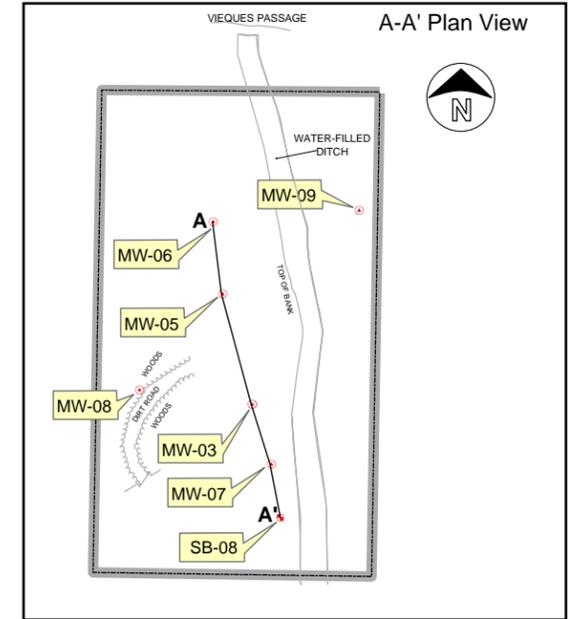
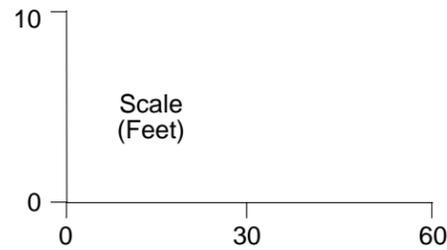
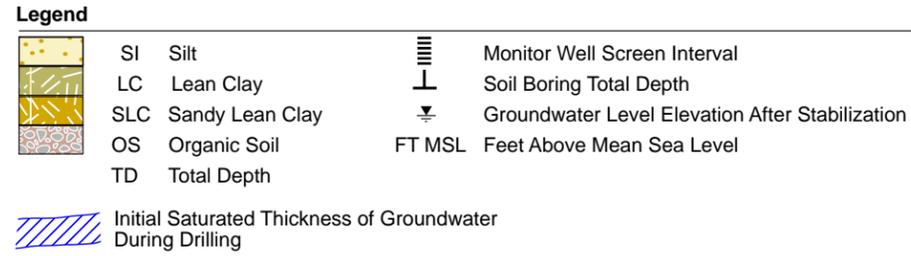


Figure 2-4  
AOC J Topographic Location Map  
Former NASD, Vieques, Puerto Rico

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

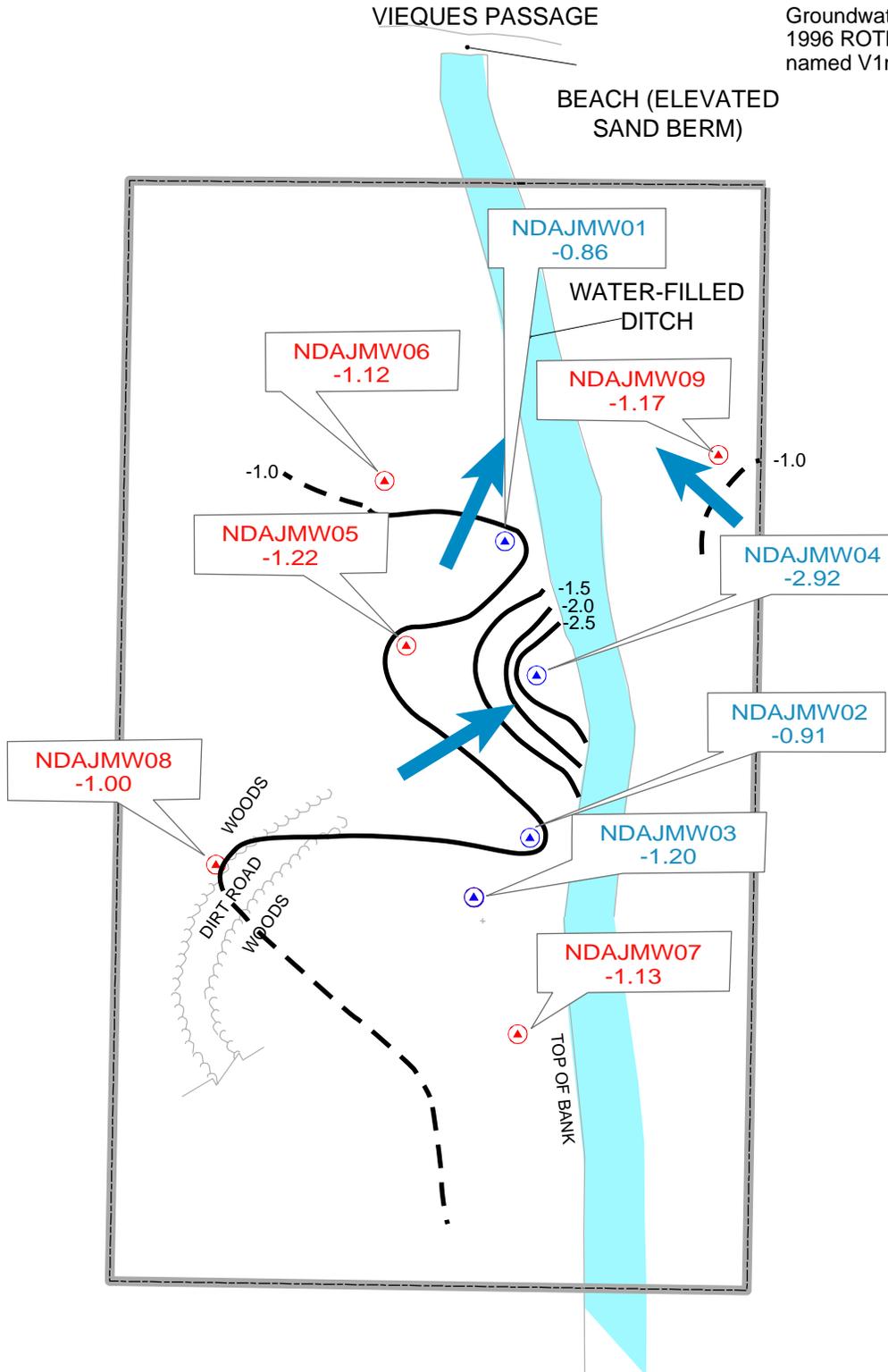


**FIGURE 2-5**  
 Geologic Cross-Section A-A'  
 AOC-J (Former Staging and Disposal Site),  
 Former NASD, Vieques, Puerto Rico



**Legend**

- Monitoring Wells
- Previously Installed Monitoring Wells
- Estimated Groundwater Contour
- 1.5 Groundwater Contours are 0.5' Interval
- Direction of Groundwater Flow
- Groundwater Elevations in ft MSL
- Water Level Readings Taken on 9/9/03
- Groundwater Elevations are based on the 1996 ROTHR concrete monument benchmark named V1mon



**FIGURE 2-6**  
Groundwater Flow Map  
AOC J, Former NASD, Vieques, Puerto Rico

# Summary of Field Investigations

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The RI field investigation at AOC J included monitoring well installation and sampling, surface and subsurface soil sampling, surface water and sediment sampling, an MEC avoidance survey, groundwater elevation monitoring and surveying, and a geophysical study to delineate waste boundaries. The field investigation was conducted at AOC J from June 10, 2003, through October 2, 2003.

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 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.

## 3.1 MEC Avoidance Results

An MEC avoidance survey was conducted by USA Environmental Inc. to ensure that all surface and subsurface sampling locations and well drilling locations within AOC J were clear of any munitions items. 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. A sweep for MEC, formerly called unexploded ordnance (UXO), 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 to identify any metal objects. USA Environmental also conducted a visual sweep of the waste area and did not find any MEC. Two empty 106 mm shell casings, one flash tube, one 106 mm cartridge base, and six cartridge canisters were observed in a waste pile onsite during the Expanded PA/SI. During the RI, one empty 106 mm casing was found. The MEC avoidance survey report is presented in Appendix A.

## 3.2 Soil Sampling

### 3.2.1 OVM Soil Screening

Soil samples were collected and screened in accordance with 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).

### 3.2.2 Surface and Subsurface Soil Samples and Analysis

Five surface soil samples (NDAJSS06, NDAJSS07, NDAJSS08, NDAJSS09, and NDAJSS10) were collected to characterize the soils adjacent to four of the debris piles located at the south end of the site. The locations of the surface soil samples are shown in Figure 3-1, and

Table 3-1 provides sample coordinates. Five soil borings advanced to a depth of 6 feet bls were installed adjacent to the debris piles. Five subsurface soil samples were collected from these borings (NDAJSB06 through NDAJSB10). This effort resulted in a total of 10 new soil samples (5 surface and 5 subsurface) as shown in Table 3-2. Figures 3-1 and 3-2 present the locations of surface and subsurface soil sample locations, respectively. 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.

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. Table 3-2 includes the number of samples and the parameters for the soil samples.

Subsurface soil samples were collected using a split-spoon sampler with an auger drilling rig. A hole was advanced to a depth of 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 2-inch-diameter split spoon was driven from 4 to 6 feet bls. 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 and between sites 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**

Five new monitoring wells were installed in addition to the four already on the site. The rationale for the well location selection was as follows:

- NDAJMW05 was installed east and downgradient of a metal scrap pile discovered during brush clearing activities to assess whether contaminants are migrating to the east

of the ephemeral stream and to better define the direction of groundwater flow along the ephemeral stream.

- NDAJMW06 was located approximately 80 feet northwest of NDAJMW01, near the northern edge of the interpreted waste boundary.
- NDAJMW07 was installed just to the northeast of the debris piles at the south end of the site to assess whether there are groundwater quality impacts from these locations.
- NDAJMW08 was installed along the access road and upgradient of the site to characterize the background groundwater quality.
- NDAJMW09 was installed across the ephemeral stream on the east side of the site approximately 100 feet northeast of NDAJMW01 to assess downgradient groundwater conditions and provide information on the hydraulic gradient across the site.

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.

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.

During the drilling of the boreholes for the monitoring wells, drill cuttings were examined continuously for lithology until groundwater was encountered. The well screens were installed within the upper portion of the shallowest water-bearing zone. All wells were logged in the field during drilling. The soil boring logs and well construction diagrams are included in Appendixes B and C, respectively. Table 3-3 summarizes well construction details.

Drill cuttings generated during monitoring well installation were collected and stored on site 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 management plan for investigation-derived waste (CH2M HILL, 2000c).

Drill rigs and auger flights were decontaminated 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. The groundwater levels were measured to the nearest 0.01 foot from the top of the PVC casing. 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 using a peristaltic pump and a bailer to surge the well. Development water was discharged into 55-gallon drums.

The peristaltic pump tubing was placed at the bottom of the screen, and the well was pumped until clear water (minimal turbidity) was produced. A bailer was used intermittently throughout the developing process. The bailer was pulled 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 up to a new portion of the screen. Pumping and swabbing continued until the water was clear and free of sediment.

New tubing was used with the peristaltic pump for each monitoring well.

The bailer was decontaminated between development 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 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 AOC J on September 10, 2003. An electronic water level meter was used to measure the depth to water from the TOC of each monitoring well. Table 3-5 summarizes the results of these measurements. Figure 2-6 illustrates the results of the groundwater measurements taken at AOC J. The general groundwater flow direction in the former NASD is northerly, toward Vieques Passage. At AOC J, the groundwater flows generally in a more easterly to northeasterly direction.

### 3.3.4 Monitoring Well Sampling and Analysis

The five newly installed monitoring wells (NDAJMW05 through NDAJMW09) and four existing wells (NDAJMW01 through NDAJMW04) were sampled for total and dissolved metals, explosives, pesticides, PCBs, VOCs, SVOCs, and perchlorates to evaluate the presence of these potential constituents. The filtered samples were field-filtered prior to preservation using a 0.45-micron filter. Table 3-6 presents the number of groundwater samples collected as part of this evaluation, including QA/QC samples. The field sampling plan for the former NASD (CH2M HILL, 2001a) presents details regarding sampling, the required containers, preservatives, and holding times for groundwater and soil samples.

The wells were sampled with a peristaltic pump with Teflon® tubing and a bladder pump with Teflon® tubing. The bladder pump was used for collecting VOC samples. 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 500 ml/min or 0.14 gallon per minute (gpm). Water quality data, including temperature, specific conductance, oxidative-redox 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 on the bladder pump 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

NDAJMW08 was installed approximately 100 feet to the west 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 attributable to background conditions. The groundwater flow at AOC J is shown in Figure 2-6, which shows NDAJMW08 in an upgradient location. NDAJMW08 was sampled using the peristaltic and bladder pump.

## 3.4 Surface Water and Sediment Sampling

Three surface water sample locations from the Expanded PA/SI were resampled for SVOCs, VOCs, PCBs, explosives, perchlorate, and total and dissolved metals. These samples are designated NDAJSW01, NDAJSW03, and NDAJSW05. Two surface water samples were collected at 80-foot intervals south of NDAJSW01. Thus, NDAJSW06 is 80 feet south of NDAJSW01, and NDAJSW07 is 160 feet south of NDAJSW01. One surface water sample (NDAJSW08) was co-located with an upgradient sediment sample, as the background data point (see Figure 3-4). Surface water sample locations and elevations are shown in Table 3-7. Surface water samples were collected using a 12V Whale® pump. Water quality data, including temperature, specific conductance, ORP, dissolved oxygen, pH, salinity, and turbidity, were recorded at different depths. Water samples were collected for the parameters listed in Table 3-8. Appendix F includes surface water sampling logs. Table 3-8 presents the number of surface water samples collected as part of this evaluation, including QA/QC samples. The field sampling plan for the former NASD (CH2M HILL, 2001a) presents details regarding sampling, the required containers, preservatives, and holding times for surface water samples.

Three sediment sample locations co-located with Expanded PA/SI surface water sample locations were resampled. These samples are designated NDAJSD01, NDAJSD03, and NDAJSD05. Two sediment samples were collected at 80-foot intervals south of NDAJSD01. Thus, NDAJSD06 is 80 feet south of NDAJSD01 and NDAJSD07 is 160 feet south of NDAJSD01. Additionally, one sediment sample (NDAJSD08) was co-located with an upgradient surface water sample, as the background data point (see Figure 3-4). All sediment samples were collected using a stainless steel ponar sediment sampler. The sediment was removed from the sampling instrument 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.

Table 3-9 lists sediment sample parameters and methods and includes the number of sediment samples to be collected as part of this evaluation, including QA/QC samples. Details regarding the required containers, preservatives, and holding times for groundwater and soil samples are presented in the field sampling plan for the former NASD (CH2M HILL, 2001a).

Appendix F includes sediment sampling logs. Table 3-10 shows the coordinates of the sediment sampling locations. Figure 3-4 illustrates the location of the sediment samples within AOC J.

Sampling equipment, including the Whale pump, ponar sampler, 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

### **3.5 Background Surface Water and Sediment Sampling**

One upgradient surface water sample (NDAJSW08) was collected as the background data point. Additionally, one sediment sample (NDAJSD08) was co-located with this surface water sample.

### **3.6 Hydraulic Tidal Study**

A hydraulic tidal study was performed at AOC J on June 8 and 9, 2003, to determine if there is a tidal influence on groundwater flow at the site. Groundwater and surface water measurements were collected from NDAJMW01, NDAJMW03, NDAJMW04, and one stilling well (referred to as Stilling Well 1J) installed in the ephemeral stream that extends south to north through AOC J. Among these, NDAJMW01 is located closest to Vieques Passage at a distance of approximately 205 feet to the south, and NDAJMW03 is located farthest from Vieques Passage at a distance of approximately 395 feet to the south. NDAJMW04 is located between NDAJMW01 and NDAJMW03 in the central area of AOC J.

The stilling well is located approximately 200 feet south of Vieques Passage and adjacent to NDAJMW01. The northern access restriction boundary of the AOC J area is approximately 25 feet south of Vieques Passage. Figure 3-3 shows the locations of all monitoring wells and the stilling well within AOC J. The water elevation measured in the stilling well represents the water surface elevation in the ephemeral stream.

Groundwater and surface water levels were obtained by measuring the depth to water from a marked location on the TOC, which was surveyed to the nearest 0.01 foot msl. Time-series water-level data were obtained using an in situ data logger that provided digital water-level recordings in the three monitoring wells and the stilling well. The stilling well was installed by pushing slotted PVC pipe into the ephemeral stream sediments. The data logger transducers were then suspended inside the slotted section and secured. Water levels were recorded at approximately 10-minute intervals for a 24-hour period.

Figure 3-5 graphically shows water-level data, corrected to msl, for the three monitoring wells and the stilling well. NDAJMW01 and Stilling Well 1J are closer to the coast than NDAJMW03 and NDAJMW04 and were expected to show a tidal influence. These latter two wells, NDAJMW03 and NDAJMW04, are being slightly influenced by tides and show tidal fluctuations of approximately 0.2 foot, while the wells closer to the surface water body, Stilling Well 1J (located in the ephemeral stream) and NDAJMW01, show very little tidal influence, with a change in water level of approximately 0.04 foot.

For reference, tidal data compiled by the National Oceanic and Atmospheric Administration (NOAA) were obtained from the nearest tide gauge, which is located at the La Puntilla station, San Juan Bay, Puerto Rico. Figure 3-5 also shows water level data for the oceanic tide at the La Puntilla station. This location indicated a tidal fluctuation of up to 1.4 feet during the period of the AOC J tidal study, and this dataset shows a strong correlation in periodicity and temporal scales with NDAJMW03 and NDAJMW04.

These data indicate that groundwater at AOC J is influenced by tidal action as observed in NDAJMW03 and NDAJMW04. The tidal influence is expected to have an impact on the groundwater quality based on the rising and falling water table across the site. The tidal influence on groundwater at AOC J (0.2 foot) is minor compared to the tidal influence at SWMU 6 (0.4 foot) near Kiani Lagoon. The groundwater flow direction does not appear to be influenced by the tides. The data suggest that at high tide and low tide the groundwater generally flows to the east and northeast.

### 3.7 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 of the locations. In addition, the elevation in feet above msl was established to the nearest 0.01 foot for TOC of the monitoring wells using traditional surveying techniques and DGPS techniques for remote areas. Tables 3-1, 3-4, 3-7, and 3-10 provide the survey data. Survey data are also presented in Appendix G.

## 3.8 Geophysical Survey

NAEVA Geophysics Inc. was contracted to conduct a geophysical investigation at AOC J to delineate the lateral extent of buried 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, with data collection also occurring 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 AOC J.

The results of the geophysical investigation showed a strong influence from the area's relatively shallow, saline water table. A strong response corresponds to an area of surface debris that extends away from the northwest boundary and seems to extend beyond the survey area. Nothing in the data collected on the transect lines, however, indicates that subsurface debris extends beyond the western bank of the ephemeral stream. The geophysical survey documentation is presented in Appendix H.

**TABLE 3-1**  
Surface Soil and Soil Boring Locations and Elevations  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Northing	Easting	Elevation (ft amsl)
NDAJSS06	2005146.7755	229999.9001	2.296
NDAJSS07	2005129.6690	230004.9475	2.289
NDAJSS08	2005113.0237	230003.8939	2.326
NDAJSS09	2005186.1093	229980.0231	1.511
NDAJSS10	2005195.3238	229971.3230	1.324

Note: amsl = above mean sea level

**TABLE 3-2**  
Surface and Subsurface Soil Sample Parameters, Methods, and Quantities  
AOC J, Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples	Equipment Blanks	Field Blanks	Field Duplicates	Matrix Spike/ Duplicate	Total Number of Samples
SVOCs	8270C	10	1	1	1	2	15
VOCs	8260B	10	1	1	1	2	15
PCBs	8082	10	1	1	1	2	15
Pesticides	8081A	10	1	1	1	2	15
Metals	6010B	10	1	1	1	2	15
Explosives	8330	10	1	1	1	2	15
Perchlorate	314.0	10	1	1	1	2	15

Equipment blanks – one per matrix per day; blank for filtered samples is a filtration blank

Field Blanks – one per lot of equipment rinsate blank (ERB) source water

Field Duplicates – one per every 10 samples per matrix/medium or per batch, whichever is more frequent

Matrix Spike/Matrix Spike Duplicates – one per 20 samples per matrix or batch, whichever is more frequent

**TABLE 3-3**  
Monitoring Well Depths and Screen Intervals  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Date Installed	Boring Depth (ft bls)	Well Depth (ft bls)	Screen Interval Depth (ft bls)	Depth to Bentonite (ft bls)	Depth to Sandpack (ft bls)
NDAJMW05	08/16/03	23.0	23.0	12.0 – 22.0	9.0	10.0
NDAJMW06	08/16/03	23.0	23.0	12.0 – 22.0	8.0	9.0
NDAJMW07	08/21/03	19.0	19.0	8.0 – 18.0	5.0	6.0

**TABLE 3-3**  
Monitoring Well Depths and Screen Intervals  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Date Installed	Boring Depth (ft bls)	Well Depth (ft bls)	Screen Interval Depth (ft bls)	Depth to Bentonite (ft bls)	Depth to Sandpack (ft bls)
NDAJMW08	08/22/03	22.0	22.0	11.0 – 21.0	3.5	8.0
NDAJMW09	08/20/03	21.0	21.0	10.0 – 20.0	4.0	8.0

**TABLE 3-4**  
Monitoring Well Locations and Top of Casing Elevation  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Northing	Easting	Elevation TOC (ft amsl)
NDAJMW05	2005187.9005	229984.5224	8.42
NDAJMW06	2005212.0613	229981.3548	7.53
NDAJMW07	2005130.8923	230000.8775	10.58
NDAJMW08	2005155.7399	229956.6115	9.44
NDAJMW09	2005215.8768	230030.2994	7.42

Note: amsl = above mean sea level

**TABLE 3-5**  
Summary of Monitoring Well Water Level Measurements  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Date	Top of PVC Elevation (ft amsl)	Depth to Water	Elevation (ft amsl)
NDAJMW01	09/10/03	4.16	5.02	-0.86
NDAJMW02	09/10/03	9.64	10.55	-0.91
NDAJMW03	09/10/03	9.88	11.08	-1.20
NDAJMW04	09/10/03	6.78	9.70	-2.92
NDAJMW05	09/10/03	8.42	9.64	-1.22
NDAJMW06	09/10/03	7.53	8.65	-1.12
NDAJMW07	09/10/03	10.58	11.71	-1.13
NDAJMW08	09/10/03	9.44	10.44	-1.00
NDAJMW09	09/10/03	7.42	8.59	-1.17

Note: amsl = above mean sea level

**TABLE 3-6**

Groundwater Sample Parameters, Methods, and Quantities  
AOC J, Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples	Equipment Blanks	Field Blanks	Field Duplicates	Matrix Spike/Duplicate	Total Number of Samples
Total Metals	6010B	9	1	1	1	2	14
Dissolved Metals	6010B	9	1	1	1	2	14
Explosives	8330	9	1	1	1	2	14
Pesticides	8081A	9	1	1	1	2	14
PCBs	8082	9	1	1	1	2	14
VOCs	8260B	9	1	1	1	2	14
SVOCs	8270C	9	1	1	1	2	14
Perchlorate	314.0	9	1	1	1	2	14

Equipment blanks – one per day

Field Blanks – one per lot of ERB source water

Field Duplicates – one per every 10 samples per matrix/medium or per batch, whichever is more frequent

Matrix Spike/Matrix Spike Duplicates – one per 20 samples per matrix or batch, whichever is more frequent

**TABLE 3-7**

Surface Water Locations and Elevations  
AOC J, Former NASD, Vieques, Puerto Rico

Sample #	Northing	Easting	Elevation (ft amsl)
NDAJSW06	2005139.1232	230012.0409	-0.268
NDAJSW07	2005114.2501	230016.0917	-0.268
NDAJSW08	2005073.7458	230014.8352	-0.268

Note: amsl = above mean sea level

**TABLE 3-8**

Surface Water Sample Parameters, Methods, and Quantities  
AOC J, Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples*	Equipment Blanks	Field Blanks	Field Duplicates	Matrix Spike/Duplicate	Total Number of Samples
SVOCs	8270C	6	1	1	1	2	11
VOCs	8260B	6	1	1	1	2	11
PCBs	8082	6	1	1	1	2	11
Pesticides	8081A	6	1	1	1	2	11
Explosives	8330	6	1	1	1	2	11
Perchlorate	314.0	6	1	1	1	2	11
Total Metals	6010B	6	1	1	1	2	11
Dissolved Metals	6010B	6	1	1	1	2	11

