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FINAL REMEDIAL INVESTIGATION REPORT FOR SITE 11 WITH TRANSMITTAL LETTER

NAS WHITING FIELD FL

3/2/2000

HARDING LAWSON ASSOCIATES

Harding Lawson Associates

2534-2049

March 2, 2000

Mr. Craig Benedikt
Remedial Project Manager
Federal Facilities Branch
USEPA Region IV
61 Forsyth Street
Atlanta, Georgia 30303

Subject: **Final Remedial Investigation Report**
Site 11, Southeast Open Disposal Area (B)
Naval Air Station Whiting Field, Milton, Florida
Contract No. N62467-89D-0317/116

Dear Craig:

On behalf of Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), Harding Lawson Associates is pleased to submit the subject document for your review and files. Copies of the report have also been forwarded to the Naval Air Station Whiting Field Partnering team.

If you have any questions please call me at (850) 656-1293.

Sincerely,

HARDING LAWSON ASSOCIATES

Rao Angara
Task Order Manager

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REMEDIAL INVESTIGATION

SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B) (LANDFILL)

NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA

UNIT IDENTIFICATION CODE: N60508
CONTRACT NO.: N62467-89-D-0317/116

MARCH 2000

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA 29418

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2590 Executive Center Circle East
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MILTON, FLORIDA

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REMEDIAL INVESTIGATION REPORT

SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B) (LANDFILL)

NAVAL AIR STATION WHITING FIELD MILTON, FLORIDA

Unit Identification Code: N60508

Contract No.: N62467-89-D-0317/116

Prepared by:

Harding Lawson Associates
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Linda Martin, Code 1859, Engineer-in-Charge

February 2000

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, Harding Lawson Associates, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/116 are complete and accurate and comply with all requirements of this contract.

DATE: February 14, 2000

NAME AND TITLE OF CERTIFYING OFFICIAL: Rao Angara
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: Eric Blomberg, P.G.
Project Technical Lead

(DFAR 252.227-7036)

WHF-S11.RI
FGW.02.00

FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Installation Restoration (IR) program. This program complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), and the Hazardous and Solid Waste Amendments of 1984. These acts establish the means to assess and clean up hazardous waste sites for both private-sector and Federal facilities. The CERCLA and SARA acts form the basis for what is commonly known as the Superfund program.

Originally, the Navy's part of this program was called the Naval Assessment and Control of Installation Pollutants (NACIP) program. Early reports reflect the NACIP process and terminology. The Navy eventually adopted the program structure and terminology of the standard IR program.

The IR program is conducted in several stages as follows:

- preliminary assessment (PA),
- site inspection (SI) (formerly the PA and SI steps were called the initial assessment study under the NACIP program),
- remedial investigation and feasibility study (RI/FS), and
- remedial design and remedial action (RD/RA).

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) manages and the U.S. Environmental Protection Agency (USEPA) and the Florida Department of Environmental Protection (formerly Florida Department of Environmental Regulation) oversee the Navy environmental program at Naval Air Station (NAS) Whiting Field. All aspects of the program are conducted in compliance with State and Federal regulations, as ensured by the participation of these regulatory agencies.

Questions regarding the CERCLA program at NAS Whiting Field should be addressed to Ms. Linda Martin, Code 1859, at (803) 820-7341.

EXECUTIVE SUMMARY

A remedial investigation and feasibility study (RI/FS) is being conducted at Naval Air Station (NAS) Whiting Field in Milton, Florida, by Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), as part of the Department of Defense Installation Restoration (IR) program. The IR program was designed to identify and abate or control contaminant migration resulting from past operations at naval installations.

A phased approach was implemented to conduct the RI. Phase I was completed in May 1992. The subsequent phases of the RI were designated as Phase IIA and Phase IIB. Fieldwork for Phase IIA was completed in March 1994. Phase IIB was completed in November 1996. A source removal action was conducted by CH2M Hill in June 1999 to address exceedances of residential and industrial cleanup criteria by benzo(a)pyrene.

This RI report contains the results of assessment activities used to characterize site-specific chemicals detected in environmental media (soil gas, soil, and groundwater) at Site 11, Southeast Open Disposal Area (B) (Landfill) at NAS Whiting Field. Data obtained from these activities were used to evaluate the nature and extent of contamination at the site and support feasibility studies (if required) and baseline risk assessments. Human health and ecological baseline risk assessments are included with the RI report.