Equipment blanks – one per matrix per day; blank for filtered samples is a filtration blank

Field Blanks – one per lot of ERB source water

Field Duplicates – one per every 10 samples per matrix/medium or per batch, whichever is more frequent

Matrix Spike/Matrix Spike Duplicates – one per 20 samples per matrix or batch, whichever is more frequent

**TABLE 3-9**  
Sediment Sample Parameters, Methods, and Quantities  
AOC J, Former NASD, Vieques, Puerto Rico

Parameter	Method	No. of Samples	Equipment Blanks	Field Blanks	Field Duplicates	Matrix Spike/ Duplicate	Total Number of Samples
SVOCs	8270C	6	1	1	1	2	11
VOCs	8260B	6	1	1	1	2	11
PCBs	8082	6	1	1	1	2	11
Pesticides	8081A	6	1	1	1	2	11
Explosives	8330	6	1	1	1	2	11
Perchlorate	314.0	6	1	1	1	2	11
Total Metals	6010B	6	1	1	1	2	11

Equipment blanks – one per matrix per day; blank for filtered samples is a filtration blank

Field Blanks – one per matrix per day

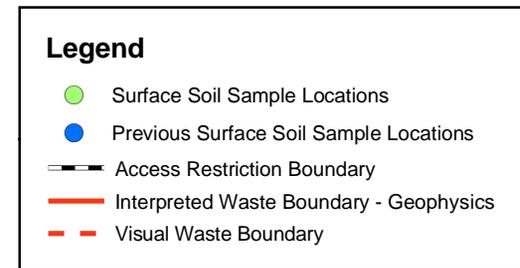
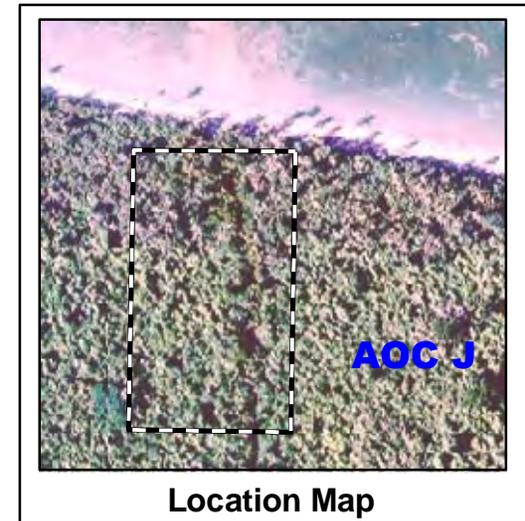
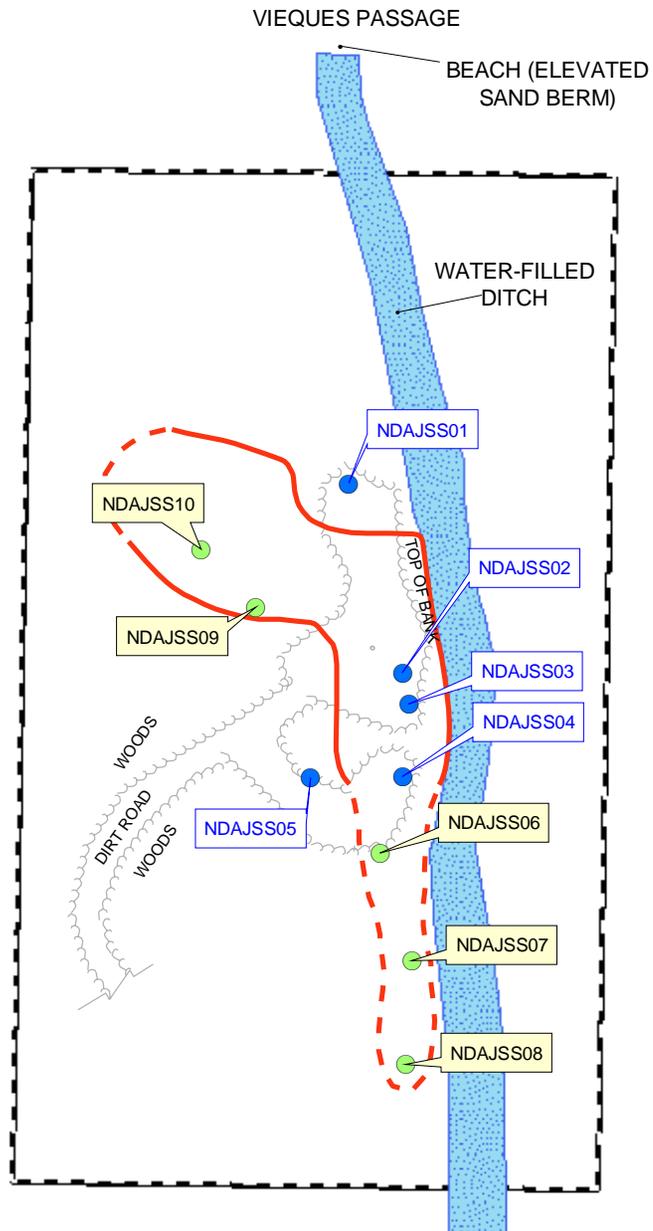
Field Duplicates – one per every 10 samples per matrix/medium

Matrix Spike/Matrix Spike Duplicates – one per 20 samples per matrix

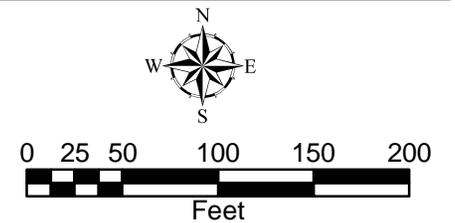
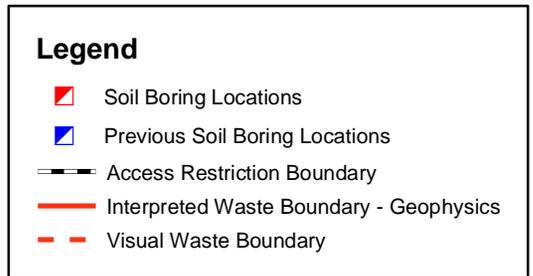
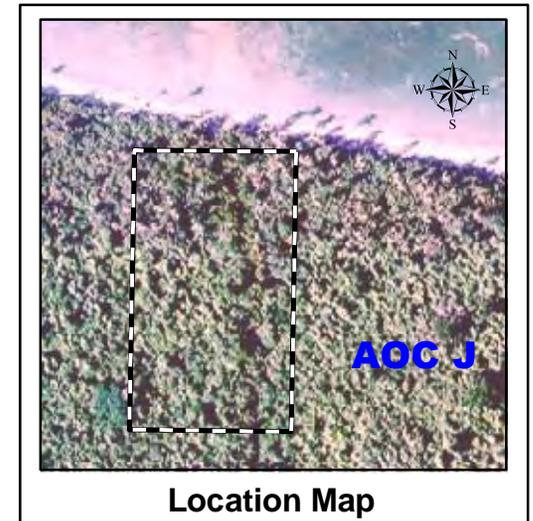
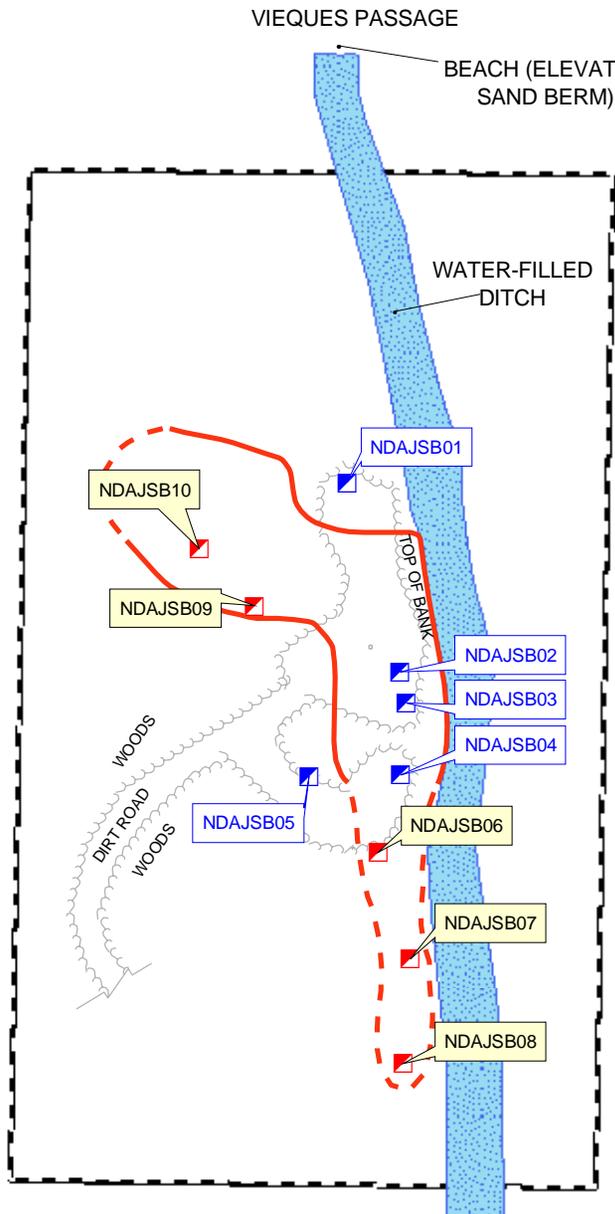
**TABLE 3-10**  
Sediment Sampling Locations and Elevations  
AOC J, Former NASD, Vieques, Puerto Rico

Well ID	Northing	Easting	Elevation (ft amsl)
NDAJSD06	2005139.1232	230012.0409	-0.879
NDAJSD07	2005114.2501	230016.0917	-0.879
NDAJSD08	2005073.7458	230014.8352	-0.879

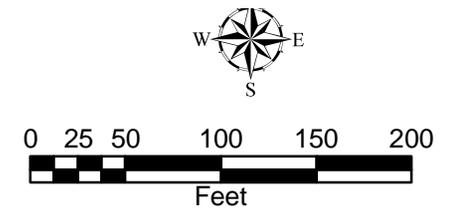
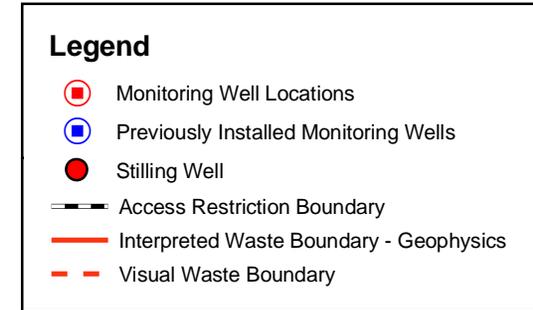
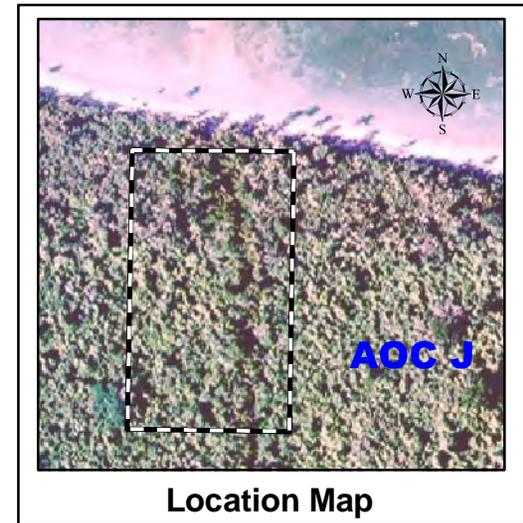
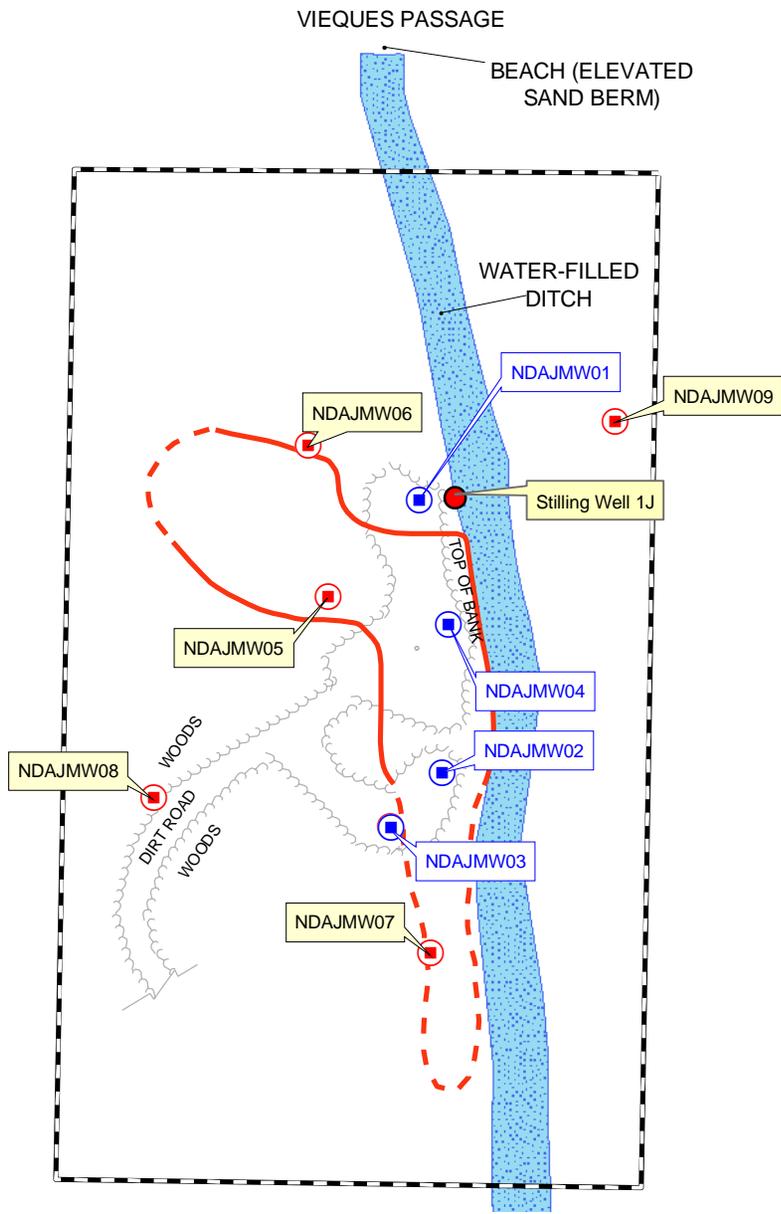
Note: amsl = above mean sea level



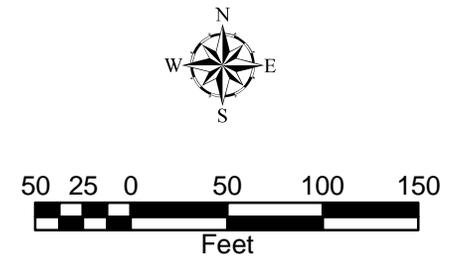
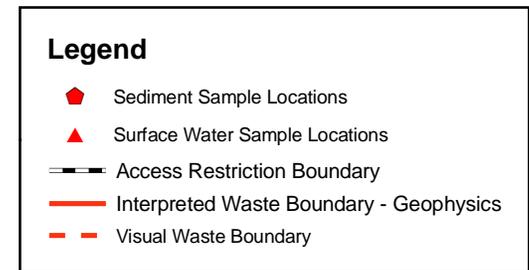
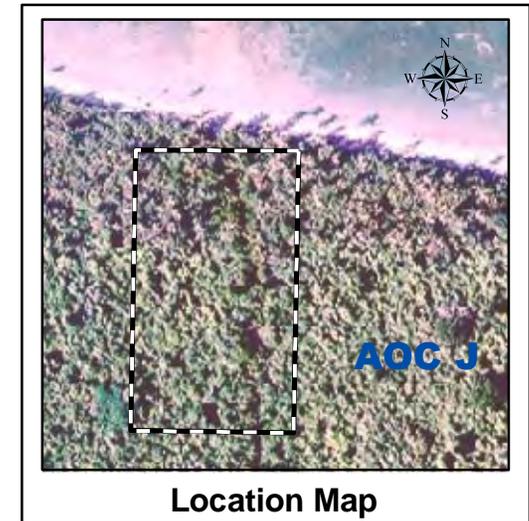
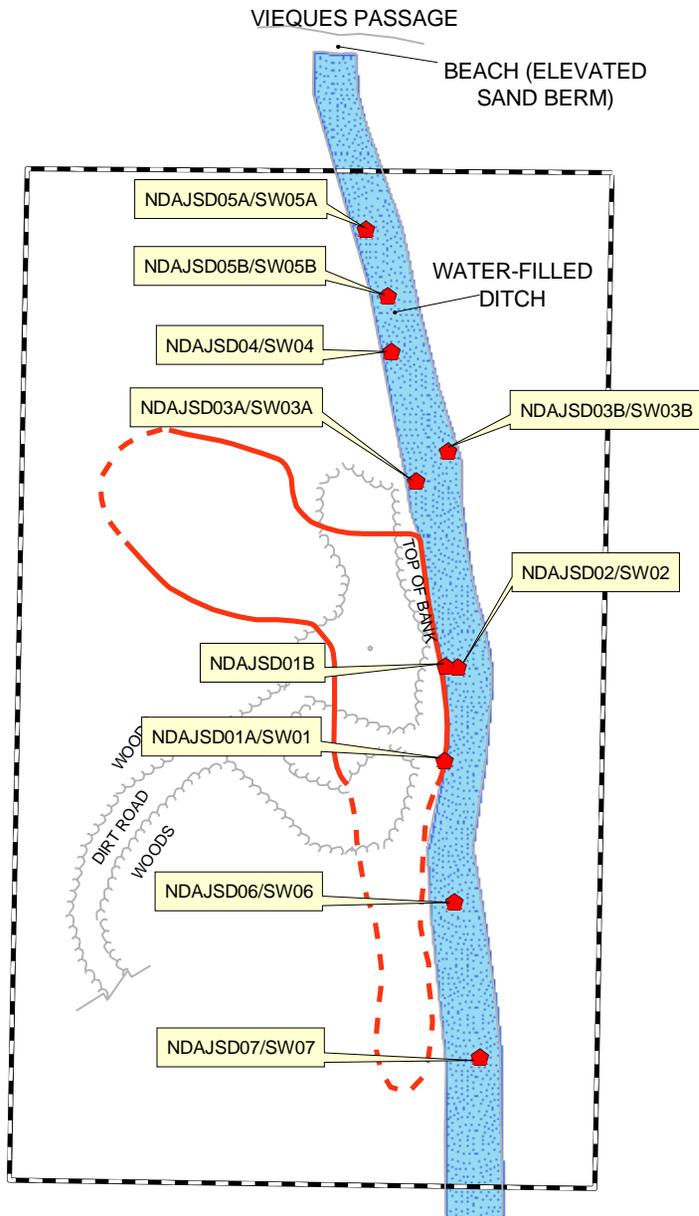
**Figure 3-1**  
**Remedial Investigation Surface Soil Location Map**  
*AOC J, Former NASD, Vieques, Puerto Rico*



**Figure 3-2**  
**Remedial Investigation Soil Boring Location Map**  
 AOC J, Former NASD, Vieques, Puerto Rico



**Figure 3-3**  
**Remedial Investigation Monitoring Well Location Map**  
*AOC J, Former NASD, Vieques, Puerto Rico*



**Figure 3-4**  
**Remedial Investigation Sediment and Surface Water Location Map**  
*AOC J, Former NASD, Vieques, Puerto Rico*

## SECTION 4

# Nature and Extent of Contamination

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This section presents a discussion of the nature and extent of contamination found in the soil, groundwater, surface water, and sediment at AOC J during the RI. The discussion of AOC J 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. Section 4.2 presents a discussion of the results of the sampling activities for each medium at the site. The discussion of AOC J addresses surface soil, subsurface soil, groundwater, surface water, and sediment. The background results for soil, groundwater, surface water, and sediment are also presented and discussed (CH2M HILL, 2002b).

In addition to 2003 RI data, the Expanded PA/SI data collected in 2000 are also presented and discussed in this section to characterize more completely the nature and extent of contamination at the site.

A detailed discussion of sampling procedures and other RI activities is presented in Section 3.

It should be noted that the description of the nature and extent of contamination at AOC J 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, is 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 Analytical Results Data Quality Evaluation Summary and Conclusions

The analytical data for AOC J were collected in two investigations. The Expanded PA/SI was performed in December 2000 through January 2001, and the report was finalized in February 2001. The RI was executed from August through October 2003. Details of the data quality evaluation (DQE) are presented in Appendix J.

The Expanded PA/SI and the RI data were validated by independent contractors Heartland Environmental Services Inc. and Environmental Data Services, respectively, in accordance with EPA Region 2 *Functional Guidelines for Data Review Standard Operating Procedures*. Following this guidance, the DQE included evaluation of the laboratory performance and

possible impact on the usability of data due to matrix interferences. The DQE focused on the usability of the data to support project data interpretation and the decision-making process.

The completeness for these data was calculated to be 98.7 percent (11,080/11,225 total records). The 145 records were rejected due to:

- 52 volatile results for low relative response factors
- low recoveries of the laboratory control standard (LCS) that resulted in rejection of 86 nondetect records
- 7 zinc records for high concentrations of zinc detected in the equipment blank
- 112 records for surrogate recoveries less than 10 percent; in every case, a valid value remained for each sample and target compound from a re-extracted sample; therefore, these 112 rejected results have no effect on the overall dataset.

Ambient, equipment, and trip blanks were collected during the field efforts. According to the EPA functional guidelines, concentrations of common organic lab contaminants detected in samples at less than 10 times the concentration associated with blanks can be attributed to field sampling and laboratory contamination rather than environmental contamination from site activities. For other inorganic and organic chemicals, five times the concentration detected in the associated blanks is used to qualify results as potential field/laboratory contamination.

Data qualified due to blank contamination consisted of 45 records including volatile contaminants acetone, methylene chloride, and toluene. The ubiquitous phthalates from the semivolatile fraction were also present in blanks and elicited qualification for diethyl phthalate.

Data summary tables are presented in Appendix I and the DQE in Appendix J.

#### 4.1.2 Data Tracking and Validation

The management and tracking of data form 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. 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 Work Plan (CH2M HILL, 2003b) to determine whether all designated samples were collected and submitted for the appropriate analytical methodologies. 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 target analytes. Field-specified quality control samples annotated on the chain-of-custody documentation 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. Complete analytical reports are provided in Appendix I and DQE results in Appendix J. 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 the data into the Environmental Data Management System (EDMS) database. Validation procedures established by the National Functional Guidelines for organic analyses (EPA, 1999a) and inorganic analyses (EPA, 2002a) as modified by Region 2 were followed during the validation process.

Overall conclusions of the data quality are that the laboratory analyzed the samples according to the EPA methods stated in the work plan. The project objectives were met, and the data can be used in the project for site characterization, risk assessment, and the ultimate site decision making as qualified by the data quality evaluation process (Appendix J).

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 be used in the appropriate context of their qualified detections. The following primary flags were used to qualify the data:

- “U” indicates that the analyte was not detected, and the associated number indicates the approximate sample concentration necessary for detection.
- “UJ” indicates that the analyte was not detected and the quantitation limit is not precise.
- “J” indicates 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.
- “=” indicates that the analyte is present. The reported value is the measured concentration.
- “R” indicates 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. These data are not used during site characterization.

### 4.1.3 Evaluation of Non-Site-Related Analytical Results

Many of the organic and inorganic constituents detected in soil and groundwater at AOC J 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.

#### 4.1.3.1 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. Exhibit 1 of Appendix J includes a list of various blanks included per matrix for AOC J. Types of blank samples included:

- **Trip Blank:** A trip blank (TB) 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. A minimum of one TB was included in each sample cooler that contains samples for VOC analysis.

- **Equipment Rinse Blank:** An equipment rinse 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. A minimum of one ERB was collected per day of sampling, per type of sampling equipment.
- **Field Blank or Ambient Blank:** The field blank (FB) is an aliquot of the water used for equipment decontamination. This blank monitors contamination that may be introduced from the water used for decontamination. A minimum of one FB was 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 is prepared and analyzed for every 20 samples or per analytical batch, whichever is more frequent.

Chemicals detected in the blanks indicate that detection of these chemicals in the site samples may not be associated with the site. According to the EPA guidance on Contract Laboratory Program (CLP) National Functional Guidelines (NFG) for organic data review (EPA, 1999a) and inorganic data review (EPA, 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, five 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, indicating false positive occurs when the value reported is dismissed as a biased high, or false positive. Detection of perchlorate in water samples is one such example.