The fieldwork conducted during the RI included the following tasks:

- soil gas survey,
- geophysical survey,
- test pit investigations,
- subsurface soil sampling,
- surface soil sampling,
- monitoring well installation,
- groundwater sampling, and
- hydrogeologic investigations.

Soil gas samples were analyzed for methane and other volatile organic compounds (VOCs). Soil and groundwater samples were analyzed for target compound list organic analytes, and target analyte list inorganic analytes.

The following conclusions are based on results of the RI investigation activities at Site 11, Southeast Open Disposal Area, NAS Whiting Field.

- Interpretation of the geophysical survey suggested the presence of a single well-defined landfill boundary and three additional smaller anomalies likely caused by surface ferromagnetic metal lying on or near the ground surface.

- Methane and total volatile organic compounds (TVOCs) were detected at 2 of the 46 soil gas locations investigated. At these locations, methane accounted for 58 percent and 100 percent of the total gas measurement. However, the occurrence of soil gas appears to be limited in areal extent and there is no evidence of off-site migration.

- Surface soil samples were reported to contain one VOC, fourteen semivolatile organic compounds (SVOCs), and nine pesticide compounds. However, only concentrations of two SVOCs (benzo(a)pyrene and benzo(a)anthracene) and one pesticide compound (dieldrin) were detected at concentrations exceeding either the USEPA Region III RBCs or their Florida soil cleanup target levels. The location of the benzo(a)pyrene and benzo(a)anthracene exceedances was excavated in June 1999 as part of a source removal action.

- Twenty-three inorganic analytes were detected in the surface soil. Aluminum, arsenic, iron, manganese, and lead were detected in one or more samples in excess of either or both the applicable USEPA Region III risk-based concentrations (RBCs) or the Florida soil cleanup target levels for residential soil.

- Subsurface soil samples were reported to contain three VOCs, one SVOC, five pesticides, and two PCB compounds. However, none of the organic compounds were detected at concentrations exceeding the USEPA Region III RBCs or Florida soil cleanup target levels.

- Nineteen inorganic analytes were detected in the subsurface soil samples. Concentrations of aluminum, beryllium, iron, and manganese in samples exceeded one or more of the USEPA Region III residential or industrial RBCs, or the Florida soil cleanup target levels.

- All of the pH values except one reported for groundwater samples collected at Site 11 were outside the range of Florida Secondary Drinking Water Standards. However, all of the values except two were within the range observed in background samples collected at NAS Whiting Field.

- Four VOCs and two SVOCs were detected in groundwater samples from monitoring wells at Site 11. The detected concentrations of two of the VOCs (vinyl chloride and benzene) exceeded the Florida groundwater cleanup target levels for these compounds. No SVOCs, pesticides, or PCBs were detected in groundwater samples at concentrations exceeding the Florida groundwater cleanup target levels or Federal MCLs. Seventeen inorganic analytes were detected in the Phase IIB groundwater samples. Three inorganic analytes (aluminum, iron, and manganese) were detected at levels that exceeded their respective Florida groundwater cleanup target levels and Federal MCLs.

- At Site 11, the groundwater flow direction is toward the southeast across the site and likely discharges to Big Coldwater Creek. Big Coldwater Creek is located approximately 9,000 feet downgradient of the site. The average horizontal hydraulic gradient for the site area is 0.0029 ft/ft. The geometric mean for the hydraulic conductivity data of monitoring wells in the site area was 8.38 ft/day, and the average seepage velocity value was 0.074 ft/day.

- The Human Health Risk Assessment identified six polynuclear aromatic hydrocarbons (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene),

one pesticide compound (dieldrin), and three inorganic analytes (arsenic, iron, and lead) as the HHCPCs for surface soil at Site 11. No analytes were selected as HHCPCs for subsurface soil. In groundwater samples, three VOCs (1,2-dichloroethene, benzene, vinyl chloride), one SVOC (bis(2-ethylhexyl)phthalate),y and five inorganic analytes (aluminum, arsenic, iron, manganese, and thallium) were identified as HHCPCs.

- The HHCPCs detected in surface soil, subsurface soil, and groundwater do not pose unacceptable carcinogenic risks to the evaluated receptors based on USEPA target risk range of 1×10^{-4} to 1×10^{-6}.

- The total ELCR at Site 11 associated with ingestion of soil by a hypothetical future resident (7×10^{-5}) exceeds Florida's target risk level of concern (1×10^{-6}) due to benzo(a)pyrene and arsenic. The total ELCR at Site 11 associated with ingestion of groundwater by hypothetical future resident (9×10^{-5} exceeds Florida's target level of concern due to vinyl chloride and arsenic.

- The surface soil, subsurface soil, and groundwater noncancer risks are at or below USEPA and FDEP target levels for all potential current and hypothetical future receptors.

- Risks associated with exposures to ECPCs in Site 11 surface soil were evaluated for terrestrial wildlife. Based on the results of the food-web model, lethal risks to terrestrial wildlife at Site 11 are not predicted.

- Sublethal risks to terrestrial wildlife associated with ingestion of pesticides and lead in surface soil and food items were identified; however, elevated concentrations of 4,4'-DDD and lead are localized in the immediate area surrounding sampling location 11-SL-02. Sublethal risks to small mammals and birds appear to be localized to location 11-SL-02 while impacts to top predator populations are predicted over the entire area of Site 11.

- The ERA concluded that growth and reproduction of small mammal and bird populations may be impacted in the area near sample location 11-SL-02, while sublethal impacts to top predator populations are likely over the entire area of Site 11. In addition, the survival of terrestrial invertebrates and consequent abundance for foraging mammals and birds may be impacted from contaminants detected at surface soil location 11S00201 due to TPH and 4,4'-DDT.

RECOMMENDATIONS. Based upon the interpretation of findings from the remedial investigation activities, a feasibility study is recommended for Site 11 to evaluate potential strategies for the reduction in human health and ecological risks associated with surface soil at the site. In addition, the presence of vinyl chloride in Site 11 groundwater samples at concentration exceeding Florida's target risk level indicates that additional sampling and remedial measures may be required. However, all groundwater contamination issues, including soil leaching, will be addressed as part of the current remedial investigation for the facilitywide groundwater study (Site 40).

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
ARAR	applicable or relevant and appropriate requirement
BAF	bioaccumulation factor
BAT	Bengt-Arne-Torstensson
bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm/sec	centimeters per second
CO_2	carbon dioxide
CPC	chemical of potential concern
CRDL	contract-required detection limit
CT	central tendency
%D	percent Difference
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DQO	data quality objective
ECPC	ecological chemical of potential concern
Eh	redox potential
ELCR	excess lifetime cancer risk
EM	electromagnetic
EPC	exposure point concentration
ERA	ecological risk assessment
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FS	feasibility study
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
GIR	General Information Report
HHCPC	human health chemical of potential concern
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HRS	Hazard Ranking System
IAS	initial assessment study
IDL	instrument detection limit
IR	Installation Restoration
IRIS	Integrated Risk Information System

GLOSSARY (Continued)

K	hydraulic conductivity
LOAEL	lowest observed adverse effects level
MAG	magnetometry
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MS/MSD	matrix spike and matrix spike duplicate
μg/kg	micrograms per kilogram
μg/ℓ	micrograms per liter
n	effective porosity
NAS	Naval Air Station
NACIP	Navy Assessment and Control of Installation Pollutants
NCP	National Oil and Hazardous Substances Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAEL	no observable adverse effects level
NPL	National Priority List
NTU	nephelometric turbidity unit
O_2	carbon dioxide
OVA	organic vapor analyzer
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCE	perchloroethylene
PCPT	piezocone penetrometer test
PDE	potential dietary exposure
PCSCC	Petroleum Contamination Site Cleanup Criteria
PVC	polyvinyl chloride
QAPP	Quality Assurance Program Plan
RBC	risk-based concentration
RGO	remedial goal option
%RSD	percent Relative Standard Deviation
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
RME	reasonable maximum exposure
RPD	relative percent difference
RTV	reference toxicity value
SARA	Superfund Amendments and Reauthorization Act
SDG	sample delivery group
SFF	site foraging frequency
SI	site inspection
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
SQL	sample quantitation limit
SCTL	Soil Cleanup Target Level

GLOSSARY (Continued)

SU	standard unit
SVOC	semivolatile organic compound
TAL	target analyte list
TCE	trichloroethene
TCL	target compound list
TM	trademark
TPH	total petroleum hydrocarbons
TVOC	total volatile organic compound
UCL	upper confidence limit
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

Harding Lawson Associates (HLA), under contract to the Department of Navy, Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), is submitting the Remedial Investigation (RI) Report for Site 11, Southeast Open Disposal Area, at Naval Air Station (NAS) Whiting Field located in Milton, Florida. The RI Report for Site 11 is one in a series of site-specific reports being completed in conjunction with the NAS Whiting Field General Information Report (GIR) (ABB-ES, 1998) to summarize the previous investigations and to present the results of the RI.