Perchlorate was analyzed using EPA analytical method 314.0. This method is recommended by EPA only for groundwater analysis for drinking water systems, and the results are reliable at concentrations greater than 4 µg/L. This method is unreliable for other matrixes such as soils and for 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 quantified 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.

Phthalates are used as plasticizers and are common laboratory and field contaminants. The most common is bis(2-ethylhexyl) phthalate (BEHP) and diethyl phthalate. 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.

Appendix J contains a detailed listing of the various blank data identified during the DQE. Exhibit 4 of the Appendix J includes the chemicals detected in the blanks per medium. The common laboratory contaminants detected in the blank samples by medium are listed here. Surface soil blanks data had acetone (10.8 to 19.4 µg/kg), the subsurface soil blanks had acetone (11.6 to 42 µg/kg), diethyl phthalate (96 to 652 µg/kg), methylene chloride (0.6 to 1.2 µg/kg), and toluene (0.77 µg/kg) sediment samples had toluene (0.35 to 1.5 µg/kg), and zinc (7.3 to 12.8 mg/kg), groundwater had toluene (0.5 to 1.3 µg/L), and surface water had acetone (2.9 to 3.9 µg/L), and toluene (0.29 to 0.68 µg/L). Any detection of the above-listed chemicals in the site samples should exceed at least 10 times the above-listed concentrations in order for them to be considered specific to the site. Other organic chemicals are often seen as field contaminants from equipment decontamination solvents such as methanol and isopropanol.

#### 4.1.3.2 Background Conditions

Environmental media samples were collected and analyzed to evaluate background, or native 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.

Site-specific background samples were collected for groundwater, surface water, and sediment at AOC J. Background concentrations were determined from upgradient sample locations. 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 AOC J.

Salinity measurements for groundwater samples collected during the Expanded PA/SI indicated that the groundwater at AOC J is brackish to saline, with salinity readings ranging from 11.6 parts per thousand (ppt) in well NDAJMW03 to 37.3 ppt in well NDAJMW01. By comparison, the salinity of seawater generally ranges from 32 to 37 ppt. These salinity readings are not unexpected given the site's low elevation and proximity to Vieques Passage and indicate that groundwater is impacted by and intermixed with saltwater. The high salinity renders the groundwater at AOC J unsuitable for potable water use without desalinization.

#### 4.1.4 Regulatory, Health-Based, and Ecological Screening Levels

The nature and extent of contamination is defined at AOC J based on detected chemicals exceeding conservative screening criteria. All the detected chemicals were screened for COPC selection in HHRA and ERA sections independently of this Section 4. The COPC screening process used for the nature and extent definition is described below. Analytical results for all media were compared against common regulatory, human health-based, and ecological standards or criteria. The screening type are identified below, according to each medium.

- Surface soil results were compared to the EPA (2002) Region 9 residential risk-based concentrations, which are the PRGs adjusted to a hazard index (HI) of 0.1 for non-carcinogenic chemicals; the EPA (2002) Region 9 leachability criteria for soil (Soil Screening Level [SSL] based on a dilution attenuation factor [DAF] of 10; 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 soil and litter invertebrates and heterotrophic process* (Efroymson et al., 1997a) or *Toxicological benchmarks for screening contaminants of potential concern for effects on terrestrial plants*, (Efroymson et al., 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; CCME, 1996), Dutch Soil Quality Standards (MHSPE, 1994), and U.S. Fish and Wildlife Service 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 = 10]).
- Groundwater results were compared to EPA Region 9 tap-water PRGs, adjusted to an HI of 0.1.
- Surface water results were compared to the lower of either the EPA National Recommended Water Quality Criteria (EPA, 2002) or the PREQB Water Quality Standards.
- Sediment results were compared to screening values selected from one of two reference sources: *Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments* (Long et al., 1995) and 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 levels follow.

- Region 9 Preliminary Remediation Goals (PRGs) for Residential Surface Soil, Tapwater, and Soil Screening Levels (October 2002) - The criteria presented in the Region 9 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 are

developed using protective default exposure scenarios recommended by EPA (1991a,b) 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 7 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.

- Toxicological benchmarks for screening contaminants of potential concern 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 Agency (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 U.S. Fish and Wildlife Service (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*, Canadian Council of Ministers of the Environment (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, 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.

### 4.1.5 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, surface water, and sediment) at AOC J. The data are presented in two ways. Tables are presented that list detected concentrations for each parameter for each group of samples and exceedances above various comparison criteria. Tables are also provided that summarize the maximum and minimum concentrations, along with the detection frequency, for each group of samples. 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 AOC J. 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. Site-specific background samples were collected for groundwater (NDAJMW08), surface water (NDAJSW08), and sediment (NDAJSD08) at AOC J. The results from these site-specific background samples are presented in this section.

#### 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 AOC J, one monitoring well (NDAJMW08) 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 Surface Water**

Background surface water concentrations were determined on a site-specific basis. At AOC J, one surface water sample was collected from NDAJSW08 and used as a site-specific background sample. A summary of the analytical results from this site-specific background sample is provided in Table 4-2.

#### **4.2.1.4 Sediment**

Background sediment concentrations were determined on a site-specific basis. One sediment sample was collected from NDAJSD08 as a site-specific background sample. A summary of the analytical results from this site-specific background sample is provided in Table 4-3.

#### **4.2.1.5 Essential Human Nutrients**

In accordance with EPA guidance, the presence of several essential human nutrients was evaluated to determine whether these constituents should be further evaluated. *Risk Assessment Guidance for Superfund: Human health Evaluation Manual 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 assess if the detected nutrient levels exceed the allowable intake levels, 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 4-4 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*, 10<sup>th</sup> Edition, National Academy of Sciences, National Research Council, Food and Nutrition Board (1989).

As can be seen in Table 4-4, daily intake of the essential nutrients calcium, magnesium, potassium, and sodium from soil consumption (based on the maximum soil concentration) generally represents a 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; therefore, these chemicals are eliminated from further evaluation in this report.

## **4.2.2 AOC J – Former Operations Area Disposal Site**

The sampling activities conducted at AOC J during the Expanded PA/SI and RI fieldwork of 2000 through 2003 consisted of surface and subsurface soil sampling; groundwater sampling from permanent wells; surface water sampling; and sediment sampling. The results of these sampling activities and the nature and extent of contamination in the soil, groundwater, surface water, and sediment are discussed in this section.

Tables 4-5 through 4-8 present the detected chemicals in surface soil, groundwater, surface water, and sediment, respectively. Summaries of chemicals detected above screening criteria are presented in Tables 4-9 through 4-12 for surface soil, groundwater, surface water, and sediment, respectively.

### **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. Five surface soil samples (0 to 6 inches bls) were collected during the 2000 Expanded PA/SI. The soil samples were analyzed for metals VOCs, SVOCs, pesticides, PCBs, and explosives.

Five additional surface soil samples were collected at AOC J during the RI. Surface soil samples were analyzed for metals, VOCs, SVOCs, pesticides, PCBs, explosives, and perchlorate. Table I-2 in Appendix I includes a list of all detected concentrations compared against human health and ecological protection based criteria discussed above. Table 4-5 presents a summary of the detected concentrations in each sample, where inorganic chemicals that are above criteria and the background levels and organic chemicals above criteria are included for the AOC J surface soil samples. Table 4-9 presents statistical summaries of the chemicals that exceed screening criteria. Figure 4-1 shows chemical concentrations that exceed screening criteria including background concentrations in the surface soil samples at AOC J.

#### **4.2.2.1.1 Inorganic Analytes**

A total of 23 inorganic analytes were detected in surface soil samples at AOC J (see Table I-2 in Appendix I). Six inorganic analytes were detected above screening criteria in at least one surface soil sample. Iron, manganese, and thallium exceed their respective EPA Region 9 residential PRGs (HI=0.1). Calcium, magnesium, potassium, and sodium occur at high concentration in natural environmental media, and these are also essential nutrients. As previously discussed, these essential human nutrients were not identified as COPCs in accordance with EPA Risk Assessment Guidance for Superfund (RAGS; EPA, 1989).

Iron, lead, manganese, and zinc exceeded their respective ecological screening criteria in at least one surface soil sample. These chemicals are carried through the ecological risk evaluation as presented in Section 7.

No inorganic chemicals were detected above their respective leachability criteria in surface soil. Leaching criteria were not available for 13 metals (aluminum, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, thallium, and mercury).

Figure 4-1 shows concentrations of inorganic analytes that were found above screening criteria and background concentrations in soils. Inorganic analytes that exceeded screening criteria are discussed below.

**Iron** was detected in all 10 surface soil samples at AOC J. One sample contained iron above its background concentration of 37,531 mg/kg (CH2M HILL, 2002b). All 10 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 10 surface soil samples at AOC J. Six samples contained lead above its background concentration of 6.9 mg/kg (CH2M HILL, 2002b). Lead was not detected above its residential PRG. One sample contained lead above its ecological screening criterion. An SSL was not available for lead.

**Manganese** was detected in all 10 surface soil samples at AOC J. Two samples contained manganese above its background concentration of 1,167 mg/kg (CH2M HILL, 2002b). All 10 samples contained manganese at concentrations that exceed its residential PRG and its ecological screening criterion. An SSL was not available for manganese.

**Thallium** was detected in 8 of 10 surface soil samples at AOC J. Two samples contained thallium above its background concentration of 0.67 mg/kg (CH2M HILL, 2002b). Seven samples contained thallium at concentrations that exceed its residential PRG. Thallium was not detected above its ecological screening criterion. An SSL was not available for thallium.

**Zinc** was detected in all 10 surface soil samples at AOC J. Three 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 AOC J. Zinc was detected above its ecological screening criterion in three samples.

#### 4.2.2.1.2 Pesticides

Three pesticides were detected in three surface soil sample locations. None were found at concentrations above their respective residential PRGs, ecological screening criteria, or SSLs (see Table I-2 in Appendix I).

#### 4.2.2.1.3 Semivolatile Organic Compounds

Three SVOCs were detected in 3 of the 10 surface soil samples. The detected SVOCs consisted of two PAHs, benzo(b)fluoranthene and benzo(k)fluoranthene, and bis(2-ethylhexyl)phthalate (see Table I-2 in Appendix I). None of the detected SVOCs exceeded their respective residential PRGs, ecological screening criteria, or SSLs.

#### 4.2.2.1.4 Volatile Organic Compounds

VOCs were detected in 8 of the 10 samples collected during the RI. Five VOCs (acetone, carbon disulfide, 2-hexanone, methylene chloride, and 1,1,2,2-tetrachloroethane) were

detected in the surface soil during the RI (see Table I-2 in Appendix I). VOCs were not detected above health-based screening criteria or available SSLs. Ecological screening criteria were not available for any of the detected VOCs, and an SSL was not available for 2-hexanone.

#### **4.2.2.1.5 Perchlorate**

Perchlorate was detected in two of five surface soil samples. It was not detected above its residential PRG. Ecological and leaching criteria were not available for perchlorate. Perchlorate detection in soils was at low levels and may be a false positive detection (DoD, 2004), as previously discussed.

#### **4.2.2.2 Subsurface Soil**

Results from subsurface soil samples collected during both the 2000 Expanded PA/SI sampling event and the 2003 RI event are presented and evaluated in this subsection. Five subsurface soil samples were collected during the 2000 Expanded PA/SI. The soil samples were analyzed for metals VOCs, SVOCs, pesticides, PCBs, and explosives.

Five additional subsurface soil samples (4 to 6 feet bls) were collected at AOC J during the RI. Subsurface soil samples were analyzed for metals, VOCs, SVOCs, pesticides, PCBs, explosives, and perchlorate. Table I-2 in Appendix I includes a comparison of all the detected chemicals in each sample against the leachability criteria.

##### **4.2.2.2.1 Inorganic Analytes**

A total of 23 inorganic analytes were detected in subsurface soil samples at AOC J (see Table I-2 in Appendix I). Inorganic chemicals were not detected above available SSLs in subsurface soil. Leaching criteria were not available for 12 metals from EPA (aluminum, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, thallium). None of the detected inorganic chemicals exceeded the screening criteria; thus a table of exceedances was not included in the text.

##### **4.2.2.2.2 Perchlorate**

Perchlorate was not detected in subsurface soil at AOC J.

##### **4.2.2.2.3 Pesticides**

No pesticides were detected in subsurface soil at AOC J.

##### **4.2.2.2.4 Semivolatile Organic Compounds**

One SVOC (di-n-butyl phthalate) was detected in a single subsurface soil sample. It was detected at a concentration below its SSL.

##### **4.2.2.2.5 Volatile Organic Compounds**

Five VOCs (acetone, carbon disulfide, methyl isobutyl ketone, methylene chloride, and xylenes) were detected in 4 of the 10 sample locations. Acetone and methylene chloride were also detected in the blank samples. None of the detected VOCs were detected at concentrations that exceed their respective SSLs. An SSL was not available for methyl isobutyl keytone. It was detected in one subsurface soil sample.

### 4.2.2.3 Groundwater

Four monitoring wells were installed and sampled as part of the Expanded PA/SI. The samples were analyzed for total and dissolved metals, VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate.

During the RI, samples were collected from the existing monitoring wells. Five new monitoring wells were also installed and sampled. Groundwater samples were analyzed for total and dissolved metals, SVOCs, VOCs, PCBs, pesticides, explosives, and perchlorate. One of the newly installed monitoring wells (NDAJMW08) was installed upgradient of the site as a site-specific background well. The details of this sampling are presented in Section 3. Table 4-6 presents the detected concentrations in each well that are above screening criteria, inorganic chemicals that are above background and the screening criteria, and organic chemicals above the screening criteria in AOC J groundwater samples. Table 4-10 presents the statistical summaries of chemicals that exceed their respective screening criteria. Figures 4-2 through 4-4 show the concentrations of those parameters that exceed background and applicable screening criteria.

#### 4.2.2.3.1 Inorganic Analytes

A total of 22 inorganic analytes were detected in unfiltered groundwater samples (see Table I-2 in Appendix I). Eighteen inorganic analytes were detected in filtered samples. Table 4-6 presents the chemicals detected above criteria in groundwater at AOC J. Ten metals (aluminum, arsenic, barium, cadmium, chromium, iron, lead, manganese, selenium, and vanadium) were detected above screening criteria in unfiltered samples. Nine of these metals were detected above their respective EPA Region 9 tap water PRGs in filtered samples: arsenic, barium, cadmium, chromium, iron, lead, manganese, selenium, and thallium. Figure 4-2 presents the inorganic chemicals detected above criteria in AOC J groundwater.

**Arsenic** was detected in 8 of 12 unfiltered and 2 of 12 filtered groundwater samples collected at AOC J. Detected concentrations were all above the tap-water PRG for arsenic. The unfiltered sample collected in 2000 from NDAJMW02 and the sample collected in 2003 from NDAJMW01 both contained arsenic at concentrations that exceeded screening criteria. The unfiltered sample collected in 2003 from NDAJMW02 contained arsenic above its screening criterion, but arsenic was not detected in the filtered sample. Arsenic was not detected in the filtered or unfiltered sample in 2000 from NDAJMW01.

**Barium** was detected in all 12 unfiltered and filtered groundwater samples collected at AOC J. Six unfiltered samples and five filtered samples contained barium at concentrations that exceeded the background concentrations (348 µg/L unfiltered and 344 µg/L filtered) measured in the upgradient well NDAJMW08. Nine samples (filtered and unfiltered) contained barium at concentrations that exceed its EPA Region 9 PRG.

**Cadmium** was detected in 3 of 12 unfiltered and 1 of 12 filtered groundwater samples collected at AOC J. Detected concentrations were above the tap water PRG in one unfiltered and one filtered sample. The unfiltered sample that exceeded screening criteria was collected in 2000 and the filtered sample was collected in 2003.

**Chromium** was detected in all 12 unfiltered and 6 of 12 filtered groundwater samples collected at AOC J. Ten unfiltered samples and six filtered samples contained chromium at

concentrations that exceeded the background concentrations (2.9 µg/L unfiltered and 0.696 µg/L filtered) measured in the upgradient well NDAJMW08. Five unfiltered and one filtered sample exceeded the chromium tap-water PRG.

**Iron** was detected in 9 of 12 unfiltered and 3 of 12 filtered groundwater samples collected at AOC J. Seven unfiltered samples contained iron at concentrations that exceeded its unfiltered background concentration (801 µg/L) measured in the upgradient well NDAJMW08 and its PRG. Iron was detected in one filtered sample above its PRG. Iron was not detected in the filtered background sample (83.5 U µg/L).

**Lead** was detected in 6 of 12 unfiltered and 1 of 12 filtered groundwater samples collected at AOC J. All of the detected concentrations were above the background concentration because lead was not detected in the unfiltered sample from the upgradient background sample and was detected at an estimated concentration of 2 J µg/L in the filtered sample. A tap-water PRG was not available for lead. The drinking water treatment technique action limit (TTAL) of 15 µg/L was used as a screening criterion. Four unfiltered samples exceeded the screening criterion; one filtered sample exceeded the criterion.

**Manganese** was detected in all 12 unfiltered filtered groundwater samples collected at AOC J. All 12 unfiltered and filtered samples contained manganese above its tap-water PRG of 87.6 µg/L. One unfiltered samples and one filtered sample contained manganese at concentrations that exceeded the site-specific background concentrations (24,300 µg/L unfiltered and 24,400 µg/L filtered).

**Selenium** was detected in 7 of 12 unfiltered and 6 of 12 filtered groundwater samples. All but one of the detected concentrations were above the background concentration. Selenium was not detected in the unfiltered sample from the upgradient background sample and detected at a concentration of 9.55 µg/L in the filtered sample. All but two of the detected concentrations were above the tap-water PRG of 18.2 µg/L except for the samples (filtered and unfiltered) collected from NDAJMW09.

**Thallium** was not detected in any of the unfiltered samples collected from AOC J. Thallium was detected in 2 of 12 filtered samples at reported concentrations exceeding the tap-water PRG (0.241 µg/L). Detected thallium concentrations were also above the background concentration, as thallium was not detected in the site-specific background sample collected from NDAJMW08.

#### 4.2.2.3.2 Volatile Organic Compounds

Eight VOCs were detected in the groundwater samples collected from AOC J. Four VOCs were detected above their respective EPA Region 9 PRGs: acetone, bromodichloromethane, chloroform, and trichloroethene (TCE). Table 4-6 and Figure 4-3 present the VOCs detected above screening criteria.

**Acetone** was detected in three of eight groundwater samples collected at AOC J. One sample contained acetone above its EPA Region 9 PRG of 60.8 µg/L.

**Bromodichloromethane** was detected in 1 of 12 groundwater samples collected at AOC J. The single detection was above the EPA Region 9 PRG of 0.181 µg/L.

**Chloroform** was detected in 3 of 8 groundwater samples collected at AOC J. The detected concentrations all exceeded the EPA Region 9 PRG of 0.617 µg/L.

TCE was detected in 1 of 12 groundwater samples collected at AOC J. The detection in well NDAJMW05 at 10 µg/L, was above the EPA Region 9 PRG of 0.028 µg/L. Resampling of this well in 2004 (see Appendix I) did not confirm the detection, as the VOCs were below detection limits in the resampling.

#### **4.2.2.3.3 Semivolatile Organic Compounds**

Six SVOCs were detected in the groundwater samples collected from AOC J. Only one SVOC, bis(2ethylhexyl)phthalate, was detected at a concentration that exceeded its EPA Region 9 PRG. Figure 4-4 presents the location of the bis(2ethylhexyl)phthalate above criteria.

**Bis(2ethylhexyl)phthalate** was detected in 2 of 8 groundwater samples collected at AOC J. The detected concentration exceeded the EPA Region 9 PRG of 4.8 µg/L. It is also a common laboratory contaminant as discussed above in Section 4.1.

#### **4.2.2.3.4 Pesticides**

Pesticides were not detected in any of the groundwater samples collected from AOC J.

#### **4.2.2.3.5 Polychlorinated Biphenyls**

PCBs were not detected above screening criteria in the groundwater samples collected from AOC J.

#### **4.2.2.3.6 Explosives**

Explosives were not detected in any of the groundwater samples collected from AOC J.

#### **4.2.2.3.7 Perchlorate**

Perchlorate was detected in 1 of 12 groundwater samples collected from AOC J. It was detected at an estimated concentration of 48 µg/L in a sample collected in 2000 above its EPA Region 9 PRG of 0.365 µg/L. Perchlorate was not detected in the sample collected in 2003 from the same well. 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 Surface Water**

During the Expanded PA/SI, five surface water samples were collected and analyzed for metals, VOCs, SVOCs, PCBs, pesticides, and explosives. None of the samples was filtered. During the RI, six additional surface water samples were collected and analyzed for total and dissolved (filtered) metals, VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate. Surface water samples NDAJSW01, NDAJSW03, and NDAJSW05 were collected at previously sampled locations, and the station identification numbers were the same for the 2000 and 2003 sampling efforts. One of the surface water samples (NDAJSW08) was collected as a site-specific background sample. The details of this sampling are presented in Section 3. Table I-2 in Appendix I presents all the detected chemicals in surface water compared against screening criteria. Table 4-7 presents the screening criteria, and exceedances of each chemical in AOC J surface water samples. Table 4-11 presents the statistical summaries of chemicals that exceeded their respective screening criteria. Figure 4-5 shows the chemicals above screening criteria and background in surface water at AOC J.

Analytical results from the surface water samples were compared to appropriate ecological screening criteria, and the results of the comparison are presented below.

#### 4.2.2.4.1 Inorganic Analytes

Seventeen inorganic chemicals were detected in site surface water samples (see Table 4-7). Two inorganic chemicals, barium and beryllium exceeded background and ecological screening criteria in the unfiltered samples. Screening criteria were not available for eight other inorganic chemicals.

**Barium** was detected in 9 of 10 unfiltered and all 5 filtered surface water samples at AOC J. An ecological screening criterion was not available for barium. Barium was detected in the site-specific background sample (NDAJSW08) at a concentration of 321 J µg/L in the unfiltered sample and 314 J µg/L in the filtered sample.

**Beryllium** was detected in 1 of 10 unfiltered surface water samples at a concentration of 2.25 J µg/L. The single detection was during the 2003 sampling effort and exceeded the ecological screening criteria (0.53 µg/L). It was not detected in any of the five filtered samples, including the filtered sample collected at the same location. Beryllium was not detected in the site-specific background sample (NDAJSW08, 1.89 U µg/L).

#### 4.2.2.4.2 Volatile Organic Compounds

Two VOCs, toluene and vinyl chloride, were detected in one surface water sample each. Detected concentrations did not exceed ecological screening criteria.

#### 4.2.2.4.3 Semivolatile Organic Compounds

One SVOC, bis(2-ethylhexyl)phthalate, was detected in one surface water sample collected at AOC J. The detected concentration did not exceed its ecological screening criterion.

#### 4.2.2.4.4 Polychlorinated Biphenyls

PCBs were not detected in any surface water samples collected at AOC J.

#### 4.2.2.4.5 Pesticides

Pesticides were not detected in any surface water samples collected at AOC J.

#### 4.2.2.4.6 Explosives

Explosive compounds were not detected in any surface water samples collected at AOC J.

#### 4.2.2.4.7 Perchlorate

Perchlorate was not detected in any surface water sample collected at AOC J.

#### 4.2.2.5 Sediment

During the Expanded PA/SI, five sediment samples were collected and analyzed for metals, VOCs, SVOCs, PCBs, pesticides, and explosives. During the RI, six additional sediment samples were collected and analyzed for metals, VOCs, SVOCs, PCBs, pesticides, explosives, and perchlorate. Sediment samples NDAJSD01, NDAJSD03, and NDAJSD05 were collected at previously sampled locations, and the station identification numbers were the same for the 2000 and 2003 sampling efforts. One of the sediment samples (NDAJSD08) was collected as a site-specific background sample. The details of this sampling are presented in Section 3. Table I-2 in Appendix I presents all the detected chemicals compared to screening criteria. Table 4-8 presents the organic chemicals detected above the screening criteria and inorganic chemicals above background and screening criteria in AOC J sediment samples. Table 4-12 presents the statistical summaries of chemicals that exceed their respective screening criteria. Figure 4-6 illustrates the two chemicals detected above criteria in the sediments at AOC J.

Analytical results from the sediment samples were compared to appropriate ecological screening criteria, and the results of the comparison are presented below.