The Remedial Investigation and Feasibility Study (RI/FS) is being conducted on behalf of the Navy at NAS Whiting Field under contract No. N62467-89-D-0317. The RI was conducted in three phases. The Phase I RI field program was completed in May 1992. The Phase IIA RI field program was conducted between May 1992 and March 1994. The Phase IIB RI field program was completed in November 1996.

A source removal action was conducted by CH2M Hill in June 1999 to address exceedances of residential and industrial cleanup criteria by benzo(a)pyrene. Details of the source removal are presented in Appendix J.

Installation Location and Description. NAS Whiting Field is located in Santa Rosa County, in Florida's northwest coastal area, approximately 7 miles north of Milton and 20 miles northeast of Pensacola (Figure 1-1). NAS Whiting Field presently consists of two air fields separated by an industrial area. The installation is approximately 2,560 acres. Figure 1-2 presents the installation layout and locations of RI/FS sites at NAS Whiting Field. A complete description of historic operations at the facility is presented in Section 1.3 and Appendix A of the NAS Whiting Field GIR (ABB-ES, 1998).

1.1 PURPOSE OF THE RI/FS. The purpose of the NAS Whiting Field RI is to identify and characterize the nature and extent of chemicals in environmental media and potential risks to human and ecological receptors that might be posed by toxic or hazardous chemicals present onsite. The chemicals were potentially released to the environment during past waste disposal practices or spills. The data collected during the RI field program will also be used in an FS (if necessary) to screen, evaluate, and select remedial alternatives to provide permanent, feasible solutions to environmental impacts that may be a result of past waste disposal practices or spills.

1.2 SITE DESCRIPTION. Site 11 is located along the eastern facility property boundary near the South Air Field (Figure 1-2). The site was originally identified as an approximately 3-acre area encompassing an old borrow pit that was used as an open disposal area from 1943 until approximately 1970. The site had uncontrolled access and received a wide variety of wastes, including general refuse, construction debris, tree clippings, furniture, waste solvents, paint, transformer oils, hydraulic fluid, and various other oils. Background information was gathered from the Initial Assessment Study (IAS) (Envirodyne Engineers, Inc., 1985).

When disposal operations were discontinued in 1970, a final covering was placed over the site and pine trees were planted (Geraghty & Miller, December 1986).

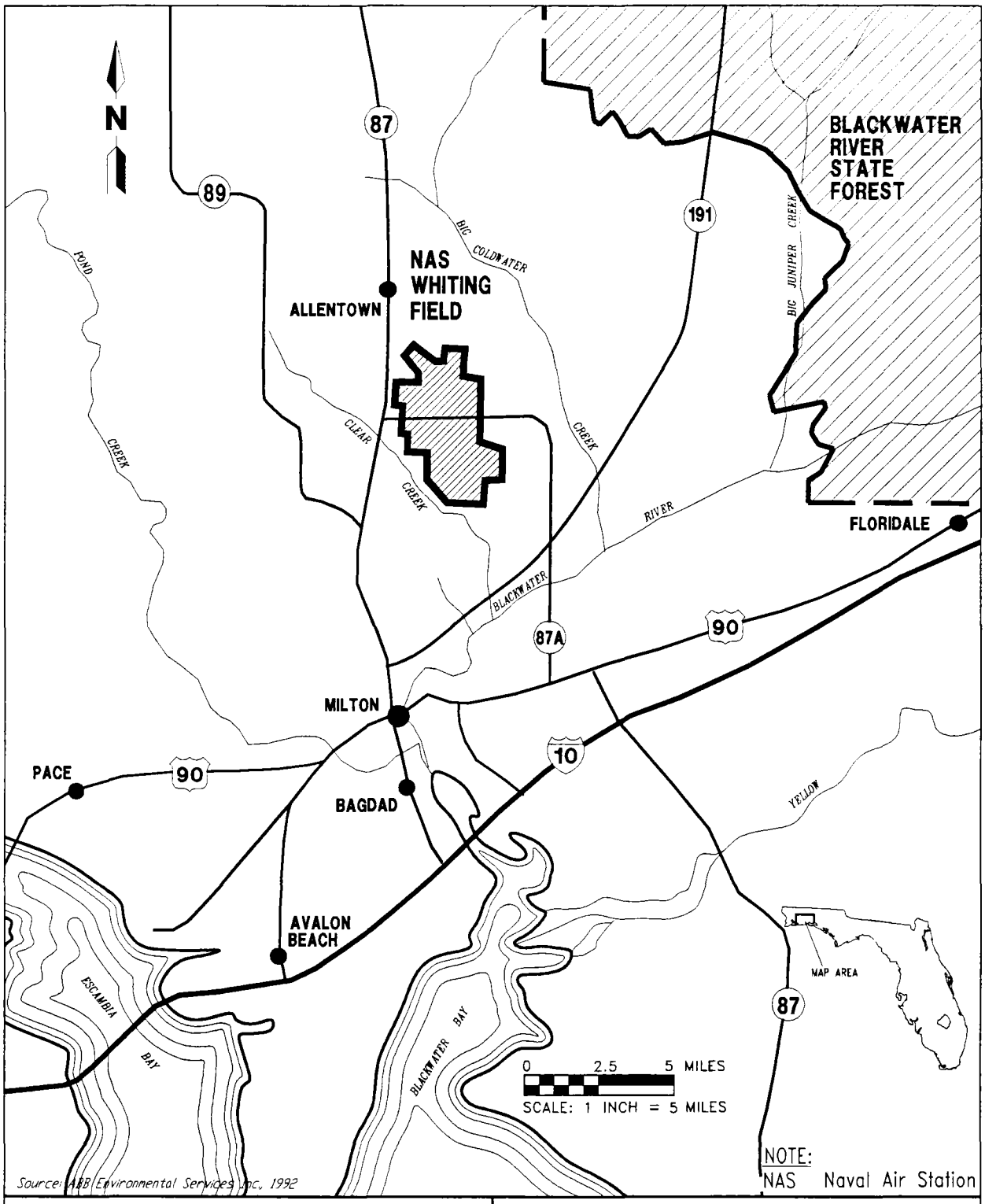

FIGURE 1-1
FACILITY LOCATION MAP

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REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

Figure 1-2 Location of RI/FS Sites at NAS Whiting Field

11 x 17

1.3 REGULATORY SETTING. The Navy Installation Restoration (IR) program was designed to identify and abate or control contaminant migration resulting from past operations at naval installations. The IR program is the Navy response authority under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and Executive Order 12580. CERCLA requires that Federal facilities comply with the act, both procedurally and substantively. SOUTHNAVFACENGCOM is the agency responsible for the Navy IR program in the southeastern United States. Therefore, SOUTHNAVFACENGCOM has the responsibility to process NAS Whiting Field through preliminary assessment, site inspection, RI/FS, and remedial response selection in compliance with the guidelines of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300).

Section 105(a)(8)(A) of SARA requires the U.S. Environmental Protection Agency (USEPA) to develop criteria to set priorities for remedial action for chemicals detected in environmental media based on relative risk to human health and the environment. To meet this requirement, USEPA has established the Hazard Ranking System (HRS) as Appendix A to the NCP. First promulgated in 1982, the HRS was amended in December 1990, effective March 14, 1991 (55 Federal Register No. 241:51532-51667), to comply with requirements of Section 105(c)(1) of SARA to increase the accuracy of the assessment of relative risk. The HRS has been substantially revised and is designed to prioritize sites after the site inspection (SI) phase of the CERCLA process. The HRS score for NAS Whiting Field was generated in 1993. The score was sufficient to place NAS Whiting Field on the National Priority List (NPL).

In January 1994, the USEPA placed NAS Whiting Field on a proposed list of sites to be included on the NPL (40 CFR 300, Federal Register, 18 January 1994), and on May 31, 1994, NAS Whiting Field was placed on the NPL effective June 30, 1994 (40 CFR 300, Federal Register, May 31, 1994). As a result, the RI/FS for NAS Whiting Field must follow the requirements of the NCP, as amended by SARA, and regulatory guidance for conducting RI/FS programs under CERCLA.

1.4 REPORT ORGANIZATION. The RI Report is organized into nine chapters (Chapters 1.0 to 9.0). Chapter 1.0 presents the purpose, site description, and regulatory setting for the RI at NAS Whiting Field. Chapter 2.0 summarizes previous investigations. Chapter 3.0 presents the investigative methodology for Phase IIA and Phase IIB of the RI. Chapter 4.0 presents the site-specific data quality assessment. Chapter 5.0 discusses the investigative results of the assessment. Chapter 6.0 presents the Human Health Risk Assessment (HHRA), and Chapter 7.0 presents the Ecological Risk Assessment (ERA). Chapter 8.0 discusses the fate and transport of chemicals determined to be human and/or ecological chemicals of potential concern. Chapter 9.0 provides a summary of the conclusions and recommendations. Chapter 10.0 presents professional review certification.