#### **4.2.2.5.1 Inorganic Analytes**

Twenty-two inorganic chemicals were detected in site sediment samples (see Table I-2 in Appendix I). One inorganic chemical, barium, exceeded its ecological screening criterion. Screening criteria were not available for 12 other inorganic chemicals.

**Barium** was detected in all 10 sediment samples. Three samples contained barium at concentrations that exceed its ecological screening criterion and seven samples contained barium at concentrations that exceed its site-specific background concentration (6.76 mg/kg).

#### **4.2.2.5.2 Volatile Organic Compounds**

Three VOCs, carbon disulfide, methyl ethyl ketone, and methylene chloride, were detected in one sediment sample at AOC J. Ecological screening criteria were not available for any of the detected VOCs. Most of these VOCs were also detected in the blank samples from same SDGs (see Appendix J, Exhibit 4).

#### **4.2.2.5.3 Semivolatile Organic Compounds**

SVOCs were not detected in any sediment samples collected at AOC J.

#### **4.2.2.5.4 Polychlorinated Biphenyls**

PCBs were not detected in any sediment samples collected at AOC J.

#### **4.2.2.5.5 Pesticides**

DDD, DDE, and DDT were detected in two sediment samples collected at AOC J. DDT was detected in 1 of 10 samples at a concentration that exceeded its ecological screening criterion. These three pesticides were also detected in the background sediment sample (see Table 4-3).

#### **4.2.2.5.6 Explosives**

Explosive compounds were not detected in any sediment samples collected at AOC J.

#### **4.2.2.5.7 Perchlorate**

Perchlorate was not detected in any sediment samples collected at AOC J.

**TABLE 4-1**

Analytical Results From Background Groundwater Sample (NDAJMW08)  
 AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration			
	Total	Qualifier	Dissolved	Qualifier
<i>Metals (ug/L)</i>				
ALUMINUM	116	J	37.1	J
ANTIMONY	12.5	U	2.5	U
ARSENIC	10.2	UJ	2.04	UJ
BARIUM	348	=	344	=
BERYLLIUM	0.472	U	0.0945	U
CADMIUM	1.78	U	0.485	J
CALCIUM	736000	=	741000	=
CHROMIUM, TOTAL	2.9	J	0.696	J
COBALT	30.9	J	30.6	J
COPPER	5.85	U	1.31	J
IRON	83.5	U	801	=
LEAD	8.8	U	2	J
MAGNESIUM	545000	=	550000	=
MANGANESE	24300	=	24400	=
MERCURY	0.0162	U	0.0162	U
NICKEL	5.87	J	4.83	J
POTASSIUM	11400	J	11400	J
SELENIUM	10.5	U	9.55	=
SILVER	1.62	U	0.995	J
SODIUM	1140000	=	1140000	=
THALLIUM	12.7	U	2.54	U
VANADIUM	2.24	U	0.447	U
ZINC	2.04	U	0.409	U

Chemical	Concentration	
	Total	Qualifier
<i>Volatile Organic Compounds (ug/L)</i>		
1,1,1-TRICHLOROETHANE	0.5	U
1,1,2,2-TETRACHLOROETHANE	0.5	U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.5	U
1,1,2-TRICHLOROETHANE	0.5	U
1,1-DICHLOROETHANE	0.5	U
1,1-DICHLOROETHENE	0.5	U
1,2,3-TRICHLOROBENZENE	0.5	U
1,2,4-TRICHLOROBENZENE	0.5	U
1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.5	U
1,2-DICHLOROETHANE	0.5	U
1,2-DICHLOROPROPANE	0.5	U
1,3-DICHLOROBENZENE	0.5	U
1,4-DICHLOROBENZENE	0.5	U
2-HEXANONE	5	U
ACETONE	5.5	=
BENZENE	0.5	U
BROMOCHLOROMETHANE	0.5	U
BROMODICHLOROMETHANE	0.5	U
BROMOFORM	0.5	U
BROMOMETHANE	0.5	U
CARBON DISULFIDE	0.5	U

**TABLE 4-1**

Analytical Results From Background Groundwater Sample (NDAJMW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
CARBON TETRACHLORIDE	0.5	U
CHLORO BENZENE	0.5	U
CHLOROETHANE	0.5	U
CHLOROFORM	5.7	=
CHLOROMETHANE	0.5	U
cis-1,2-DICHLOROETHYLENE	0.5	U
cis-1,3-DICHLOROPROPENE	0.5	U
CYCLOHEXANE	0.5	U
DIBROMOCHLOROMETHANE	0.5	U
DICHLORODIFLUOROMETHANE	0.5	U
ETHYLBENZENE	0.5	U
METHYL ACETATE	2	U
METHYL ETHYL KETONE (2-BUTANONE)	5	U
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	5	U
METHYLCYCLOHEXANE	0.5	U
METHYLENE CHLORIDE	0.5	U
STYRENE	0.5	U
tert-BUTYL METHYL ETHER	0.5	U
TETRACHLOROETHYLENE(PCE)	0.5	U
TOLUENE	0.81	U
trans-1,2-DICHLOROETHENE	0.5	U
trans-1,3-DICHLOROPROPENE	0.5	U
TRICHLOROETHYLENE (TCE)	0.5	U
TRICHLOROFLUOROMETHANE	0.5	U
VINYL CHLORIDE	0.5	U
XYLENES, TOTAL	2	U
<b>Semivolatile Organic Compounds (ug/L)</b>		
1,2,4,5-TETRACHLOROBENZENE	5	U
2,4,5-TRICHLOROPHENOL	20	U
2,4,6-TRICHLOROPHENOL	5	U
2,4-DICHLOROPHENOL	5	U
2,4-DIMETHYLPHENOL	5	U
2,4-DINITROPHENOL	20	UJ
2,4-DINITROTOLUENE	5	U
2,6-DINITROTOLUENE	5	U
2-CHLORONAPHTHALENE	5	U
2-CHLOROPHENOL	5	U
2-METHYLNAPHTHALENE	5	U
2-METHYLPHENOL (o-CRESOL)	5	U
2-NITROANILINE	20	U
2-NITROPHENOL	5	U
3,3'-DICHLOROBENZIDINE	5	U
3-NITROANILINE	20	U
4,6-DINITRO-2-METHYLPHENOL	20	U
4-BROMOPHENYL PHENYL ETHER	5	U
4-CHLORO-3-METHYLPHENOL	5	U
4-CHLOROANILINE	5	U
4-CHLOROPHENYL PHENYL ETHER	5	U
4-METHYLPHENOL (p-CRESOL)	5	U
4-NITROANILINE	20	U

**TABLE 4-1**

Analytical Results From Background Groundwater Sample (NDAJMW08)  
 AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
4-NITROPHENOL	20	U
ACENAPHTHENE	5	U
ACENAPHTHYLENE	5	U
ACETOPHENONE	5	U
ANTHRACENE	5	U
ATRAZINE	5	U
Benzaldehyde	5	U
BENZO(a)ANTHRACENE	5	U
BENZO(a)PYRENE	5	U
BENZO(b)FLUORANTHENE	5	U
BENZO(g,h,i)PERYLENE	5	U
BENZO(k)FLUORANTHENE	5	U
BENZYL BUTYL PHTHALATE	5	U
BIPHENYL (DIPHENYL)	5	U
bis(2-CHLOROETHOXY) METHANE	5	U
bis(2-CHLOROETHYL) ETHER (2-CHLOROETHYL ETHEI	5	U
bis(2-CHLOROISOPROPYL) ETHER	5	U
bis(2-ETHYLHEXYL) PHTHALATE	10	U
CARBAZOLE	10	U
CHRYSENE	5	U
DI-n-BUTYL PHTHALATE	5	U
DI-n-OCTYLPHTHALATE	5	U
DIBENZ(a,h)ANTHRACENE	5	U
DIBENZOFURAN	5	U
DIETHYL PHTHALATE	5	U
DIMETHYL PHTHALATE	5	U
FLUORANTHENE	5	U
FLUORENE	5	U
HEXACHLOROBENZENE	5	U
HEXACHLOROBUTADIENE	5	U
HEXACHLOROCYCLOPENTADIENE	5	U
HEXACHLOROETHANE	5	U
INDENO(1,2,3-c,d)PYRENE	5	U
ISOPHORONE	5	U
N-NITROSODI-n-PROPYLAMINE	5	U
N-NITROSODIPHENYLAMINE	5	U
NAPHTHALENE	5	U
NITROBENZENE	5	U
PENTACHLOROPHENOL	20	U
PHENANTHRENE	5	U
PHENOL	5	U
PYRENE	5	U
<b>Explosives (ug/L)</b>		
1,3,5-TRINITROBENZENE	2.5	U
1,3-DINITROBENZENE	2.5	U
2,4,6-TRINITROTOLUENE	2.5	U
2,4-DINITROTOLUENE	2.5	U
2,6-DINITROTOLUENE	2.5	U
2-NITROTOLUENE	2.5	U
3-NITROTOLUENE	2.5	U

**TABLE 4-1**

Analytical Results From Background Groundwater Sample (NDAJMW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
4-NITROTOLUENE	2.5	U
HEXAHYDRO-1,3,5-TRINITRO-1,3,5,7-TETRAZOCINE	2.5	U
NITROBENZENE	2.5	U
OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCIN	2.5	U
TETRYL	2.5	U
<b>Perchlorate (ug/L)</b>		
Perchlorate	20	U
<b>Pesticides (ug/L)</b>		
ALDRIN	0.01	U
ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	0.01	U
ALPHA ENDOSULFAN	0.01	U
ALPHA-CHLORDANE	0.01	U
BETA BHC (BETA HEXACHLOROCYCLOHEXANE)	0.01	U
BETA ENDOSULFAN	0.02	U
DELTA BHC (DELTA HEXACHLOROCYCLOHEXANE)	0.01	U
DIELDRIN	0.02	U
ENDOSULFAN SULFATE	0.02	U
ENDRIN	0.02	U
ENDRIN ALDEHYDE	0.02	U
ENDRIN KETONE	0.02	U
GAMMA BHC (LINDANE)	0.01	U
GAMMA-CHLORDANE	0.01	U
HEPTACHLOR	0.01	U
HEPTACHLOR EPOXIDE	0.01	U
METHOXYCHLOR	0.1	U
p,p'-DDD	0.02	U
p,p'-DDE	0.02	U
p,p'-DDT	0.02	U
TOXAPHENE	0.051	UJ
<b>Polychlorinated Biphenyls (ug/L)</b>		
PCB-1016 (AROCHLOR 1016)	1	U
PCB-1221 (AROCHLOR 1221)	0.2	U
PCB-1232 (AROCHLOR 1232)	0.41	U
PCB-1242 (AROCHLOR 1242)	0.2	U
PCB-1248 (AROCHLOR 1248)	0.2	U
PCB-1254 (AROCHLOR 1254)	0.2	U
PCB-1260 (AROCHLOR 1260)	0.2	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

Analytical Results From Background Surface Water Sample (NDAJSW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration			
	Total	Qualifier	Dissolved	Qualifier
<i>Metals (ug/L)</i>				
ALUMINUM	700	U	700	U
ANTIMONY	50	UJ	50	U
ARSENIC	40.8	UJ	40.8	U
BARIUM	321	J	314	J
BERYLLIUM	1.89	U	1.89	U
CADMIUM	7.12	U	7.12	U
CALCIUM	213000	J	201000	=
CHROMIUM, TOTAL	11.4	U	11.4	U
COBALT	11.4	U	11.4	U
COPPER	23.4	U	23.4	U
IRON	334	U	334	UJ
LEAD	35.2	UJ	35.2	U
MAGNESIUM	516000	J	487000	=
MANGANESE	1670	J	1660	=
MERCURY	0.0162	U	0.0162	U
NICKEL	19.9	U	19.9	U
POTASSIUM	241000	J	226000	J
SELENIUM	66.4	J	42	U
SILVER	9.44	U	9.44	U
SODIUM	4080000	J	3930000	=
THALLIUM	50.8	UJ	50.8	U
VANADIUM	8.94	U	8.94	U
ZINC	8.18	U	8.18	U

Chemical	Concentration	
	Total	Qualifier
<i>Volatile Organic Compounds (ug/L)</i>		
1,1,1-TRICHLOROETHANE	0.5	U
1,1,2,2-TETRACHLOROETHANE	0.5	U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.5	U
1,1,2-TRICHLOROETHANE	0.5	U
1,1-DICHLOROETHANE	0.5	U
1,1-DICHLOROETHENE	0.5	U
1,2,3-TRICHLOROBENZENE	0.5	UJ
1,2,4-TRICHLOROBENZENE	0.5	UJ
1,2-DIBROMO-3-CHLOROPROPANE	2	UJ
1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.5	U
1,2-DICHLOROBENZENE	0.5	U
1,2-DICHLOROETHANE	0.5	U
1,2-DICHLOROPROPANE	0.5	U
1,3-DICHLOROBENZENE	0.5	U
1,4-DICHLOROBENZENE	0.5	U
2-HEXANONE	5	U
ACETONE	5	U
BENZENE	0.5	U
BROMOCHLOROMETHANE	0.5	U
BROMODICHLOROMETHANE	0.5	U

TABLE 4-2

Analytical Results From Background Surface Water Sample (NDAJSW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
BROMOFORM	0.5	U
BROMOMETHANE	0.5	U
CARBON DISULFIDE	0.9	=
CARBON TETRACHLORIDE	0.5	U
CHLORO BENZENE	0.5	U
CHLOROETHANE	0.5	U
CHLOROFORM	0.5	U
CHLOROMETHANE	0.5	U
cis-1,2-DICHLOROETHYLENE	0.5	U
cis-1,3-DICHLOROPROPENE	0.5	U
CYCLOHEXANE	0.5	U
DIBROMOCHLOROMETHANE	0.5	U
DICHLORODIFLUOROMETHANE	0.5	U
ETHYLBENZENE	0.5	U
ISOPROPYLBENZENE (CUMENE)	0.5	U
METHYL ACETATE	2	U
METHYL ETHYL KETONE (2-BUTANONE)	5	U
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANO)	5	U
METHYLCYCLOHEXANE	0.5	U
METHYLENE CHLORIDE	0.5	U
STYRENE	0.5	U
tert-BUTYL METHYL ETHER	0.5	U
TETRACHLOROETHYLENE(PCE)	0.5	U
TOLUENE	0.5	U
trans-1,2-DICHLOROETHENE	0.5	U
trans-1,3-DICHLOROPROPENE	0.5	U
TRICHLOROETHYLENE (TCE)	0.5	U
TRICHLOROFLUOROMETHANE	0.5	U
VINYL CHLORIDE	0.5	U
XYLENES, TOTAL	2	U
<b>Semivolatile Organic Compounds (ug/L)</b>		
2,4,5-TRICHLOROPHENOL	510	U
2,4,6-TRICHLOROPHENOL	128	U
2,4-DICHLOROPHENOL	128	U
2,4-DIMETHYLPHENOL	128	U
2,4-DINITROPHENOL	510	U
2,4-DINITROTOLUENE	128	U
2-CHLORONAPHTHALENE	128	U
2-CHLOROPHENOL	128	U
2-METHYLNAPHTHALENE	128	U
2-METHYLPHENOL (o-CRESOL)	128	U
2-NITROANILINE	510	U
2-NITROPHENOL	128	U
3,3'-DICHLOROBENZIDINE	128	U
3-NITROANILINE	510	U
4,6-DINITRO-2-METHYLPHENOL	510	U
4-BROMOPHENYL PHENYL ETHER	128	U
4-CHLORO-3-METHYLPHENOL	128	U
4-CHLOROANILINE	128	U

TABLE 4-2

Analytical Results From Background Surface Water Sample (NDAJSW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
4-CHLOROPHENYL PHENYL ETHER	128	U
4-METHYLPHENOL (p-CRESOL)	128	U
4-NITROANILINE	510	U
4-NITROPHENOL	510	U
ACENAPHTHENE	128	U
ACENAPHTHYLENE	128	U
ACETOPHENONE	128	U
ANTHRACENE	128	U
ATRAZINE	128	U
Benzaldehyde	128	U
BENZO(a)ANTHRACENE	128	U
BENZO(a)PYRENE	128	U
BENZO(b)FLUORANTHENE	128	U
BENZO(g,h,i)PERYLENE	128	U
BENZO(k)FLUORANTHENE	128	U
BENZYL BUTYL PHTHALATE	128	U
BIPHENYL (DIPHENYL)	128	U
bis(2-CHLOROETHOXY) METHANE	128	U
bis(2-CHLOROETHYL) ETHER (2-CHLOROETHYL ET	128	U
bis(2-ETHYLHEXYL) PHTHALATE	255	U
CARBAZOLE	255	U
CHRYSENE	128	U
DI-n-BUTYL PHTHALATE	128	U
DI-n-OCTYLPHTHALATE	128	U
DIBENZ(a,h)ANTHRACENE	128	U
DIBENZOFURAN	128	U
DIETHYL PHTHALATE	128	U
DIMETHYL PHTHALATE	128	U
FLUORANTHENE	128	U
FLUORENE	128	U
HEXACHLOROBENZENE	128	U
HEXACHLOROBUTADIENE	128	U
HEXACHLOROCYCLOPENTADIENE	128	U
HEXACHLOROETHANE	128	U
INDENO(1,2,3-c,d)PYRENE	128	U
ISOPHORONE	128	U
N-NITROSODI-n-PROPYLAMINE	128	U
N-NITROSODIPHENYLAMINE	128	U
NAPHTHALENE	128	U
NITROBENZENE	128	U
PENTACHLOROPHENOL	510	U
PHENANTHRENE	128	U
PHENOL	128	U
PYRENE	128	U
<b>Explosives (ug/L)</b>		
1,3,5-TRINITROBENZENE	2.5	U
1,3-DINITROBENZENE	2.5	U
2,4,6-TRINITROTOLUENE	2.5	U
2,4-DINITROTOLUENE	2.5	U

TABLE 4-2

Analytical Results From Background Surface Water Sample (NDAJSW08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	
	Total	Qualifier
2,6-DINITROTOLUENE	2.5	U
2-NITROTOLUENE	2.5	U
3-NITROTOLUENE	2.5	U
4-NITROTOLUENE	2.5	U
HEXAHYDRO-1,3,5-TRINITRO-1,3,5,7-TETRAZOCINE	2.5	U
NITROBENZENE	2.5	U
OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZO(	2.5	U
TETRYL	2.5	U
<b>Perchlorate (ug/L)</b>		
Perchlorate	20	U
<b>Pesticides (ug/L)</b>		
ALDRIN	0.01	U
ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	0.01	UJ
ALPHA ENDOSULFAN	0.01	U
ALPHA-CHLORDANE	0.01	U
BETA BHC (BETA HEXACHLOROCYCLOHEXANE)	0.01	U
BETA ENDOSULFAN	0.021	U
DELTA BHC (DELTA HEXACHLOROCYCLOHEXANE)	0.01	U
DIELDRIN	0.021	U
ENDOSULFAN SULFATE	0.021	U
ENDRIN	0.021	U
ENDRIN ALDEHYDE	0.021	U
ENDRIN KETONE	0.021	U
GAMMA BHC (LINDANE)	0.01	UJ
GAMMA-CHLORDANE	0.01	U
HEPTACHLOR	0.01	U
HEPTACHLOR EPOXIDE	0.01	U
METHOXYCHLOR	0.1	U
p,p'-DDD	0.021	U
p,p'-DDE	0.021	U
p,p'-DDT	0.021	U
TOXAPHENE	0.052	U
<b>Polychlorinated Biphenyls (ug/L)</b>		
PCB-1016 (AROCHLOR 1016)	1	U
PCB-1221 (AROCHLOR 1221)	0.21	U
PCB-1232 (AROCHLOR 1232)	0.41	U
PCB-1242 (AROCHLOR 1242)	0.21	U
PCB-1248 (AROCHLOR 1248)	0.21	U
PCB-1254 (AROCHLOR 1254)	0.21	U
PCB-1260 (AROCHLOR 1260)	0.21	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 4-3

Analytical Results From Background Sediment Sample (NDAJSD08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	Qualifier
<b>Metals (mg/Kg)</b>		
ALUMINUM	1770	=
ANTIMONY	0.211	J
ARSENIC	0.265	J
BARIUM	6.76	J
BERYLLIUM	0.0911	J
CADMIUM	0.0132	U
CALCIUM	1040	=
CHROMIUM, TOTAL	1.74	J
COBALT	2.82	J
COPPER	8.27	=
IRON	6660	=
LEAD	1.92	=
MAGNESIUM	720	J
MANGANESE	67.5	=
MERCURY	0.00213	J
NICKEL	0.85	J
POTASSIUM	521	J
SELENIUM	0.206	U
SILVER	0.057	J
SODIUM	1460	=
THALLIUM	0.461	J
VANADIUM	22.6	=
<b>Volatile Organic Compounds (mg/Kg)</b>		
1,1,1-TRICHLOROETHANE	0.0125	U
1,1,2,2-TETRACHLOROETHANE	0.0125	U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.0125	U
1,1,2-TRICHLOROETHANE	0.0125	U
1,1-DICHLOROETHANE	0.0125	U
1,1-DICHLOROETHENE	0.0125	U
1,2,4-TRICHLOROBENZENE	0.0125	U
1,2-DIBROMO-3-CHLOROPROPANE	0.0125	U
1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.0125	U
1,2-DICHLOROBENZENE	0.0125	U
1,2-DICHLOROETHANE	0.0125	U
1,2-DICHLOROPROPANE	0.0125	U
1,3-DICHLOROBENZENE	0.0125	U
1,4-DICHLOROBENZENE	0.0125	U
2-HEXANONE	0.0125	U
ACETONE	0.0125	U
BENZENE	0.0125	U
BROMODICHLOROMETHANE	0.0125	U
BROMOFORM	0.0125	U
BROMOMETHANE	0.0125	UJ
CARBON DISULFIDE	0.00094	J
CARBON TETRACHLORIDE	0.0125	U
CHLOROBENZENE	0.0125	U
CHLOROETHANE	0.0125	U
CHLOROFORM	0.0125	U

TABLE 4-3

Analytical Results From Background Sediment Sample (NDAJSD08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	Qualifier
CHLOROMETHANE	0.0125	U
cis-1,2-DICHLOROETHYLENE	0.0125	U
cis-1,3-DICHLOROPROPENE	0.0125	U
CYCLOHEXANE	0.0125	U
DIBROMOCHLOROMETHANE	0.0125	U
DICHLORODIFLUOROMETHANE	0.0125	UJ
ETHYLBENZENE	0.0125	U
ISOPROPYLBENZENE (CUMENE)	0.0125	U
METHYL ACETATE	0.0125	U
METHYL ETHYL KETONE (2-BUTANONE)	0.0125	U
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	0.0125	U
METHYLCYCLOHEXANE	0.0125	U
METHYLENE CHLORIDE	0.0125	U
STYRENE	0.0125	U
tert-BUTYL METHYL ETHER	0.0125	U
TETRACHLOROETHYLENE(PCE)	0.0125	U
TOLUENE	0.0125	U
trans-1,2-DICHLOROETHENE	0.0125	U
trans-1,3-DICHLOROPROPENE	0.0125	U
TRICHLOROETHYLENE (TCE)	0.0125	U
TRICHLOROFLUOROMETHANE	0.0125	U
VINYL CHLORIDE	0.0125	U
XYLENES, TOTAL	0.0125	U
<b>Semivolatile Organic Compounds (mg/Kg)</b>		
2,4,5-TRICHLOROPHENOL	1.3	U
2,4,6-TRICHLOROPHENOL	0.433	U
2,4-DICHLOROPHENOL	0.433	U
2,4-DIMETHYLPHENOL	0.433	U
2,4-DINITROPHENOL	1.3	U
2,4-DINITROTOLUENE	0.433	U
2,6-DINITROTOLUENE	0.433	U
2-CHLORONAPHTHALENE	0.433	U
2-CHLOROPHENOL	0.433	U
2-METHYLNAPHTHALENE	0.433	U
2-METHYLPHENOL (o-CRESOL)	0.433	U
2-NITROANILINE	1.3	U
2-NITROPHENOL	0.433	U
3,3'-DICHLOROBENZIDINE	0.88	U
3-NITROANILINE	1.3	U
4,6-DINITRO-2-METHYLPHENOL	1.3	U
4-BROMOPHENYL PHENYL ETHER	0.433	U
4-CHLORO-3-METHYLPHENOL	0.433	U
4-CHLOROPHENYL PHENYL ETHER	0.433	U
4-METHYLPHENOL (p-CRESOL)	0.433	U
4-NITROANILINE	1.3	U
4-NITROPHENOL	1.3	U
ACENAPHTHENE	0.433	U
ACENAPHTHYLENE	0.433	U
ACETOPHENONE	0.433	U