CHAPTER 2.0

2.0 PREVIOUS INVESTIGATIONS

This chapter summarizes the previous investigations at Site 11, Southeast Open Disposal Area, at NAS Whiting Field. Previous investigations include an IAS, Verification Study, and the Phase I of the RI.

2.1 INITIAL ASSESSMENT STUDY. Background information was gathered for the IAS (Envirodyne Engineers, Inc., 1985) by conducting a record search, performing an onsite survey, and conducting interviews with long-time employees and retired personnel familiar with the site. Interviews with facility personnel and record reviews indicated that prior to the 1970s most of the hazardous waste was disposed of at various onbase disposal pits.

Site 11 was originally identified as an approximately 3-acre area encompassing an old borrow pit that was used as an open disposal area from 1943 until approximately 1970. The site had uncontrolled access and received a wide variety of wastes, including general refuse, construction debris, tree clippings, furniture, waste solvents, paint, transformer oils, hydraulic fluid, and various other oils (Envirodyne Engineers, Inc., 1985).

Envirodyne Engineers, Inc., recommended in the IAS that a confirmation study be completed based on the types of wastes possibly disposed of at the site, the potential for off-site migration, and the presence of human and ecological receptors. The confirmation study would typically consist of two parts: verification and characterization; however, only the verification phase was conducted.

2.2 VERIFICATION STUDY. The Verification Study (Geraghty & Miller, 1986) at Site 11 consisted of the installation of one monitoring well (WHF-11-1) along the eastern side of the site. Monitoring well WHF-11-1 was installed to a depth of 127 feet below land surface (bls) and later water-level measurements (ABB-ES, 1995a) indicate the well to be hydraulically crossgradient to the site.

One groundwater sample was collected from monitoring well WHF-11-1 and analyzed for USEPA priority pollutants and additional herbicide compounds. Bis-(2-ethylhexyl)phthalate was detected at 23 micrograms per liter ($\mu g/\ell$), and mercury and zinc were detected at concentrations below the State and Federal maximum contaminant levels (MCLs) in effect at that time.

2.3 RI PHASE I INVESTIGATION, 1990-1992. In December 1990, HLA, under contract to the Department of the Navy, and SOUTHNAVFACENGCOM initiated an RI at NAS Whiting Field. The objective of Phase I of the RI was to characterize the nature and extent of contamination at sites identified during the IAS. The Phase I RI program addressed 14 of 18 previously identified sites at the installation.

The RI Phase I investigation at Site 11 consisted of collecting two groundwater samples using a piezocone penetrometer test (PCPT) and Bengt-Arne-Torstensson (BAT) sampler and installing one monitoring well. On April 11, 1991, PCPT exploration WHF-11-CPT-1 was advanced at the southeastern corner of Site 11. A shallow and a deep BAT groundwater sample were collected from WHF-11-CPT-1 at

depths of 92 and 132 feet bls. The two samples were analyzed for volatile organic compound (VOCs) and target analyte list (TAL) inorganic analytes at an off-site laboratory. Acetone and carbon disulfide were detected in the samples, but were interpreted to be artifacts resulting from decontamination procedures (ABB-ES, 1992a). Seven inorganic analytes (aluminum, barium, calcium, iron, manganese, sodium, and zinc) were detected. Detailed results are summarized in the RI Phase I Technical Memorandum No. 5 (ABB-ES, 1992a).

An additional monitoring well (WHF-11-2) was installed at an intermediate depth of 125 feet bls southwest and based on later water-level measurements, the well was determined to hydraulically crossgradient of the site (ABB-ES, 1995a). An *in situ* permeability test (slug test) was conducted to assess hydraulic properties. No groundwater sample from this well was collected for laboratory analysis during the Phase I.

CHAPTER 3.0

3.0 FIELD INVESTIGATIVE METHODS

Field investigative techniques used during the RI to collect the data are described in the RI/FS Workplan, Volume II (E.C. Jordan, 1990), which provides descriptions of sampling methods, field personnel responsibilities, sample management, chain of custody, project documentation, change in field methods, protocols on corrective actions, decontamination procedures, waste management handling, and other general project standards and procedures in Section 3.1, General Site Operations.

Field and laboratory quality assurance and quality control requirements for the RI activities comply with the RI/FS Quality Assurance Project Plan (QAPP) located in Appendix A of the RI/FS Workplan, Volume II (E.C. Jordan, 1990). Health and safety requirements were in accordance with the general Health and Safety Plan located in Volume III of the RI/FS Workplan (E.C. Jordan, 1990).