TABLE 4-3

Analytical Results From Background Sediment Sample (NDAJSD08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	Qualifier
ANTHRACENE	0.433	U
ATRAZINE	0.433	U
Benzaldehyde	0.433	U
BENZO(a)ANTHRACENE	0.433	U
BENZO(a)PYRENE	0.433	U
BENZO(b)FLUORANTHENE	0.433	U
BENZO(g,h,i)PERYLENE	0.433	U
BENZO(k)FLUORANTHENE	0.433	U
BENZYL BUTYL PHTHALATE	0.433	U
BIPHENYL (DIPHENYL)	0.433	U
bis(2-CHLOROETHYL) ETHER (2-CHLOROETHYL ETHER)	0.433	U
bis(2-CHLOROISOPROPYL) ETHER	0.433	U
bis(2-ETHYLHEXYL) PHTHALATE	0.433	U
CAPROLACTAM	0.433	U
CARBAZOLE	0.433	U
CHRYSENE	0.433	U
DI-n-BUTYL PHTHALATE	0.433	U
DI-n-OCTYLPHTHALATE	0.433	U
DIBENZ(a,h)ANTHRACENE	0.433	U
DIBENZOFURAN	0.433	U
DIETHYL PHTHALATE	0.433	U
DIMETHYL PHTHALATE	0.433	U
FLUORANTHENE	0.433	U
FLUORENE	0.433	U
HEXACHLOROBENZENE	0.433	U
HEXACHLOROCYCLOPENTADIENE	0.433	U
INDENO(1,2,3-c,d)PYRENE	0.433	U
ISOPHORONE	0.433	U
N-NITROSODI-n-PROPYLAMINE	0.433	U
N-NITROSODIPHENYLAMINE	0.433	U
NITROBENZENE	0.433	U
PENTACHLOROPHENOL	1.3	U
PHENANTHRENE	0.433	U
PHENOL	0.433	U
PYRENE	0.433	U
<b>Explosives (mg/Kg)</b>		
1,3,5-TRINITROBENZENE	0.163	U
1,3-DINITROBENZENE	0.163	U
2,4,6-TRINITROTOLUENE	0.163	U
2,4-DINITROTOLUENE	0.163	U
2,6-DINITROTOLUENE	0.163	U
2-NITROTOLUENE	0.163	U
3-NITROTOLUENE	0.163	U
4-NITROTOLUENE	0.163	U
HEXAHYDRO-1,3,5-TRINITRO-1,3,5,7-TETRAZOCINE	0.163	U
NITROBENZENE	0.163	U
OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE	0.163	U
TETRYL	0.163	UJ

TABLE 4-3

Analytical Results From Background Sediment Sample (NDAJSD08)  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Concentration	Qualifier
<b>Perchlorate (mg/Kg)</b>		
Perchlorate	0.13	U
<b>Pesticides (mg/Kg)</b>		
ALDRIN	0.0022	UJ
ALPHA BHC (ALPHA HEXACHLOROCYCLOHEXANE)	0.0022	UJ
ALPHA ENDOSULFAN	0.0022	UJ
ALPHA-CHLORDANE	0.0022	UJ
BETA BHC (BETA HEXACHLOROCYCLOHEXANE)	0.0022	UJ
BETA ENDOSULFAN	0.0044	UJ
DELTA BHC (DELTA HEXACHLOROCYCLOHEXANE)	0.0022	UJ
DIELDRIN	0.0044	UJ
ENDOSULFAN SULFATE	0.0044	UJ
ENDRIN	0.0044	UJ
ENDRIN ALDEHYDE	0.0044	UJ
ENDRIN KETONE	0.0044	UJ
GAMMA BHC (LINDANE)	0.0022	UJ
GAMMA-CHLORDANE	0.0022	UJ
HEPTACHLOR	0.0022	UJ
HEPTACHLOR EPOXIDE	0.0022	UJ
METHOXYCHLOR	0.022	UJ
p,p'-DDD	0.00023	J
p,p'-DDE	0.00021	J
p,p'-DDT	0.00045	J
TOXAPHENE	0.22	UJ
<b>Polychlorinated Biphenyls (mg/Kg)</b>		
PCB-1016 (AROCHLOR 1016)	0.044	U
PCB-1221 (AROCHLOR 1221)	0.089	U
PCB-1232 (AROCHLOR 1232)	0.044	U
PCB-1242 (AROCHLOR 1242)	0.044	U
PCB-1248 (AROCHLOR 1248)	0.044	U
PCB-1254 (AROCHLOR 1254)	0.044	U
PCB-1260 (AROCHLOR 1260)	0.044	UJ

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.

**TABLE 4-4**

Essential Nutrients in Soil

AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Maximum Concentration in Surface Soil (mg/Kg)	Background Concentration <sup>1</sup> (mg/Kg)	Daily Soil Intake <sup>2</sup> (kg/day)		Daily Nutrient Intake from Soil <sup>3</sup> (mg/day)		Recommended Daily Nutrient Intake <sup>4</sup> (mg/day)		Percent of Recommended Daily Nutrient Intake from Soil Consumption	
			Child	Adult	Child	Adult	Child	Adult	Child	Adult
			Calcium	5100	210,000	0.0002	0.0001	1.02	0.51	600
Magnesium	2370	12,834	0.0002	0.0001	0.47	0.24	105	300	0.45%	0.08%
Potassium	1270	1,700	0.0002	0.0001	0.254	0.13	1,050	2,000	0.02%	0.01%
Sodium	620	6,300	0.0002	0.0001	0.124	0.06	260	500	0.05%	0.01%

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

**TABLE 4-5**

Chemicals Detected Above Criteria in Surface Soil  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Station ID	Sample Date	Result	Qualifier	Region IX PRG <sup>1</sup>	Ecological Criteria <sup>2</sup>	SSL <sup>3</sup> (DAF=10)	Screening Criteria Exceedances		
								PRG	Ecological	SSL
<b>Metals (mg/Kg)</b>										
IRON	NDAJSS10	08/25/03	37700	J	2350	200	NA	yes	yes	na
LEAD	NDAJSS10	08/25/03	60.5	J	400	50	NA	no	yes	na
MANGANESE	NDAJSS08	08/25/03	1490	=	176	100	NA	yes	yes	na
	NDAJSS05	12/08/00	1200	=				yes	yes	na
THALLIUM	NDAJSS10	08/25/03	0.805	J	0.516	1	NA	yes	no	na
	NDAJSS05	12/08/00	0.75	J				yes	no	na
ZINC	NDAJSS03	12/08/00	220	=	2350	50	6000	no	yes	no
	NDAJSS09	08/25/03	123	=				no	yes	no
	NDAJSS10	08/25/03	91.3	=				no	yes	no
<b>Volatile Organic Compounds (mg/Kg)</b>										
<b>Semivolatile Organic Compounds (mg/Kg)</b>										

<sup>1</sup> USEPA Region IX PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.

<sup>2</sup> The lower of the toxicological benchmarks terrestrial plants, (Efroymson, 1997a) or invertebrates and heterotrophs (Efroymson, 1997b).

<sup>3</sup> USEPA Region IX PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 10.

ND indicates that the chemical was not detected.

NA indicates that the information is not available or not applicable.

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

Chemicals Detected Above Criteria in Groundwater  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Station ID	Sample Date	Concentration				Region IX PRG <sup>1</sup>	PRG Exceedances	
			Total	Qualifier	Dissolved	Qualifier		Total	Dissolved
<i>Metals (ug/L)</i>									
ALUMINUM	NDAJMW02	12/18/00	72000	=	ND		3650	yes	no
	NDAJMW03	09/04/03	57900	=	ND			yes	no
	NDAJMW04	12/18/00	30000	=	ND			yes	no
ARSENIC	NDAJMW04	09/03/03	10000	=	828	J		yes	no
	NDAJMW07	09/04/03	54.6	J	ND		0.0448	yes	no
	NDAJMW01	09/03/03	41.5	J	37.4	J		yes	yes
	NDAJMW05	09/04/03	38	J	ND			yes	no
	NDAJMW02	09/04/03	34.6	J	ND			yes	no
	NDAJMW06	09/04/03	33.1	J	ND			yes	no
	NDAJMW03	09/04/03	25.3	J	ND			yes	no
	NDAJMW04	09/03/03	24.5	J	ND			yes	no
BARIUM	NDAJMW02	12/18/00	770	=	530	=	255	yes	yes
	NDAJMW03	12/18/00	570	=	580	=		yes	yes
	NDAJMW03	09/04/03	531	J	363	J		yes	yes
	NDAJMW04	12/18/00	480	=	260	=		yes	yes
	NDAJMW01	12/18/00	430	=	370	=		yes	yes
	NDAJMW06	09/04/03	417	J	434	J		yes	yes
CADMIUM	NDAJMW02	12/18/00	3.9	J	ND		1.82	yes	no
CHROMIUM, TOTAL	NDAJMW04	12/18/00	43	=	5.5	J	11	yes	no
	NDAJMW02	12/18/00	26	=	3	J		yes	no
	NDAJMW01	09/03/03	16.5	J	13.3	J		yes	yes
	NDAJMW03	09/04/03	16.4	J	ND			yes	no
	NDAJMW06	09/04/03	14.2	J	ND			yes	no
IRON	NDAJMW02	12/18/00	68000	=	ND		1090	yes	no
	NDAJMW03	09/04/03	55200	J	ND			yes	no
	NDAJMW04	12/18/00	15000	=	ND			yes	no
	NDAJMW04	09/03/03	9000	J	ND			yes	no
	NDAJMW01	09/03/03	7710	J	6180	J		yes	yes
	NDAJMW03	12/18/00	1500	=	ND			yes	no
	NDAJMW02	09/04/03	1270	J	ND			yes	no
LEAD	NDAJMW05	09/04/03	38.2	=	ND		15	yes	no
	NDAJMW06	09/04/03	37.8	=	ND			yes	no

TABLE 4-6

Chemicals Detected Above Criteria in Groundwater  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Station ID	Sample Date	Concentration				Region IX PRG <sup>1</sup>	PRG Exceedances	
			Total	Qualifier	Dissolved	Qualifier		Total	Dissolved
MANGANESE SELENIUM	NDAJMW01	09/03/03	33.2	=	20.7	J		yes	no
	NDAJMW04	09/03/03	32.6	=	ND			yes	no
	NDAJMW06	09/04/03	27000	=	26000	=	87.6	yes	yes
	NDAJMW05	09/04/03	86.7	J	24.5	J	18.2	yes	yes
	NDAJMW07	09/04/03	42.8	J	ND			yes	no
	NDAJMW01	09/03/03	40.3	J	38.6	J		yes	yes
	NDAJMW06	09/04/03	32.2	J	ND			yes	no
VANADIUM	NDAJMW04	09/03/03	27.6	J	23.4	J		yes	yes
	NDAJMW02	09/04/03	26.7	J	41.3	J		yes	yes
	NDAJMW02	12/18/00	330	=	6.3	J	25.5	yes	no
	NDAJMW03	09/04/03	174	J	ND			yes	no
	NDAJMW04	12/18/00	160	=	3.8	J		yes	no
	NDAJMW03	12/18/00	39	J	6.1	J		yes	no
<b>Volatile Organic Compounds (ug/L)</b>									
ACETONE	NDAJMW06	09/04/03	114	J	-		60.8	yes	
BROMODICHLOROMETHANE	NDAJMW09	09/04/03	1	=	-		0.181	yes	
CHLOROFORM	NDAJMW05	09/04/03	8.5	=	-		0.617	yes	
	NDAJMW09	09/04/03	8	=	-			yes	
	NDAJMW06	09/04/03	2.8	=	-			yes	
TRICHLOROETHYLENE (TCE)	NDAJMW05	09/04/03	10.1	=	-		0.028	yes	
<b>Semivolatile Organic Compounds (ug/L)</b>									
bis(2-ETHYLHEXYL) PHTHALATE	NDAJMW01	09/03/03	6.5	J	-		4.8	yes	
<b>Polychlorinated Biphenyls (ug/L)</b>									
<b>Perchlorate (ug/L)</b>									
Perchlorate	NDAJMW01	12/18/00	48	J	-		0.365	yes	

<sup>1</sup> USEPA Region IX tap water PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.

ND indicates that the chemical was not detected.

NA indicates that the information is not available or not applicable.

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**

Chemicals Detected Above Criteria in Surface Water  
 AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Station ID	Sample Date	Concentration			Ecological Criteria <sup>1</sup>	ECO Exceedances		
			Total	Qualifier	Dissolved		Qualifier	Total	Dissolved
<i>Metals (ug/L)</i>									
BARIUM	NDAJSW07	10/02/03	385	J	369	J	NA	na	na
BERYLLIUM	NDAJSW01	10/02/03	2.25	J	ND		0.53	yes	no
<i>Volatile Organic Compounds (ug/L)</i>									
<i>Semivolatile Organic Compounds (ug/L)</i>									

<sup>1</sup> The lower of the USEPA National Recommended Water Quality Criteria (USEPA, 2002) and the Puerto Rico Environmental Quality Board (EQB) Water Quality Standards.

ND indicates that the chemical was not detected.

NA indicates that the information is not available or not applicable.

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 4-8**

Chemicals Detected Above Criteria in Sediment  
 AOC J, Former NASD, Vieques Island, Puerto Rico

<b>Chemical</b>	<b>Station ID</b>	<b>Sample Date</b>	<b>Result</b>	<b>Qualifier</b>	<b>Ecological Criteria<sup>1</sup></b>	<b>Exceedances of ECO</b>
<b>Metals (mg/Kg)</b>						
BARIUM	NDAJSD02	12/13/00	77	=	20	yes
	NDAJSD04	12/13/00	58	J		yes
	NDAJSD01	12/12/00	29	J		yes
<b>Volatile Organic Compounds (mg/Kg)</b>						
<b>Pesticides (mg/Kg)</b>						
p,p'-DDT	NDAJSD03	09/29/03	0.0043	J	0.0033	yes

<sup>1</sup> The lower of the screening criteria for marine and estuarine sediments (Long, 1995) or the USEPA guidance on Ecological Risk Assessment (USEPA, 2000).

ND indicates that the chemical was not detected.

NA indicates that the information is not available or not applicable.

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 4-9**

Summary of Surface Soil Screening Criteria Exceedances  
 AOC J, Former NASD, Vieques Island, Puerto Rico

<b>Chemical</b>	<b>Number Analyzed</b>	<b>Number Detected</b>	<b>Maximum Detect (mg/Kg)</b>	<b>Minimum Detect (mg/Kg)</b>	<b>Mean Concentration<sup>1</sup> (mg/Kg)</b>	<b>Residential PRG<sup>2</sup></b>	<b>Ecologic Screening Value<sup>3</sup></b>	<b>Leaching Screening Value<sup>4</sup></b>	<b>Background Concentration<sup>5</sup> (mg/Kg)</b>
CADMIUM	10	6	2.7	0.0379	0.483	3.7	0.4	4	0.04
IRON	10	10	37700	12400	17900	2350	200	na	37531
MANGANESE	10	10	1490	389	827	176	100	na	1167
LEAD	10	10	60.5	2.5	14.6	400	50	na	6.9
SELENIUM	10	9	1.6	0.71	0.92	39.1	1	2.5	2.0
THALLIUM	10	8	0.805	0.367	0.51	0.516	1	na	0.67
ZINC	10	10	220	18	64.8	2350	50	6000	65

<sup>1</sup> Mean concentration is based on 1/2 the detection limit for non-detects.

<sup>2</sup> USEPA Region IX PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.

<sup>3</sup> The lower of the toxicological benchmarks terrestrial plants, (Efroymson, 1997a) or invertebrates and heterotrophs (Efroymson, 1997b).

<sup>4</sup> USEPA Region IX PRG soil screening level (SSL, 2002) based on a dilution attenuation factor (DAF) of 10.

<sup>5</sup> Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002).

NA indicates that the information is not available or not applicable.

TABLE 4-10

Summary of Groundwater Exceedance of Screening Criteria  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (ug/L)	Minimum Detect (ug/L)	Mean Concentration <sup>1</sup> (ug/L)	Tap Water PRG <sup>2</sup>	Background Concentrations	
							Site-Specific <sup>3</sup> (ug/L)	Base-Wide <sup>4</sup> (ug/L)
<b>Dissolved Metals</b>								
ARSENIC, DISSOLVED	12	2	37.4	6.4	9.2	0.0448	2.04 UJ	5.5
BARIUM, DISSOLVED	12	12	580	180	334	255	344 =	870
CADMIUM, DISSOLVED	12	1	5.18	5.18	1.38	1.82	0.485 J	1
CHROMIUM, DISSOLVED	12	6	13.3	0.715	3.77	11	0.696 J	5
IRON, DISSOLVED	12	3	6180	19.6	584	1090	801 =	490
MANGANESE, DISSOLVED	12	12	26000	444	13500	87.6	24400 =	18000
LEAD, DISSOLVED	12	1	20.7	20.7	6.47	15	2 J	NA
SELENIUM, DISSOLVED	12	6	41.3	3.69	15.4	18.2	9.55 =	NA
THALLIUM, DISSOLVED	12	2	43.1	34.1	12.4	0.241	2.54 U	16
<b>Total Metals</b>								
ALUMINUM	12	9	72000	210	14800	3650	116 J	3500
ARSENIC	12	8	54.6	5	21.8	0.0448	10.2 UJ	NA
BARIUM	12	12	770	169	389	255	348 =	960
CADMIUM	12	3	3.9	0.49	1.54	1.82	1.78 U	1
CHROMIUM, TOTAL	12	12	43	1.13	13.1	11	2.9 J	6.8
IRON	12	9	68000	250	13200	1090	83.5 U	4800
MANGANESE	12	12	27000	433	15100	87.6	24300 =	17000
LEAD	12	6	38.2	6.9	15.8	15	8.8 U	NA
SELENIUM	12	7	86.7	4.89	23.4	18.2	10.5 U	2.3
VANADIUM	12	7	330	6.8	62.1	25.5	2.24 U	75
<b>Organic Chemicals</b>								
ACETONE	8	3	114	6.6	17.9	60.8	na	na
BROMODICHLOROMETHANE	12	1	1	1	0.396	0.181	na	na
CHLOROFORM	12	3	8.5	2.8	1.88	0.617	na	na
TRICHLOROETHYLENE (TCE)	12	1	10.1	10.1	1.15	0.028	na	na
bis(2-ETHYLHEXYL) PHTHALATE	12	2	6.5	1.2	4.36	4.8	na	na
Perchlorate	12	1	48	48	11.5	0.365	na	na

<sup>1</sup> Mean concentration is based on 1/2 the detection limit for non-detects.

<sup>2</sup> USEPA Region IX tap water PRG (2002) based on a hazard index (HI) of 0.1 for non-carcinogens.

<sup>3</sup> Site-specific background sample from well NDW07MW08.

<sup>4</sup> Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002).

NA indicates that the information is not available or not applicable.

**TABLE 4-11**

Summary of Surface Water COPCs Exceedances of Screening Criteria  
 AOC J, Former NASD, Vieques Island, Puerto Rico

<b>Chemical</b>	<b>Number Analyzed</b>	<b>Number Detected</b>	<b>Maximum Detect (ug/L)</b>	<b>Minimum Detect (ug/L)</b>	<b>Mean Concentration <sup>1</sup> (ug/L)</b>	<b>Ecological Screening Criteria <sup>2</sup></b>	<b>Background Concentration <sup>3</sup> (ug/L)</b>
<b>Dissolved metals</b>							
BERYLLIUM, DISSOLVED	5	0	0	0	0.945	0.53	1.89 U
<b>Total metals</b>							
BERYLLIUM	10	1	2.25	2.25	0.686	0.53	1.89 U
BARIUM	10	9	385	243	278	na	321

<sup>1</sup> Mean concentration is based on 1/2 the detection limit for non-detects.

<sup>2</sup> The lower of the USEPA National Recommended Water Quality Criteria (USEPA, 2002) and the Puerto Rico Environmental Quality Board (EQB) Water Quality Standards.

<sup>3</sup> Site-specific background sample from surface water sample NDAJSW08.

ND indicates that the chemical was not detected.

NA indicates that the information is not available or not applicable.

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 4-12**

Summary of Sediment Exceedances of Screening Criteria  
 AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Number Analyzed	Number Detected	Maximum Detect (mg/Kg)	Minimum Detect (mg/Kg)	Mean Concentration <sup>1</sup> (mg/Kg)	Ecologic Screening Value <sup>2</sup>	Background Concentrations	
							Site-Specific <sup>3</sup> (mg/Kg)	Base-Wide <sup>4</sup> (mg/Kg)
BARIUM	10	10	77	4.24	22.2	20	6.76 J	69
p,p'-DDT	10	2	0.0043	0.0006	0.00259	0.0033	na	na

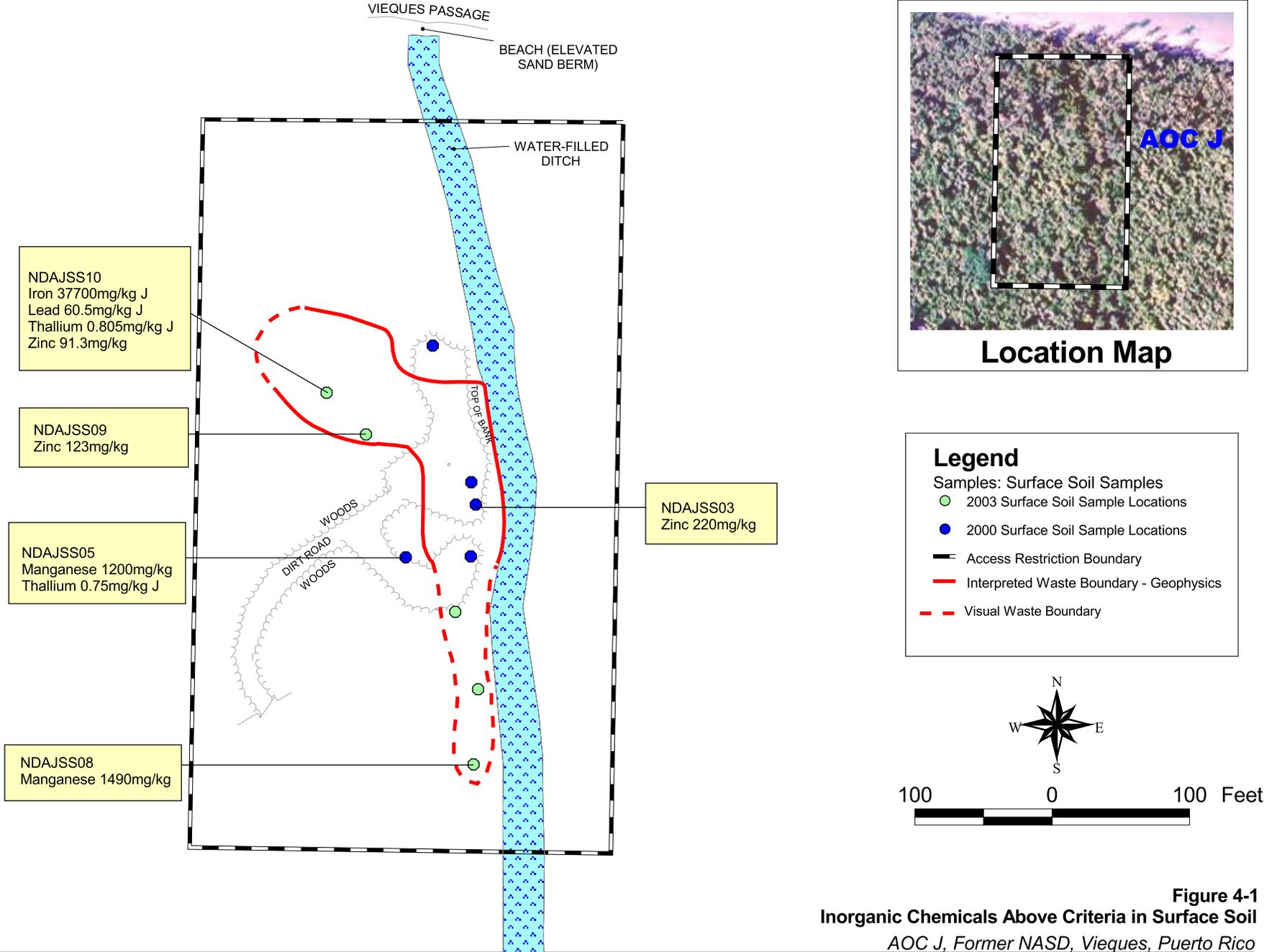
<sup>1</sup> Mean concentration is based on 1/2 the detection limit for non-detects.