Field investigative methods not covered in the documents identified above are described in Technical Memorandum No. 7, RI Phase IIB Workplan (ABB-ES, 1995b) and in the NAS Whiting Field GIR (ABB-ES, 1998).

These field and laboratory investigation techniques are in general conformance with USEPA standard operating procedure (USEPA, 1991a and 1996a) and were followed during the RI sampling and analysis program.

Following the RI Phase I, two additional phases of RI activities were conducted at Site 11. Phase IIA investigations were conducted at NAS Whiting Field from 1992 to 1994. At Site 11 these investigations consisted of a geophysical survey, surface soil sampling, test pitting and subsurface soil sampling, monitoring well installations, and groundwater sampling. A detailed summary of the Phase IIA work is presented in RI/FS Technical Memorandums No. 1 through No.6 released in 1994 and 1995. Based upon additional data needs, the RI Phase IIB was carried out during 1995 and 1996. The proposed Phase IIB work was presented in the RI/FS Technical Memorandum No. 7, Phase IIB Workplan (ABB-ES, 1995b). At Site 11, RI Phase IIB activities included a soil gas survey, surface soil sampling, monitoring well installations, and groundwater sampling.

The following sections provide a brief description of the Phase IIA and Phase IIB field investigation and sampling methodologies at Site 11.

3.1 GEOPHYSICAL SURVEY. Geophysical surveys at Site 11 were conducted in May through June 1992 as part of the Phase IIA investigation. The purpose of the geophysical surveys was to assess the lateral and vertical extent of the waste disposal area and locate buried metallic or nonmetallic objects that may indicate a potential waste disposal area.

Geophysical methods used at the site include electromagnetic (EM) induction and magnetometry (MAG). Blackhawk Geosciences, Inc., Golden, Colorado, was subcontracted by HLA to conduct the geophysical tasks. A technical report describing the methodology, results, and conclusions of the geophysical survey was prepared in February 1993 (ABB-ES, 1993).

Data from the EM and MAG surveys were collected along east to west grid lines that were spaced 40 feet apart. The grid lines were oriented with a magnetic compass and measuring tape. Data were collected at stations located at 10-foot intervals along each grid line. These grid lines were later surveyed by a Florida-licensed surveyor. The location of the grid and the plotted geophysical data are presented on Figures A-1 through A-4 in Appendix A. The results of the geophysical survey are presented in Section 5.3.

3.2 SOIL GAS SURVEY FOR METHANE. During the Phase IIB investigation, a soil gas survey was conducted in June 1995 at Site 11 to assess the presence of methane gas or other VOCs potentially emanating from the site. A total of 31 soil gas samples was collected across the site and up to 100 feet beyond the site boundary. Sample locations were determined based on a 100- by 100-foot grid. Figure 3-1 presents the locations of the active soil gas survey points. The 31 soil gas samples were collected from grid locations 9 through 20, 23 through 34, 37 through 41, and 43 through 48 (Figure 3-1).

At each location, an open-ended stainless-steel tube was pushed or manually driven to the proposed sampling depths of 1.5 feet and 3.0 feet bls. Organic vapor measurements were made at the two sampling depths. The air within the stainless-steel tube was purged with a vacuum pump to obtain a representative sample of soil gas. Organic vapor concentrations were measured in the field with either a Portafid II™ or a Foxboro OVA-128™ organic vapor analyzer (OVA). If total VOCs were detected in a soil gas sample, a granulated charcoal filter was attached to the OVA intake probe. Organic vapor measurements were recorded with and without the charcoal filter. A comparison of the two measurements allowed a qualitative analysis of the presence of methane gas. Soil gas samples were not submitted for laboratory analysis.

A common problem associated with the use of the OVAs was probe flame-out due to either high humidity or high carbon dioxide (CO_2)/low oxygen (O_2) levels in the soil-gas samples. If an OVA flame-out occurred, a landfill gas analyzer (LFG-10™) was used to measure methane and CO_2 levels. The results of the soil gas survey are presented in Section 5.4.

3.3 SURFACE SOIL ASSESSMENT. Five surface soil samples were collected at Site 11 in August 1992 as part of Phase IIA RI. An additional 13 surface soil samples were collected in January 1996 during Phase IIB RI.