<sup>2</sup> The lower of the screening criteria for marine and estuarine sediments (Long, 1995) or the USEPA guidance on Ecological Risk Assessment (USEPA, 2000).

<sup>3</sup> Site-specific background sample from sediment sample NDAJSD08.

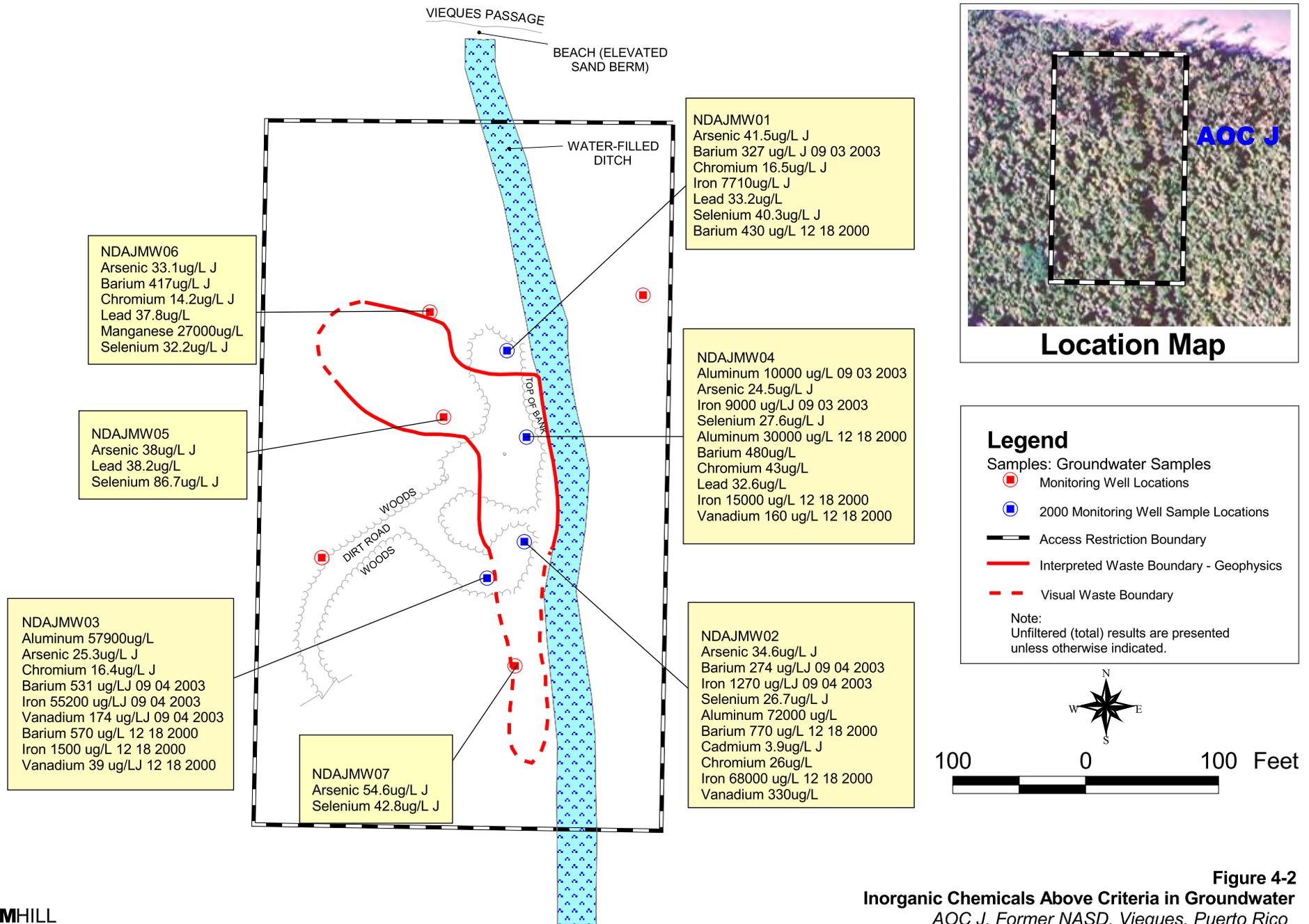
<sup>4</sup> Final Soil, Groundwater, Surface Water, and Sediment Background Investigation Report (CH2M Hill, 2002).

NA indicates that the information is not available or not applicable.

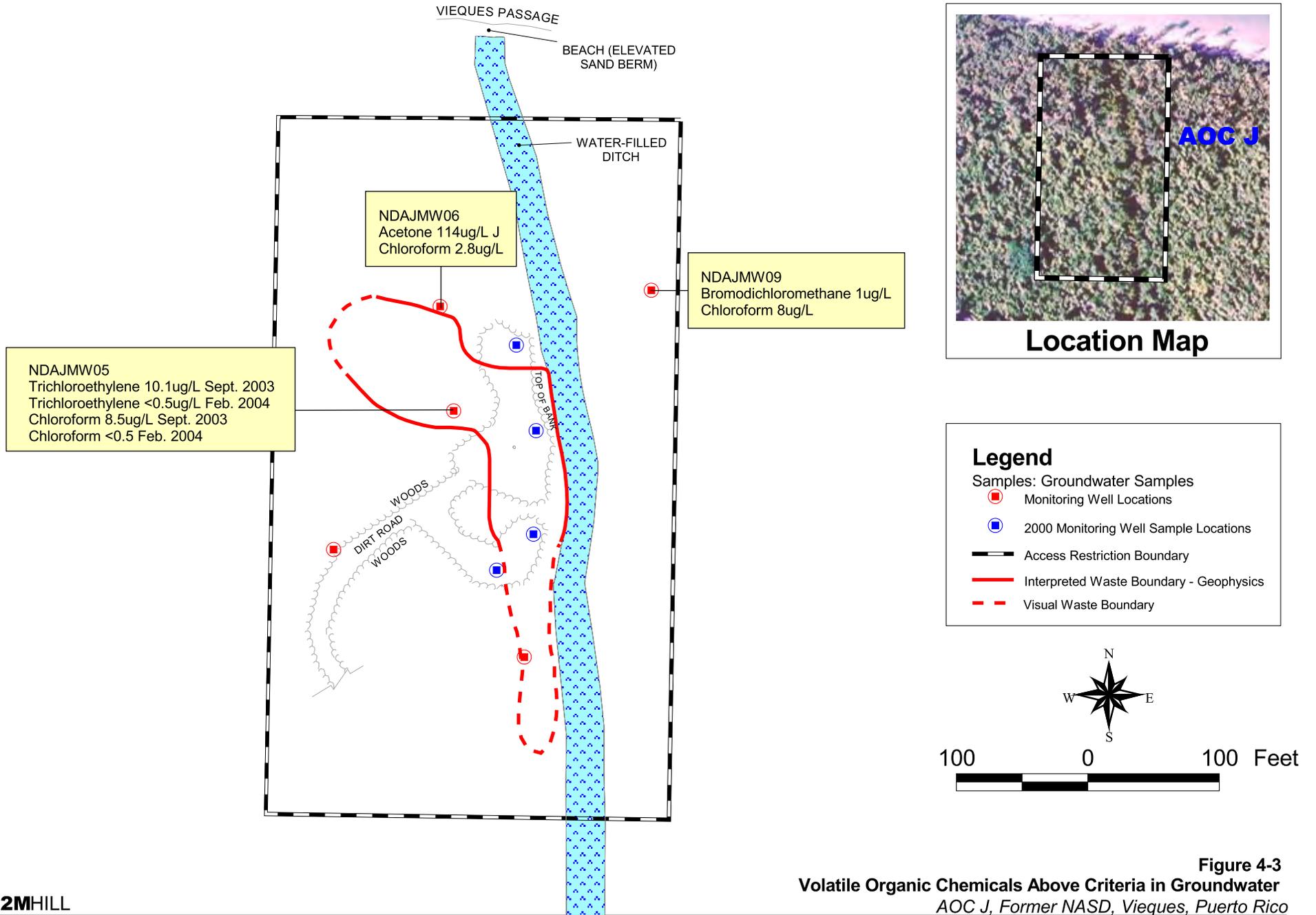


**Figure 4-1**  
**Inorganic Chemicals Above Criteria in Surface Soil**  
 AOC J, Former NASD, Vieques, Puerto Rico

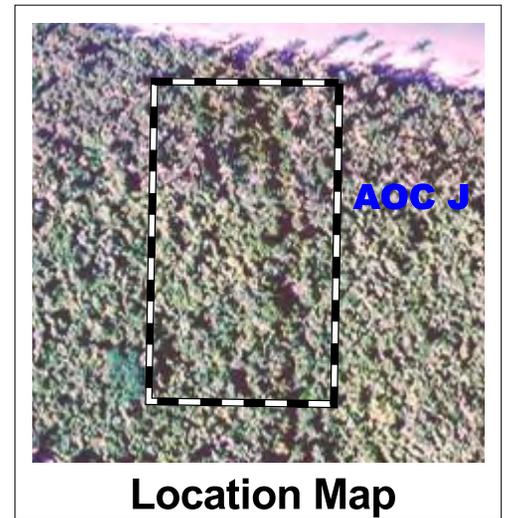
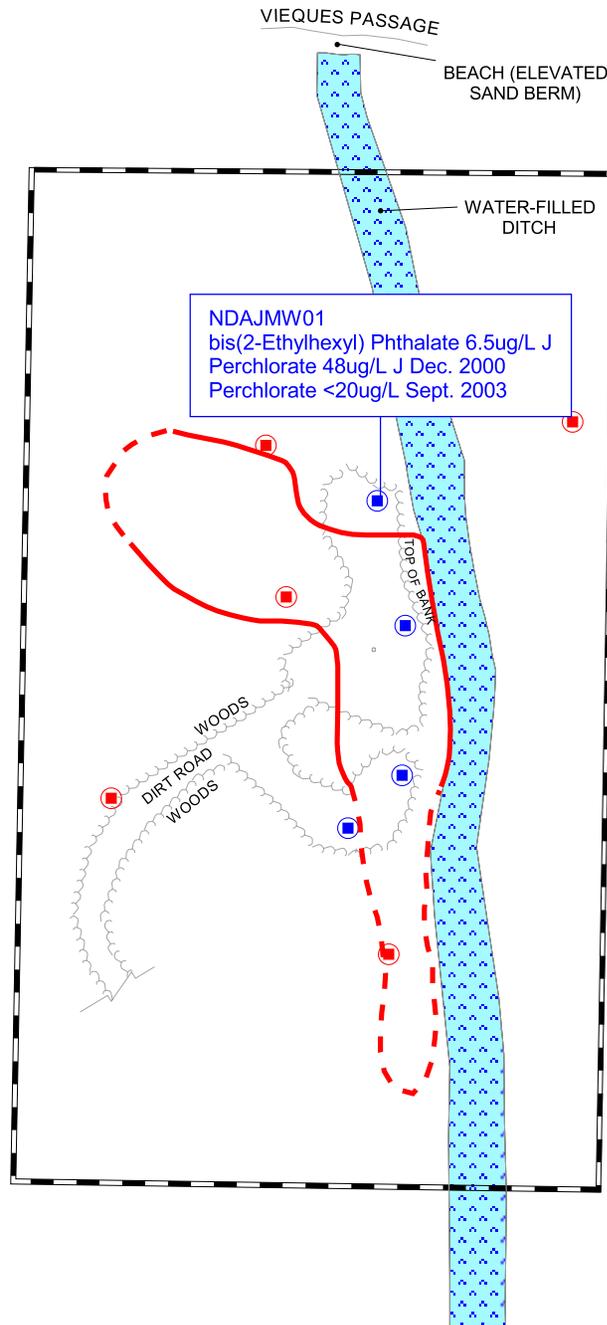
NOTE: Original figure created in color



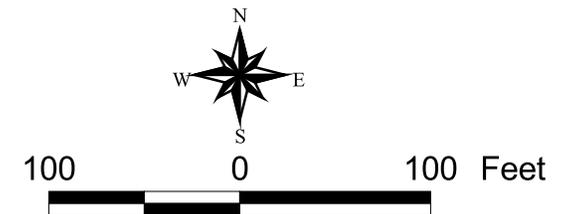
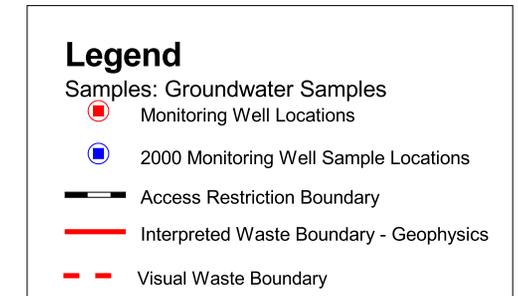
**Figure 4-2**  
**Inorganic Chemicals Above Criteria in Groundwater**  
*AOC J, Former NASD, Vieques, Puerto Rico*



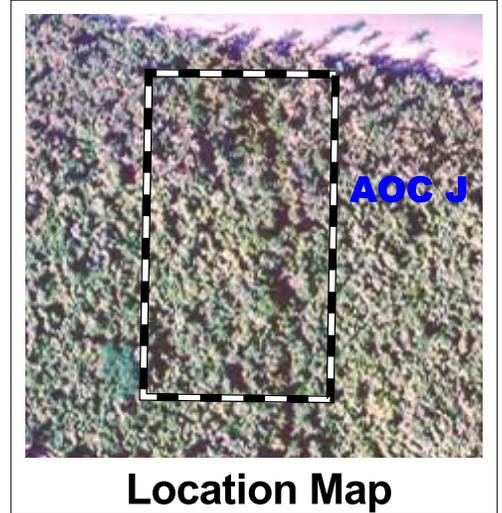
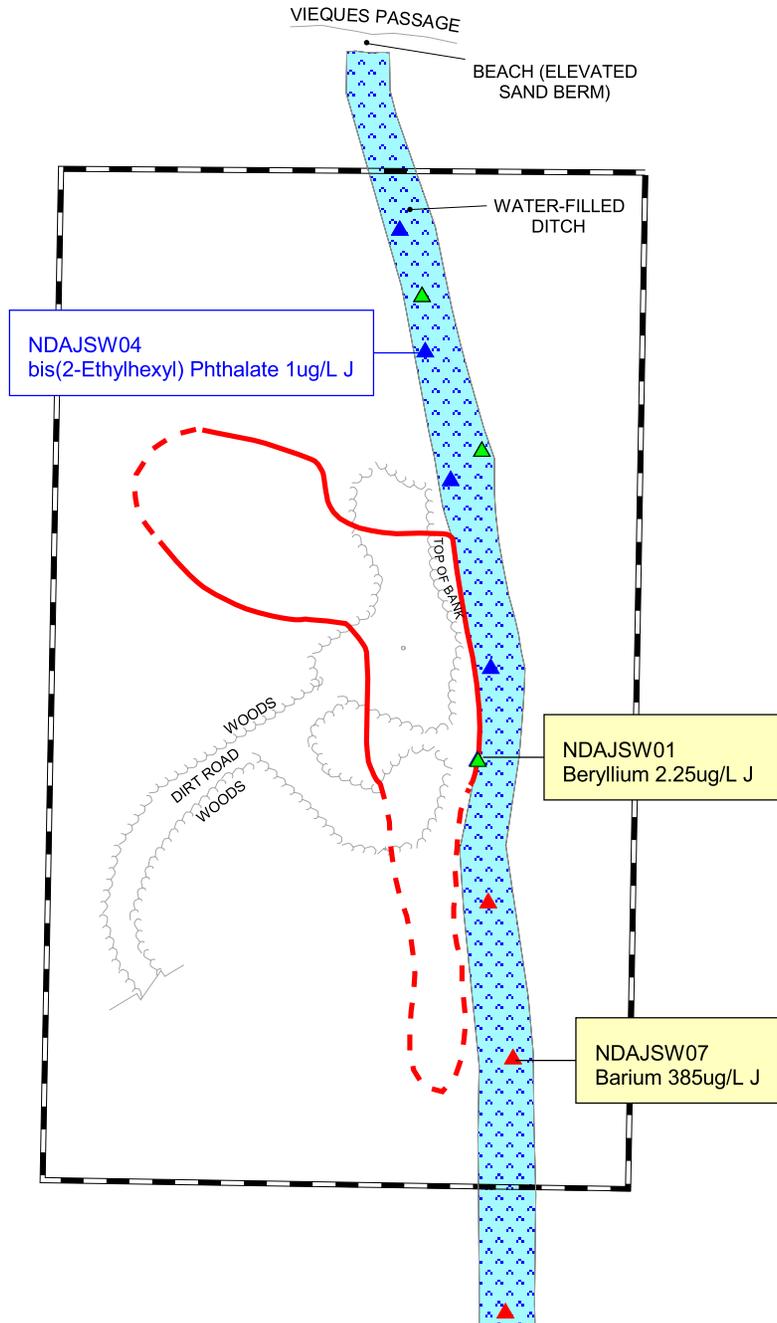
**Figure 4-3**  
**Volatile Organic Chemicals Above Criteria in Groundwater**  
*AOC J, Former NASD, Vieques, Puerto Rico*



**Location Map**



**Figure 4-4**  
**Semivolatile Organic Chemicals**  
**and Perchlorate Above Criteria in Groundwater**  
*AOC J, Former NASD, Vieques, Puerto Rico*

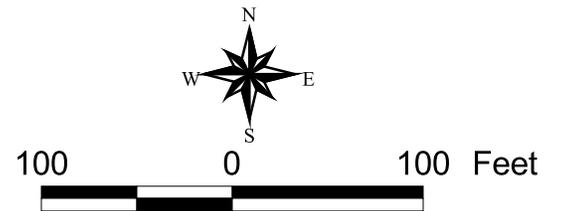


**Legend**

Samples: Surface Water Samples

- ▲ 2003 Surface Water Sample Locations
- ▲ 2000 Surface Water Sample Locations
- ▲ 2002 and 2003 Surface Water Sample Locations
- Access Restriction Boundary
- Interpreted Waste Boundary - Geophysics
- - - Visual Waste Boundary

Note:  
Unfiltered (total) results are presented unless otherwise indicated.



**Figure 4-5**  
**Inorganic Chemicals Above Criteria in Surface Water**  
*AOC J, Former NASD, Vieques, Puerto Rico*



## SECTION 5

# Contaminant Fate and Transport

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This section presents an assessment of contaminant migration potential at AOC J through an environmental contaminant fate and transport evaluation. The site physical characteristics, source characteristics, and extent of contamination presented in Sections 3 and 4 were combined to form the basis of the contaminant fate and transport evaluation.

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.

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.

## 5.1 Potential Sources for Contamination

AOC J was used by the former NASD as a construction staging area and disposal site for solid waste from the mid-1960s until 1973. The Environmental Baseline Survey (EBS; Program Management Company, 2000) indicated that material discarded at the site included scrap metal, glass, and wood waste. Although most of the debris was removed and placed in a municipal landfill, some waste remains on site. Several debris piles and one empty drum have been found at the site since the initial investigation. MEC avoidance surveys conducted in 2000 and 2003 found no UXO/OE items at the site. However, two 106 mm shell casings, one flash tube, one 106 mm cartridge base, and six cartridge canisters were observed in the 2000 survey (CH2M HILL, 2000d).

A geophysical survey was conducted at AOC J to delineate the extent of the buried waste, as described in Section 3. Subsurface debris does not extend beyond the ephemeral stream's western bank.

## 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 prepared for the site (Figure 5-1). The site is located in a national wildlife refuge and is ecologically active, potentially attracting lizards and birds. No human receptors are currently located at the site.

AOC J is a relatively flat area south of Vieques Passage. It is in a thorn scrub forest, and the eastern portion includes an ephemeral stream. The 20- to 40-foot-wide ephemeral stream is heavily vegetated and ranges in depth from 3 to 6 feet. Surface water in the ephemeral stream flows to the north, toward Vieques Passage. Most of the solid waste at AOC J is immediately adjacent to the ephemeral stream, but some debris piles are up to 100 feet west of the ephemeral stream. A graphical representation of the CSM for AOC J is presented in Figure 5-2.

The geology at AOC J consists of clay, organic soil, and silt. As shown on Figure 2-5, the top 10 to 14 feet of the subsurface consists of clay and organic soil. This is underlain by a sandy clay to the maximum depth of the investigation (23 feet). A few silt lenses are also present. Trace gravel, comprised of weathered rock, exists throughout the subsurface deposits. Iron oxide staining is prevalent on subsurface soils at a depth of 6 to 7 feet bgs. Chemicals that exceeded screening criteria in site soil include inorganics, perchlorate, VOCs, and 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.

Groundwater at AOC J exists under potentially semiconfined conditions at a depth between 3 and 9 feet bgs. AOC J does not appear to lie within the Resolución Valley aquifer system, as a sandy layer was not encountered during investigations at the site. Groundwater flows in a generally northerly direction, toward Vieques Passage. Within the waste boundary area, groundwater locally flows east-northeast toward the ephemeral stream (Figure 2-6). Based on the June 2003 hydraulic tidal study discussed in Section 3, the groundwater elevation at AOC J fluctuates approximately 0.2 foot daily due to tidal fluctuations.

The field data collected during the 2000 and 2003 groundwater sampling events are summarized in Tables 5-1 and 5-2. Table 5-3 summarizes total (unfiltered) and dissolved (filtered) metals data for several metals. These data indicate that the aquifer is likely under reducing conditions. The ORP values during the 2003 sampling event ranged from -86 to 293. Dissolved oxygen values were low in most wells. During the 2003 sampling event, dissolved (filtered) manganese in all wells was elevated and similar to the unfiltered results indicating that manganese reducing conditions are likely present in most of the aquifer. Dissolved iron concentrations in most wells was much less than total iron, indicating that ORP conditions in general were not low enough for iron reduction to be occurring. An exception to this was well NDAJMW01, in which dissolved iron was elevated and similar to the total iron concentration. A slight sulfide odor was also noted initially in this well during the 2003 sampling, indicating that this area of the aquifer may have a lower ORP (sulfate-reducing conditions) than other areas of the site. In the vicinity of this well, iron reduction may also be occurring. Under iron reducing conditions, several ORP-sensitive metals, such as iron, manganese, arsenic, and selenium, are often found at elevated concentrations due to natural geochemical processes facilitated by groundwater bacteria. The only well in which

elevated filtered arsenic was detected was well NDAJMW01. The presence of elevated arsenic in this well may be related to natural low-ORP conditions.

## 5.3 Potential Routes of Migration

One mechanism for contaminant transport from the source area at AOC J may be surface runoff. Surface runoff may enter the ephemeral stream and be transported to surface water and sediment. Vertical migration may be another mechanism for contaminant transport. Chemicals in soil and buried waste materials may leach through the vadose zone and be transported into the groundwater system. However, because of the clayey nature of the soils, this pathway may be limited. Surface soil may also be released to the air by wind erosion. However, the site is covered with vegetation that limits dust emission, so this migration pathway is not likely significant for AOC J.

### 5.3.1 Soil to Atmosphere Pathway

Wind erosion is considered to be a potential mechanism for release of site contaminants to the atmosphere from soil because most of the chemicals exceeding screening criteria are inorganics. Inorganics and many 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 AOC J is likely minimal because the site is heavily vegetated.

Volatilization is a potential mechanism by which VOCs could be released from soil to the atmosphere. However, only a few VOCs exceeded criteria in soil at AOC J, and their concentrations are very low. Therefore, this pathway is not likely a significant part of potential contaminant release at the site.

### 5.3.2 Surface Runoff Pathway

Chemicals in site soil may be transported by surface runoff to surface water and sediment contained in the ephemeral stream. Chemicals transported to the ephemeral stream can be either in the dissolved phase or as suspended particulates, which can then settle out into sediment. Except for the dirt road, the site is heavily vegetated, so surface runoff transport may be moderately restricted. Further, the planned removal action will eliminate the waste and associated contaminated soil in order to address this potential contaminant migration pathway.

Concentrations of several metals and bis(2-ethylhexyl)phthalate exceeded screening criteria in surface water. However, bis(2-ethylhexyl)phthalate was detected in only one surface water sample.

Concentrations of barium and DDT exceeded screening criteria in sediment. Barium concentrations in surface soil samples did not exceed screening criteria or background levels. DDT was detected (below screening criteria) in two surface soil samples.

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, climatological factors, and nature of surface cover present (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 in areas at which 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 is primarily 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 chemical, the nature of the soils, rainfall, 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.

The boring logs indicate the presence of clayey and organic soils at the site. Clayey soils generally have low permeability, which restricts the rate of infiltration and contaminant migration through them.

Chloroform was detected in three groundwater samples. Metals, VOCs, bis(2-ethylhexyl)phthalate, and perchlorate were identified as exceeding screening criteria in groundwater. Perchlorate and the VOCs bromodichloromethane and TCE were detected in only one monitoring well each during only one sampling event. Resampling of well NDAJMW05 did not detect TCE, indicating that the previous detection may be a false positive.

## 5.4 Contaminant Persistence

The mobility and persistence of the chemicals that exceeded criteria 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 physical and chemical properties affect the transport of chemicals in the environment. 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, whereas persistent chemicals tend to remain localized in the source area and are generally resistant to chemical and biological degradation reactions. The following are considered to be the most important properties: sorption, volatilization, degradation, transformation, and bioaccumulation.

### 5.4.1.1 Sorption

Sorption is the tendency for chemicals to adsorb to and desorb from materials in the medium or media through which the chemicals are being transported. The subsurface materials likely to sorb chemicals typically are clay 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 milliliters per gram (ml/g) (e.g., many SVOCs) have high degrees of adsorption and consequently low mobility, whereas chemicals with a  $K_{oc}$  lower than 1,000 ml/g (e.g., many VOCs) have lower degrees of adsorption and consequently 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 ( $\text{atm}\cdot\text{m}^3/\text{M}$ ) are expected to volatilize readily from water to air, whereas those with H values lower than  $10^{-5}$   $\text{atm}\cdot\text{m}^3/\text{M}$  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 processes that are occurring.

### 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 partitions from water into the lipophilic parts (e.g., 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 5-4 presents a summary of the relevant physical and chemical parameters for chemicals that exceeded criteria at AOC J. The fate and transport of chemicals exceeding screening criteria are discussed as groups (i.e., 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

Several VOCs exceeded screening criteria in environmental matrices at AOC J. These include acetone and the chlorinated VOCs (CVOCs) bromodichloromethane, chloroform, and TCE. As discussed in Section 4, some of these chemicals may be attributable to non-site-related conditions or activities. Acetone is a common laboratory contaminant and ketones (i.e., acetone, 2-hexanone, MEK, and methyl isobutyl ketone [MIBK]) are common field contaminants from equipment decontamination solvents.

The CVOCs detected at AOC J have medium to high mobility in soil with high water solubilities and low soil adsorption coefficients. In soil, these CVOCs tend to volatilize rapidly into the air from the surface or readily leach into groundwater. The rate of loss from volatilization depends on the compound, temperature, soil gas permeability, and chemical-specific vapor pressure. These compounds are not expected to persist in surface soils. Once in groundwater, chloroform may persist for a long time. In surface water, these compounds also tend to volatilize to the atmosphere and are not likely to sorb to sediment.

Aerobic and anaerobic biodegradation are important transformation processes for chlorinated aliphatic compounds in natural water systems and soil. The rate of biodegradation in soil is dependent on the soil type, substrate concentration, and ORP of the soil. In water, the biodegradation rate may be very slow compared to evaporation. TCE can undergo biological degradation in soil and groundwater under anaerobic conditions. TCE is transformed sequentially to dichloroethene (DCE), vinyl chloride, and then ethene in a process referred to as reductive dechlorination. Biodegradation of chloroform via reductive dechlorination also may occur. Bromodichloromethane also may be transformed into TCE by hydrolysis, though at a slow rate. Considerable research has been done on the degradation mechanisms and pathways for CVOCs (EPA, 1998).

Bromodichloromethane is not expected to bioaccumulate in fish or other animals. While chloroform does not appear to bioconcentrate in aquatic organisms, the data for terrestrial plants and organisms are limited (ATSDR, 1997). TCE has a low to moderate

bioconcentration potential in aquatic organisms and plants (ATSDR, 1997). However, TCE does not appear to significantly biomagnify in the food web.

#### **5.4.2.2 Semivolatile Organic Compounds**

One SVOC, bis(2-ethylhexyl)phthalate, exceeded screening criteria at AOC J. Bis(2-ethylhexyl)phthalate is a common laboratory and field contaminant. Therefore, the presence of this compound may not be site-related.

#### **5.4.2.3 Chlorinated Pesticides**

One chlorinated pesticide, DDT, exceeded screening criteria in sediment. DDT strongly sorbs to soil. Although DDT is not expected to volatilize significantly from soil surfaces, it can volatilize depending on temperature and humidity. It slowly biodegrades to DDE and DDD in the soil matrix. Due to its low water solubility, it is less likely to leach and enter the groundwater system. The most likely migration pathways for pesticides are transport in particulate emissions and transport of sorbed materials in surface runoff. DDT has been shown to bioconcentrate in aquatic organisms and bioaccumulate in the food web. Root uptake of DDT by plants is considered to be low (ATSDR, 2002).

#### **5.4.2.4 Perchlorate**

Perchlorate was detected in only two surface soil samples and one groundwater sample (NDAJMW01 in December 2000) at AOC J. It was not detected in the same monitoring well during the September 2003 sampling event. Therefore, the presence of this compound in soil and groundwater is questionable.

Perchlorate is a naturally occurring compound that has historically been used as an oxidant in missile and rocket propulsion systems (Urbansky, 2002). In the natural environment, perchlorate often occurs as an anion or salt and tends to be persistent. It can be reduced by metals and bacteria; however, reduction by metals is very slow unless perchlorate is in the form of a concentrated acid. Perchlorate salts do not sorb well to soil since both perchlorate ions and soil particles are negatively charged (ITRC, 2002). Perchlorate adsorption is usually based on simple electrostatic bonds, or Vanderwalls forces, and is dependent on pH, soil mineralogy, organic content, ionic strength, and competing ions. Perchlorate contamination in groundwater is very mobile. The perchlorate salts have varying water solubilities but are generally quite soluble (Urbansky, 2002).

Perchlorate was analyzed using EPA analytical method 314.0. This method is recommended by EPA only for groundwater analysis for drinking water systems, and the results are reliable at concentrations greater than 4 ug/L. This method is unreliable for other matrixes such as soils and for 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).

#### **5.4.2.5 Metals**

Metals have been detected in all media at AOC J. Many of these metals are naturally occurring, and their reported presence may or may not indicate a contaminant release. In soil, only iron, lead, manganese, and thallium exceeded their respective background levels

and residential PRGs. In sediment, only barium exceeded its ecological screening criterion and background level.

In the water phase, the total metal concentration includes the dissolved metal concentration and the suspended metal concentration, which is sorbed to colloidal particles. Therefore, elevated metals concentrations in surface water and groundwater may be due to the suspended load and not just to the dissolved aqueous chemistry. For all aqueous samples collected at AOC J, dissolved and total metals were analyzed.

In surface water, all inorganic chemicals that exceeded criteria were detected at concentrations consistent with background levels (less than one order of magnitude difference). While several metals were detected in unfiltered surface water samples, only barium, calcium, copper, potassium, magnesium, sodium, and mercury were detected in filtered surface water samples. This indicates that most inorganics in surface water are sorbed to soil and organic matter particulates. For groundwater, dissolved compounds were detected much less frequently than total metals in general. Of the dissolved chemicals that exceeded criteria, only arsenic, iron, manganese, lead, selenium, and thallium were detected at concentrations more than one order of magnitude above the basewide background levels. These compounds were also above their tap water PRG, if applicable. Almost all of the inorganic chemicals that exceeded criteria were detected above the site-specific background concentration.

#### 5.4.2.6 Fate and Transport of Metals

The 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 ORP in soil or groundwater can affect the chemical species present. Metals can occur in the environment as a free ion or as a complexed species, which is composed of a positively charged cation and negatively charged anion or neutral molecule. Complexing generally increases the solubility and mobility of metals in groundwater. The type of complex a metal forms is dependent 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 is dependent 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 is also dependent on several factors. The solubility of cations decreases as pH increases. For a few cations, ( $\text{Be}^{+2}$ ,  $\text{Zn}^{+2}$ ,  $\text{Al}^{+3}$ , and  $\text{Fe}^{+2}$ ), 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 phosphate, sulfate, and carbonate, forming insoluble mineral precipitates. Metal sulfide complexes, which form in reducing environments, are extremely insoluble, and their formation tends to reduce the total metals concentrations. Metals may be removed from the water phase through mechanisms such as precipitation and irreversible sorption (EPA, 1979).

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 water has been shown to be a better indicator of bioavailability and toxic response than 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 affect the amount of plant uptake of certain elements.

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

### **Cadmium, Lead, and Zinc**

Cadmium, 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 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 bioaccumulate in plants and animals but may not biomagnify in the food web.

### **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  $\text{Fe}^{+3}$  oxidation state and a borderline cation in the  $\text{Fe}^{+2}$  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 is a natural component of most foods and may be significantly bioconcentrated at lower trophic levels in water. Iron bioaccumulates in organisms, but its bioavailability is dependent on its species.

### **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 clay and manganese oxides. Thallium tends to bioaccumulate in plants and animals.

## **5.5 Contaminant Migration**

Based on the nature and extent of contaminants, the potential site migration pathways, and contaminant characteristics, the contaminant migration for chemicals exceeding screening criteria was evaluated. Residual debris at AOC J exists primarily adjacent to the ephemeral stream and several piles that have been observed up to 100 feet west of the ephemeral stream. The 10 surface soil samples were collected as locations within the area at which waste disposal occurred and adjacent to the residual waste piles to characterize the source and assess soil characteristics in areas most likely to be impacted by past waste disposal services. However, soil samples were not collected directly through the waste piles due to safety concerns. Six metals were detected above screening criteria and background concentrations in surface soil samples collected at AOC J.

Most metals detected in surface soil were reported below or at concentrations consistent with background concentrations, implying that they may not be site-related and are naturally occurring, but 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 average detected concentrations for metals were generally below their respective background concentrations. Mean concentrations of cadmium and lead exceeded their background concentrations, but concentrations of these metals were below their respective PRGs.

### **5.5.1 Surface Runoff Contaminant Migration**

One of the potential migration pathways at AOC J is the transport of site soil by stormwater runoff to surface water and sediment.

#### **5.5.1.1 Soil to Surface Water Migration**

In surface water samples, mercury exceedances of the ecological screening criterion were detected in five samples collected along the ephemeral stream, but mercury was not detected in five other surface water samples along the ephemeral stream (see Figure 4-5). The samples with non-detections of mercury were interspersed with the samples in which detections occurred. Mercury concentrations in surface soil samples did not exceed any of the screening criteria, including ecological screening criteria. Thus, a linkage between the detections of mercury in the surface water samples and mercury concentrations in surface soil is not apparent.

A single exceedance of the copper ecological screening criterion for surface water was detected in a filtered (but not the unfiltered) sample collected at NDAJSW03 during 2003. No other copper exceedances in surface water were observed (see Figure 4-5). A single exceedance of the beryllium ecological screening criterion for surface water occurred in an unfiltered surface water sample collected at NDAJSW01. Copper and beryllium concentrations in surface soil samples did not exceed any of the screening criteria, including ecological screening criteria. Thus, a linkage between the detections of copper and beryllium in the surface water samples and concentrations of these metals in surface soil is not apparent.

Bis(2-ethylhexyl)phthalate was detected at an estimated concentration of 1 ug/L in one surface water sample, NDAJSW04 (Figure 4-6). Although this compound was detected in three soil samples (NDAJSS07, NDAJSS09, and NDAJSS10), the soil sample closest to NDAJSW04 had no detections. No source of this compound was found at the site, and the compound was not detected in sediment. Also, it is a common laboratory contaminant, so its presence in surface water is probably not site-related.

As noted above, the planned removal action will eliminate the waste and associated contaminated soil, which will address this potential contaminant migration pathway.

#### **5.5.1.2 Soil to Sediment Migration**

In sediment samples, three exceedances of the barium sediment ecological screening criterion (20 mg/kg) were detected at sample locations NDAJSD01, NDAJSD02, and NDAJSD04 and ranged from 29 to 77 mg/kg. Barium concentrations in surface soil samples did not exceed any of the screening criteria, including ecological screening criteria. It should be noted that the surface soil background concentration for barium is 320 mg/kg and surface soil concentrations at AOC J ranged from 44 to 130 mg/kg. Thus the barium concentrations in sediment may be a result of surface water runoff from local soils and representative of background concentrations of barium in soil.

In sediment, a single exceedance of the DDT ecological screening criterion was detected at sample location NDAJSD03B. DDT was detected below its ecological screening criterion in sediment sample NDAJSD05B. No other detections of DDT or other pesticides in sediment samples were observed. DDT was detected in only two surface soil samples; neither concentration exceeded any screening criteria, including the ecological criterion. Thus, a linkage between the detections of DDT in sediment and concentrations of DDT in surface soil is not apparent.

As noted above, the planned removal action will eliminate the waste and associated contaminated soil, which will address this potential contaminant migration pathway.

### **5.5.2 Subsurface Leaching Contaminant Migration**

Another potential pathway at AOC J 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.

#### **5.5.2.1 Surface Soil to Subsurface Soil Migration**

Concentrations of inorganic chemicals that exceeded criteria for subsurface soils were generally comparable to their concentrations in surface soil. Exceptions to this were

aluminum, sodium, and lead. However, these metals are not present at concentrations that pose a significant risk.

Inorganic chemicals in subsurface soils were below their respective background concentrations except for lead, manganese, and thallium. The mean concentrations for these three parameters were similar to or below their respective background concentrations.

No chemicals in subsurface soil exceeded their respective leachability screening criteria. However, the uncertainty associated with surface soil-to-subsurface soil potential contaminant migration pathway will be addressed by the planned removal action.

### 5.5.2.2 Soil to Groundwater Contaminant Migration

As noted previously, groundwater beneath the waste boundary area at AOC J flows generally easterly toward the ephemeral stream and northeasterly toward Vieques Passage. The hydraulic gradient is approximately 0.02 foot per foot at the site but appears to be much lower on the western portion of the site. Based on the local geology, groundwater is not expected to move quickly.

The following observations were made for chemicals exceeding screening criteria in groundwater:

- Acetone was detected in four groundwater samples (three downgradient wells and the upgradient background well). Acetone was also detected in two upgradient surface soil samples and one upgradient subsurface soil sample at concentrations well below its leachability screening criteria. Since acetone is produced naturally in the environment, is a common laboratory contaminant, and was detected in the background well, the acetone detections are likely not site-related. However, the uncertainty associated with this will be addressed via the removal action and associated confirmatory protocol.
- Bromodichloromethane was detected at low levels in only one groundwater location, NDAJMW09. This well is located on the eastern side of the ephemeral stream, which is sidegradient to the waste disposal area. Contamination from AOC J would not be expected in this area. The compound was not detected in any other site media. Therefore, the source of the bromodichloromethane detection in groundwater is probably not related to site activities. However, the uncertainty associated with this will be addressed via the removal action and associated confirmatory protocol.
- Chloroform was detected in four groundwater samples, including the background well (NDAJMW08) and the monitoring well located on the eastern side of the ephemeral stream (NDAJMW09). Chloroform was not detected in any soil samples from the site. Because chloroform was detected in NDAJMW08 and NDAJMW09 at concentrations comparable to the two source-area/downgradient wells, the source of chloroform in groundwater is most likely not site-related. However, the uncertainty associated with this will be addressed via the removal action and associated confirmatory protocol.
- TCE was detected in only one groundwater sample, NDAJMW05, at a concentration of 10.1 ug/L. The lack of detection of TCE in any other groundwater soil surface water or sediment samples suggests that significant TCE contamination is not present at the site. Resampling of this well did not detect TCE or other VOCs. Therefore, the single

detection in groundwater appears anomalous. However, the uncertainty associated with this will be addressed via the removal action and associated confirmatory protocol.

- Bis(2-ethylhexyl)phthalate was detected in two monitoring wells, NDAJMW01 and NDAJMW03. It was not detected in subsurface soil samples, which indicates that it is not leaching to groundwater from site soils. This compound is a common field and laboratory sampling artifact. However, the uncertainty associated with its detection will be addressed via the removal action and associated confirmatory protocol.
- Perchlorate was detected in only one groundwater sample at NDAJMW01 in 2000. This well was resampled in 2003, and the compound was not detected. Although perchlorate was detected in two soil samples, these samples are in the southernmost portion of the site. The source of the December 2000 detection is probably not site-related. However, the uncertainty associated with this will be addressed via the removal action and associated confirmatory protocol.
- Detections of dissolved aluminum, arsenic, cadmium, chromium, iron, and lead were much less numerous than detections of the total concentrations for these parameters. Dissolved antimony was not detected in any samples. This implies that these metals are primarily sorbed to suspended particulates in groundwater.
- It can be seen in Tables 5-1 and 5-2 that several of the wells, particularly wells NDAJMW03 and NDAJMW04, had elevated turbidity during the sampling activities in 2000 and 2003. Turbidity is caused by soil particulates comprised of inorganics. Thus, elevated turbidity in groundwater samples causes elevated levels of inorganics, including metals, to be reported in unfiltered samples. EPA suggests a maximum turbidity of 10 NTU for unfiltered groundwater samples (EPA, 2001e). Several groundwater samples from the monitoring wells at AOC J had turbidity values significantly greater than 10 NTU. When high turbidity is present, the filtered groundwater results are considered more representative of actual metal transport in groundwater (EPA, 1992). Thus, many of the high metals values reported in unfiltered samples for wells NDAJMW02, NDAJMW03, and NDAJMW04 are considered representative of site groundwater conditions due to the high turbidity. Filtered data for these samples are likely more representative of actual groundwater quality for these wells.

Elevated concentrations of manganese in the filtered samples suggests that manganese reduction is a predominant electron-accepting process in the shallow aquifer. In this natural process, soil bacteria use naturally available soil organic matter as an electron donor and manganese present in mineral form as an electron acceptor, causing increases in soluble manganese (+2 valence). This process often occurs in aquifers with organic-rich soil and depleted oxygen under reducing (low-ORP) conditions. Other metals that are sensitive to low ORP and may be elevated under these conditions include iron, arsenic, and selenium. These three metals were elevated in at least one groundwater sample at the site. Their presence in dissolved form may be due to site-specific geochemical conditions. Barium concentrations are elevated above site-background concentrations in some wells but are not above basewide background groundwater concentration (960 ug/L), indicating that barium concentrations in groundwater may not be site-related.

Based on the above evaluation, the soil to groundwater migration pathway does not appear to be significant at this site. Site wells indicate higher salinity concentrations than the background well, which may explain the difference in concentration between some of the dissolved solids and minerals in these site wells and background. Overall, the site does not seem to have had an observable effect on site groundwater. However, the uncertainty associated with soil (waste)-to-groundwater potential contaminant migration pathway will be addressed by the planned removal action.

**TABLE 5-1**

Summary of Salinity Measurements During the Expanded PA/SI  
AOC J, Former NASD, Vieques Island, Puerto Rico

<b>Well</b>	<b>Salinity, ppm</b>	<b>ORP, mV</b>	<b>Comments</b>
NDAJMW01	37027	167	low turbidity
NDAJMW02	19855	-58	very turbid
NDAJMW03	11599	204	very turbid
NDAJMW04	22216	70	medium turbidity

ORP - Oxidative-redox potential

**TABLE 5-2**

Summary of Field Sampling Data for Groundwater, 2003  
AOC J, Former NASD, Vieques Island, Puerto Rico

Well ID	DO, mg/L	ORP, mV	Specific Conductance, $\mu$ hos/cm	TDS, mg/L*	Turbidity, NTU	Comments
NDAJMW01	8.7 - 7.6	-86	31,760	18,738	18.9	slight sulfide odor initially
NDAJMW02	<1	68	18,250	10,768	38.8	
NDAJMW03	<1	239	16,080	9,487	991+	turbid
NDAJMW04	5.8 - 0.6	129	28,430	16,774	147	milky white
NDAJMW05	1.5 - 2.2	166	28,483	16,805	2.7	
NDAJMW06	< 1	293	19,070	11,251	4.6	
NDAJMW07	1.2	196	22,911	13,517	0.5	
NDAJMW08	< 1	51	12,408	7,321	1.2	
NDAJMW09	< 1	149	54,830	32,350	7.2	

\* TDS = total dissolved solids. Estimated TDS value equal to specific conductance ( $\mu$ hos/cm) times 0.59, in mg/L. (Mem, 1985).

DO = dissolved oxygen

**TABLE 5-3**

Summary of Aluminum, Arsenic, Iron, and Manganese Concentrations in Groundwater  
AOC J, Former NASD, Vieques Island, Puerto Rico

Chemical	Station ID	Sample Date	Concentration			
			Total	Qualifier	Dissolved	Qualifier
ALUMINUM	NDAJMW02	12/18/00	72000	=	ND	
	NDAJMW03	09/04/03	57900	=	ND	
	NDAJMW04	12/18/00	30000	=	ND	
	NDAJMW04	09/03/03	10000	=	828	J
	NDAJMW02	09/04/03	2660	=	ND	
	NDAJMW03	12/18/00	2100	=	ND	
	NDAJMW01	09/03/03	1850	J	770	J
	NDAJMW09	09/04/03	319	=	ND	
	NDAJMW01	12/18/00	210	=	ND	
	NDAJGW08	09/04/03	116	J	37.1	J
ARSENIC	NDAJMW07	09/04/03	54.6	J	ND	
	NDAJMW01	09/03/03	41.5	J	37.4	J
	NDAJMW05	09/04/03	38	J	ND	
	NDAJMW02	09/04/03	34.6	J	ND	
	NDAJMW06	09/04/03	33.1	J	ND	
	NDAJMW03	09/04/03	25.3	J	ND	
	NDAJMW04	09/03/03	24.5	J	ND	
	NDAJMW02	12/18/00	ND		6.4	J
	NDAJMW04	12/18/00	5	J	ND	
	NDAJGW08	09/04/03	10.2	UJ	2.04	UJ
IRON	NDAJMW02	12/18/00	68000	=	ND	
	NDAJMW03	09/04/03	55200	J	ND	
	NDAJMW04	12/18/00	15000	=	ND	
	NDAJMW04	09/03/03	9000	J	ND	
	NDAJMW01	09/03/03	7710	J	6180	J
	NDAJMW03	12/18/00	1500	=	ND	
	NDAJMW02	09/04/03	1270	J	ND	
	NDAJMW01	12/18/00	440	=	270	=
	NDAJMW09	09/04/03	250	=	19.6	J
	NDAJGW08	09/04/03	83.5	U	801	=
MANGANESE	NDAJMW06	09/04/03	27000	=	26000	=
	NDAJMW04	09/03/03	24500	=	22700	=
	NDAJMW05	09/04/03	23900	=	23600	=
	NDAJMW04	12/18/00	17000	J	3700	=
	NDAJMW01	09/03/03	16600	=	16000	=
	NDAJMW03	09/04/03	15200	=	16100	=
	NDAJMW02	12/18/00	15000	J	12000	=
	NDAJMW01	12/18/00	14000	J	13000	=
	NDAJMW02	09/04/03	11100	=	11700	=
	NDAJMW03	12/18/00	9300	J	9100	=
VANADIUM	NDAJMW09	09/04/03	7310	=	7240	=
	NDAJMW07	09/04/03	433	=	444	=
	NDAJGW08	09/04/03	24300	=	24400	=
	NDAJMW02	12/18/00	330	=	6.3	J
	NDAJMW03	09/04/03	174	J	ND	
	NDAJMW04	12/18/00	160	=	3.8	J
	NDAJMW03	12/18/00	39	J	6.1	J
	NDAJMW04	09/03/03	16.4	J	ND	
	NDAJMW09	09/04/03	8.01	J	8.1	J
	NDAJMW01	12/18/00	6.8	J	6.5	J

Note: The well NDAJMW08 is a site-specific background well.

TABLE 5-4

Fate and Transport Parameters for Selected COPCs  
AOC J, Former NASD, Vieques Island, Puerto Rico

Compound	Chemical Group	Soil Distribution		Water Solubility (mg/L)	Henry's Law Constant/H (atm <sup>3</sup> m <sup>3</sup> /Mol)	Octanol Water Partition Coefficient/ Kow (L/kg)			
		Coefficient/ Kd (L/kg)	# a						
Antimony	Inorganic		# a						
Arsenic	Inorganic		# a						
Barium	Inorganic			4.10E+01	a				
Beryllium	Inorganic			7.90E+02	a				
Cadmium	Inorganic			7.50E+01	a				
CALCIUM	Inorganic			NL					
Chromium, Total	Inorganic			1.90E+01	a				
Cobalt	Inorganic			1.26E+02	c				
Copper	Inorganic			5.01E+02	c				
IRON	Inorganic			NL					
Lead	Inorganic			1.58E+04	c				
MAGNESIUM	Inorganic			NL					
MANGANESE	Inorganic			NL					
Manganese	Inorganic			5.20E+01	a	1.14E-02	a		
POTASSIUM	Inorganic			NL					
Selenium	Inorganic			5.00E+00	a				
SODIUM	Inorganic			NL					
Thallium	Inorganic			7.10E+01	a				
Vanadium	Inorganic			1.00E+03	a				
Zinc	Inorganic			6.20E+01	a				
p,p'-DDT	Pesticide	2.63E+06	a	2.50E-02	a	8.10E-06	a	1.05E+06	b
bis(2-Ethylhexyl) Phthalate	SVOC	1.51E+07	a	3.40E-01	a	1.02E-07	a	1.58E+04	e
Benzo(B)Fluoranthene	SVOC	1.23E+06	a	1.50E-03	a	1.11E-04	a	1.10E+06	b
Benzo(K)Fluoranthene	SVOC	1.23E+06	a	8.00E-04	a	8.29E-07	a	1.15E+06	b
Acetone	VOC	5.75E-01	a	1.00E+06	a	3.88E-05	a	5.75E-01	b
Bromodichloromethane	VOC	5.50E+01	a	6.74E+03	a	1.60E-03	a	1.26E+02	b
Carbon Disulfide	VOC	4.57E+01	a	1.19E+03	a	3.02E-02	a	6.92E+01	b
Chloroform	VOC	3.98E+01	a	7.92E+03	a	3.66E-03	a	9.33E+01	b
2-Hexanone	VOC	1.34E+02	d	3.00E+04	b	3.39E-04	b	2.40E+01	b
Methyl Ethyl Ketone (2-Butanone)	VOC	3.55E+00	b	1.36E+05	b	5.77E-05	b	1.95E+00	b
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	VOC	1.90E+01	e	2.04E+04	e	3.90E-04	e	1.55E+01	e
Methylene Chloride	VOC	1.17E+01	a	1.30E+04	a	2.19E-03	a	2.00E+01	b
1,1,2,2-Tetrachloroethane	VOC	9.33E+01	a	2.97E+03	a	3.44E-04	a	2.45E+02	b
Toluene	VOC	1.82E+02	a	5.26E+02	a	6.63E-03	a	5.25E+02	b
Trichloroethylene	VOC	1.66E+02	a	1.10E+03	a	1.03E-02	a	2.63E+02	b
Perchlorate	Perchlorate	Low	f	2.00E+05	i	Nonvolatile	f	1.45E-06	f

**Notes:**

- The soil distribution parameter for metals assumes a typical soil pH of 6.8.
- Transport properties for inorganics are highly variable dependent on the chemical species and the site-specific environment. Therefore, the solubility, H, and Kow were not listed for metals.

**Sources:**

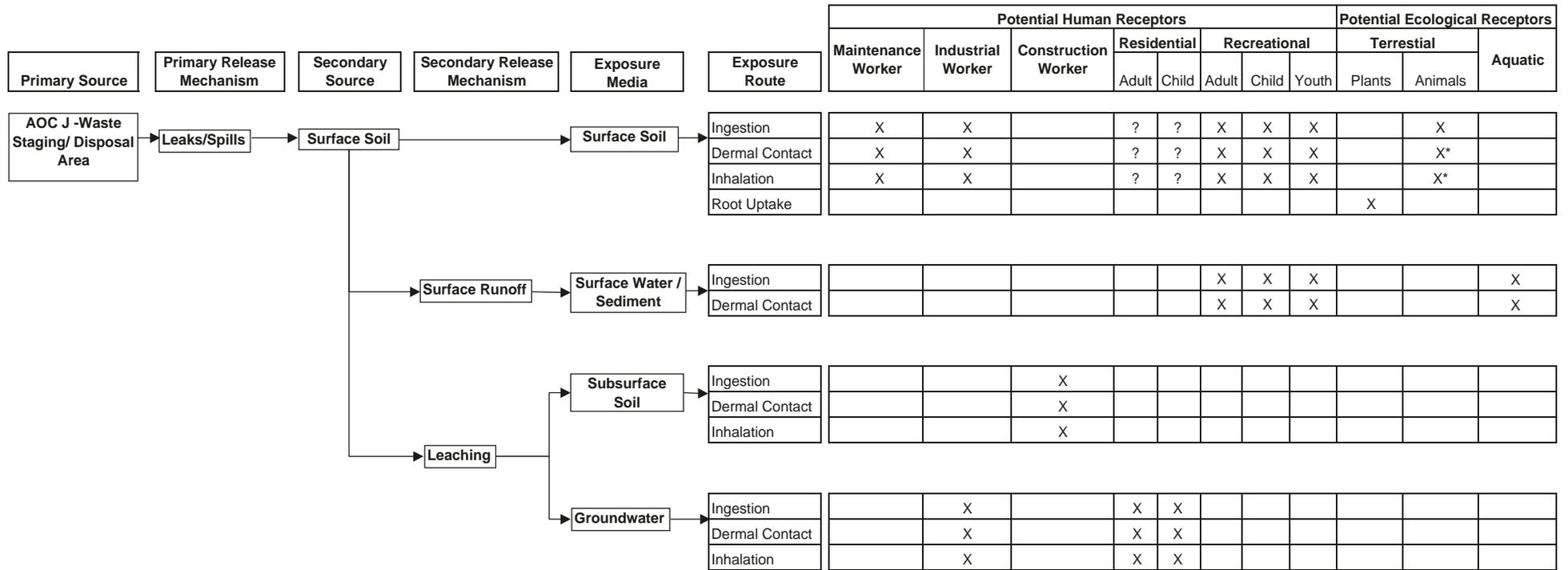
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f. Interstate Technology and Regulatory Council. August 2002. *A Systematic Approach to In Situ Bioremediation in Groundwater Including Decision Trees on In Situ Bioremediation for Nitrates, Carbon Tetrachloride, and Perchlorate*. In Situ Bioremediation Team.

L/kg = liters per kilogram

mg/L = milligrams per liter

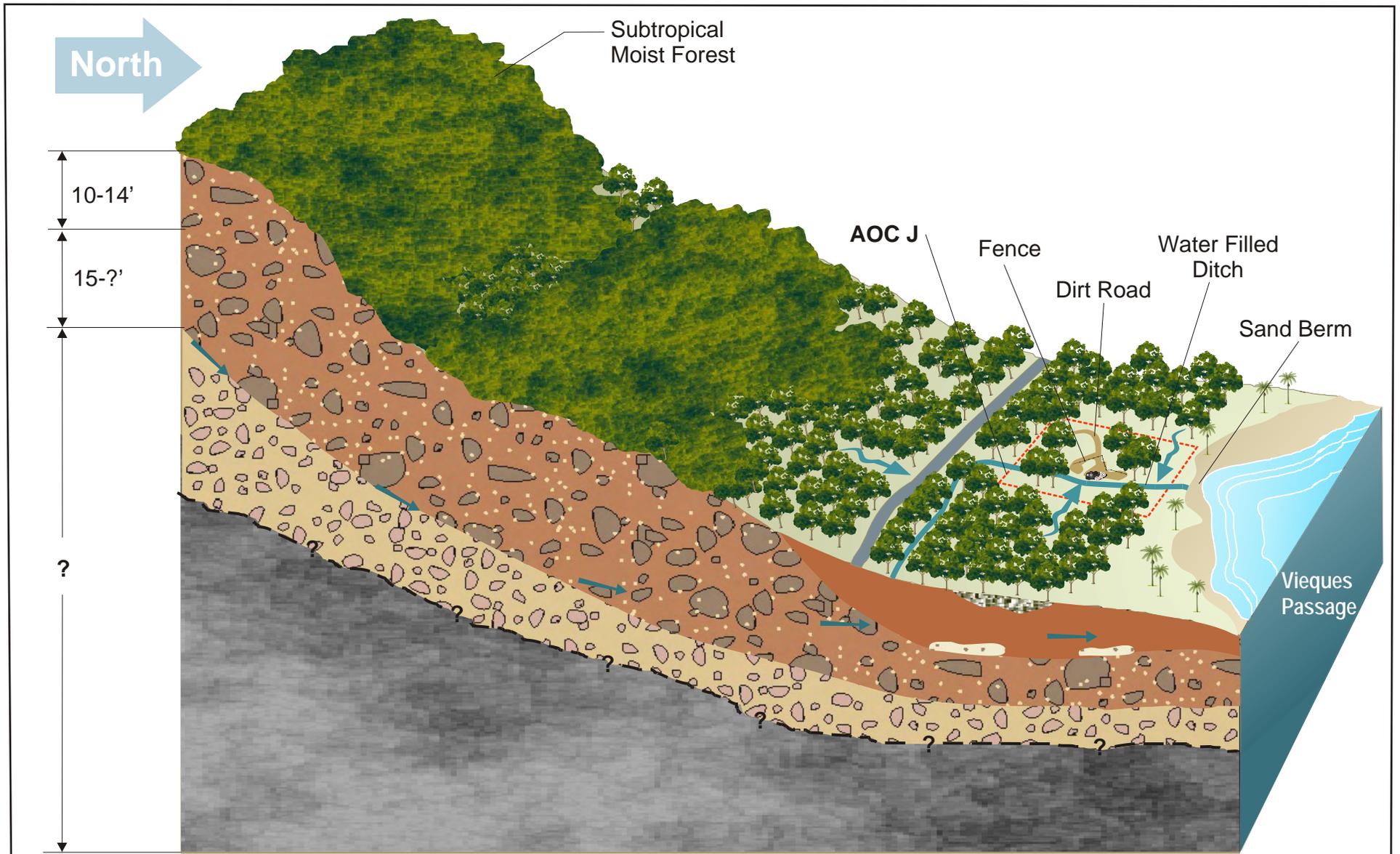
atm<sup>3</sup>m<sup>3</sup>/Mol = atmosphere times cubic meters per mole



**Legend**

- X - Potentially complete exposure pathways identified
- ? = Questionable pathway; however included in the risk assessment for comparison purpose.
- \* = Receptor not evaluated quantitatively in Section 6

**Figure 5-1**  
**Conceptual Site Model for AOC J: Former Staging and Disposal Area Site**  
 AOC J, Former NASD, Vieques, Puerto Rico



**LEGEND**

- |   |   |  |
|---|---|--|
|  Granite             |  SI Silt         |  Surface Water Flow |
|  Saprolite           |  LC Lean Clay    |  Groundwater Flow   |
|  SLC Sandy Lean Clay |  OS Organic Soil |  Inferred Contact   |

**Figure 5-2**  
 Conceptual Site Model  
 AOC J, Former NASD, Vieques Island, Puerto Rico

## SECTION 6

# Remedial Investigation Conclusions and Recommendations

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This section presents the conclusions and recommendations from the AOC J RI.

## 6.1 Summary and Conclusions

AOC J is a former solid waste disposal site on the former NASD in the western portion of Vieques Island, Puerto Rico. In April 2004, the Draft RI Report for AOC J 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 2006), refined as applicable in accordance with regulatory agency comments.

The AOC J area is located approximately 2 miles west of the entrance to the former Navy property, approximately 50 feet south of Vieques Passage. The site is in a wooded area next to an ephemeral stream on the northern edge of the former NASD. The site elevation ranges from approximately sea level to 10 feet above msl. It is accessed by a dirt road extending north from Highway 200. Historical waste disposal activities occurred at the site in an area approximately 1.2 acre in size along the ephemeral stream that extends through eastern side of the site.

The site was used from 1965 to 1973 for waste disposal for construction staging activities. After 1973, most of the unidentified waste was removed from the site and placed in a

municipal landfill off base. No records were kept indicating the size and location of the waste disposal area or the specific types of waste discarded and later removed from the site. No UXO/OE items were found at the site.

The ephemeral stream is the only surface water near the site. It is located just within the eastern access restriction boundary of AOC J. During periods of heavy and prolonged rainfall or ocean surge action, this normally stagnant water body periodically opens to Vieques Passage to the north.

AOC J is underlain by a potentially semiconfined groundwater system composed of alluvial deposits made up of clay and sandy clay. Groundwater was encountered at the site at depths of 3 feet bls near the shore to 9 feet bls at the upgradient well. The Resolución Valley aquifer system, a regional aquifer of western Vieques, was not encountered at the site. Regional groundwater flow is to the north toward Vieques Passage. At AOC J, the local groundwater flow is in an easterly direction toward the ephemeral stream and northeasterly toward Vieques Passage. Overall gradients are relatively flat, indicating slow groundwater movement.

Salinity measurements for groundwater samples collected during the Expanded PA/SI indicate that the groundwater at AOC J is brackish to saline. These salinity readings are not unexpected given the site's low elevation and proximity to Vieques Passage; they indicate that groundwater is intermixed with saltwater. The high salinity renders the groundwater at AOC J unsuitable for potable use without desalinization.

### **6.1.1 Remedial Investigation Activities**

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

- Geophysical surveys to delineate the extent of the solid waste disposed of at the site and to confirm that no MEC are present at proposed sampling locations.
- Completion of five subsurface soil borings with the collection of five surface soil samples and five subsurface samples to characterize the site geology and provide samples for laboratory analysis. The analyses of these samples supplement the analyses of the 12 soil samples previously collected as part of the Expanded PA/SI and the EBS.
- Installation of four monitoring wells to supplement data from four monitoring wells installed during the Expanded PA/SI to characterize the groundwater flow conditions and provide groundwater samples for analyses.
- Collection of groundwater elevation data and groundwater samples from eight monitoring wells to assess the groundwater flow conditions and groundwater quality.
- Collection of five surface water and five sediment samples to assess the potential environmental impacts to the ephemeral stream at AOC J. These samples supplement the data from five surface water samples and five sediment samples previously collected at the site.
- Completion of laboratory analysis of the collected samples for metals, VOCs, SVOCs, pesticides, PCBs, and explosives.

- Collection of site-specific background samples for groundwater, sediment, and surface water for comparison with inorganic chemicals detected in these media at AOC J. For soils, previously established background inorganic chemical values were used for comparison.

The RI was completed in accordance with the provisions of CERCLA and followed the interim final *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). The analytical data were compared to EPA Region 9 PRGs and ecological screening criteria, and the detected chemicals were included in a detailed human health and ecological risk assessment.

## 6.1.2 Nature and Extent of Contamination

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 Soils

The following conclusions were derived from the analytical results of the soil samples:

- A total of 23 metals were analyzed, and results were compared against background levels and screening criteria.
- Five metals (iron lead, manganese, thallium, and zinc) were detected in surface soil above screening criteria and background values.
- Perchlorate was detected in two of five surface soil samples but was not detected above its residential PRG. Ecological and leaching criteria were not available for perchlorate. Perchlorate is also prone to false positive detections at the low levels that were detected at the site (DoD, 2004). Perchlorate was included as a COPC in the HHRA and ERA.
- None of the surface soil samples contained levels of VOCs, SVOCs, pesticides, PCBs, or explosives above screening criteria.
- A total of 10 subsurface soil samples were analyzed for the full suite of chemicals, which included metals, VOCs, SVOCs, PCBs, pesticides, perchlorate and explosives.
- The analytical results of the subsurface soil samples did not have any exceedances above leachability criteria and background, and thus no chemicals were identified for a nature and extent determination in subsurface soil at AOC J.
- None of the subsurface soil samples contained detectable levels of organic chemicals including VOCs, SVOCs, pesticides, PCBs, or explosives above their leachability screening criteria.

The chemicals exceeding the screening criteria were evaluated in the human health and ecological risk assessments.

### 6.1.2.2 Groundwater

The following conclusions were derived from the analytical results of the groundwater samples:

- The analytical results of the unfiltered groundwater samples show concentrations of 10 metals (aluminum, arsenic, barium, cadmium, chromium, iron, lead, manganese, selenium, and vanadium) exceeding background levels and screening criteria at one or more sites or downgradient wells.
- The higher concentration of unfiltered metals within the groundwater compared with the dissolved metals concentrations, as well as the presence of the onsite clay soils, indicate that suspended solids in the groundwater are likely contributing to the elevated unfiltered metals concentrations.
- Elevated concentrations of manganese in the filtered samples suggest that manganese reduction is likely a predominant electron-accepting process in the shallow aquifer. In this natural process, soil bacteria metabolize soil organic matter and manganese present in mineral form, causing increases in soluble manganese (+2 valence). This process often occurs in aquifers with organic-rich soil and depleted oxygen under reducing (low ORP) conditions. Other metals that are sensitive to low ORP and may be elevated under these conditions include iron, arsenic, selenium, and vanadium. These metals were elevated in at least one groundwater sample at the site and these metals plus manganese comprised most of the exceedances of screening criteria in filtered groundwater samples. Their presence in dissolved form may be due to site-specific background geochemical conditions.
- The dissolved metals analyses show that eight metals exceeded screening criteria and background levels. However, only three of the metals (arsenic, barium, selenium) exceeded site-specific background and PRG levels at more than one location. Barium did not exceed its basewide background value of 960 ug/L.
- Four VOCs were detected in the groundwater above PRGs: acetone, bromodichloromethane, chloroform, and TCE. Except for TCE, these VOCs are common laboratory contaminants. TCE was not detected in a subsequent groundwater sample collected from the well where it was originally detected.
- During the Expanded PA/SI in 2000, perchlorate was detected in 1 of 12 groundwater samples above its PRG. This chemical was not detected in the sample collected in 2003 from the same well. Perchlorate was evaluated in the risk assessments.
- None of the groundwater samples contained detectable levels of SVOCs, pesticides, PCBs, or explosives above PRGs.

An HHRA was completed to evaluate whether constituents detected above PRGs pose an unacceptable risk to human health and the environment.

### 6.1.2.3 Surface Water and Sediment

The analytical results of the surface water samples showed that none of the chemicals analyzed exceeded both ecological screening criteria and background levels.

A total of 10 sediment samples were collected and analyzed for the full analytical list of chemicals. When the results were screened against site-specific background and ecological receptor protection-based screening criteria, two metals were identified as exceeding the comparison criteria. These included barium and DDT, which were included for ecological risk assessment. Sediments also were included for human health risk assessment.

Ten surface water samples were analyzed for the full suite of chemicals. Two metals, barium and beryllium, were identified as exceeding the background value and the ecological protection-based screening criteria.

#### **6.1.2.4 Summary**

In summary, the analytical results indicate that the site may have contributed to elevated levels of a few metals detected in the soils, groundwater, and sediments. However, the occurrences of contaminants are sporadic and not widespread across the site. The absence of VOCs, SVOCs, pesticides (except DDT at one location), PCBs, and explosives above PRGs or ecological screening values indicates that these constituents are not likely significant contaminants at the site. It is recognized that there is uncertainty associated with this conclusion due to the absence of soil samples directly through the debris piles. However, this uncertainty will be addressed via the removal action, confirmatory sampling, and residual risk assessments.

To evaluate whether any of these constituents pose an unacceptable risk to human health and the environment, human health and ecological risk assessments were completed.

#### **6.1.3 Human Health Risk Assessment**

The discussion below is a summary of the human health risk assessment conducted for AOC J, 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.

An HHRA was conducted to evaluate whether the elevated levels of COPCs detected above PRGs pose an unacceptable risk to human health. To provide a conservative assessment of risk and meet the guidelines of EPA Region 2, COPCs exceeding PRGs but below background levels were included in the risk assessment. In addition, the maximum detected chemical concentration was compared against the screening criteria presented in the RAGS Part D tables in Appendix L.

The sampling data collected at AOC J from the Expanded PA/SI and this RI were used to select the COPCs. The media evaluated included the surface soil, subsurface soil, sediment, surface water, and groundwater.

The chemicals identified as COPCs for the various media included: several inorganic chemicals in soils and sediments; one VOC and several inorganic chemicals in surface water; and one SVOC, three VOCs, and several inorganic chemicals in groundwater. 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).

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 risks and HI for the various receptors from potential exposure to soils, surface water, sediment, and groundwater were evaluated. Table 6-10 includes a summary of the risks and HI estimated for the various receptors from potential exposure to soils, surface water, sediment, and groundwater.

A major conclusion from the risk assessment was that for the existing and anticipated land use (recreational) potential risks from human exposures to the site conditions are within EPA's target risk range. It was also concluded that human exposures by maintenance workers and construction workers to the site soils are within the target risk range. It is recognized 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.

The carcinogenic risk for a future industrial worker from exposure to groundwater is  $3.0E-4$ , which is above the upper-bound risk range of  $1E-4$ . The estimated HI is 24.6, which is also above the target value of 1.0. Both carcinogenic and noncarcinogenic risks were above the target risk range, primarily from arsenic and manganese in groundwater.

The risk assessment for residential land use at the site shows that the risk levels were above the target risk range, primarily due to the presence of iron and vanadium in the soils. However, both of these chemicals were detected within the range of background levels. The potential risks from exposure to groundwater through potable use exceeded the target risk range due to the following:

- For a future residential adult, risk from groundwater is above the target risk range; the HI from groundwater is 69. The exceedance is attributable to arsenic, perchlorate, and manganese.
- For a future residential child, the ELCR is  $1.6 E-6$  from surface soil and  $4.6E-4$  from groundwater, primarily from arsenic. The HI for exposure to surface soils is 3.8, which exceeds the target HI of 1.0 due to the presence of iron and vanadium in soil. The HI from groundwater is 160 from aluminum, arsenic, iron, manganese, and vanadium and one detection of perchlorate. Perchlorate was not detected in subsequent sampling of the same well.

The groundwater at the site is not suitable for potable use without desalinization due to its high salinity. The presence of manganese-reducing conditions in the aquifer, which are produced by natural geochemical processes, are conducive to elevated concentrations of

other ORP-sensitive metals such as iron, arsenic, vanadium, and selenium. The high salinity may also contribute to the elevated levels of metals detected in the downgradient wells compared to the upgradient wells.

Based on the results of the risk assessment, site-related impacts do not likely pose an unacceptable risk for existing and anticipated land uses. 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.

#### **6.1.4 Ecological Risk Assessment**

The discussion below is a summary of the ecological risk assessment conducted for AOC J, 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.

A SERA, constituting Steps 1 and 2 of the ERA process and the first step (Step 3) of a BERA, was conducted for AOC J using the sampling data from the site.

The screening problem formulation includes the selection of ecological endpoints and risk hypotheses, which are based upon the preliminary CSM. The toxicological properties and fate and transport behavior of the chemicals present at AOC J, particularly the potential to bioaccumulate, are also considered during this process. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process (EPA, 1997a). An assessment endpoint is an explicit expression of the environmental component or a value that is to be protected.

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 AOC J. 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.

Direct ingestion of surface water is only considered when the salinity is below 15 parts per thousand, the approximate toxic threshold for wildlife receptors (Humphreys, 1988). The

onsite ephemeral stream is typically saline due to its proximity to the ocean and thus not a reliable source of drinking water for wildlife except possibly during storm events when runoff flowing through the ephemeral stream may be temporarily fresh. As a conservative measure, direct ingestion of surface water from the ephemeral stream was considered in the food web model.

Upper trophic level receptor species quantitatively evaluated in the ERA were limited to birds and mammals, the taxonomic groups with the most available information regarding exposure and toxicological effects. Because of the limited amount of ingestion-related toxicological data available for amphibians and reptiles, exposures via the food web for these taxa were evaluated using bird and mammal receptors as surrogates.

Lower trophic level receptor species were evaluated in the ERA based upon those taxonomic groupings for which screening values have been developed; these groupings and screening values are used in the ERA.

HQs exceeding 1.0 indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure estimates are derived using intentionally conservative assumptions such that HQs greater than or equal to 1.0 do not necessarily indicate that risks are present or impacts are occurring. Rather, these HQs identify chemical-pathway-receptor combinations requiring further evaluation. HQs that are less than 1.0 indicate that risks are very unlikely, allowing a conclusion of no unacceptable risk to be reached with a high degree of confidence.

In summary, none of the COPCs carried forward from Step 2 were considered as final COCs following the Step 3A refinement. Although many metals and some organic chemicals were identified as COPCs, risks to lower trophic level receptors were considered to be acceptable based on low magnitude of screening value exceedances and comparisons to background/upgradient data. There were no exceedances (based upon LOAELs) for food web exposures.

In conclusion, sufficient data are available within acceptable uncertainty at AOC J to conclude that there are no unacceptable ecological risks, but it is recognized 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.

## 6.2 Conclusions and 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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