The five Phase IIA surface soil sampling locations (11-SL-01 through 11-SL-05, and duplicate sample 11-SL-01A) were identified based upon visual inspection and geophysical anomalies (Figure 3-2). Surface soil samples were collected from the land surface to a maximum depth of 12 inches bls using a decontaminated stainless-steel auger. To minimize volatilization, samples for VOC analyses were directly transferred from the stainless-steel auger bucket with a stainless-steel spoon into standard soil sample jars. The remaining sample was emptied into a glass bowl using a stainless-steel spoon. Soil samples for all other analyses were thoroughly mixed in a glass bowl prior to transferring into standard sample containers. Surface soil samples were analyzed for target compound list (TCL), VOCs, semivolatile organic compound (SVOCs), pesticides and polychlorinated biphenyls (PCBs), and TAL inorganic analytes.

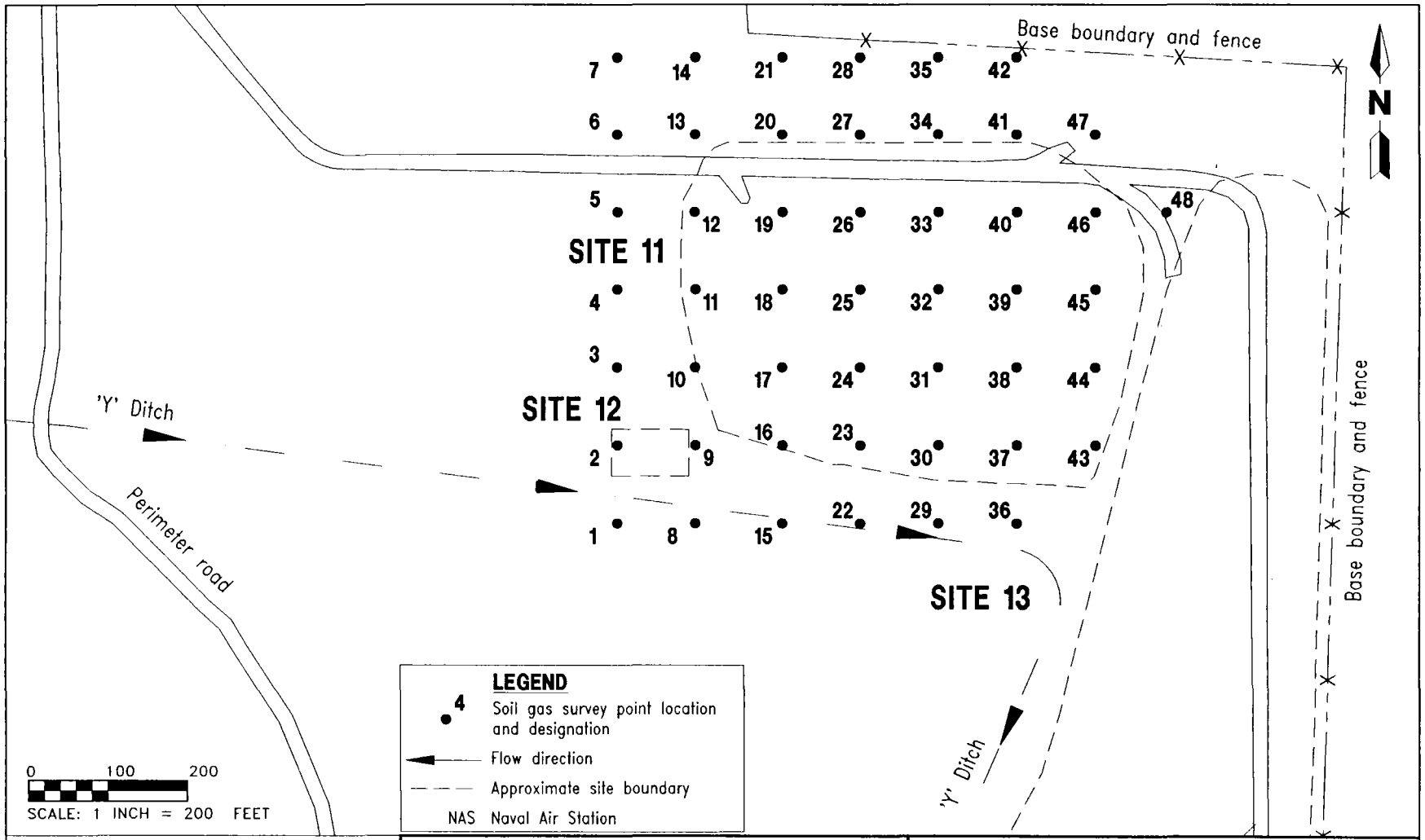

FIGURE 3-1
LOCATION OF ACTIVE SOIL GAS SURVEY POINTS

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

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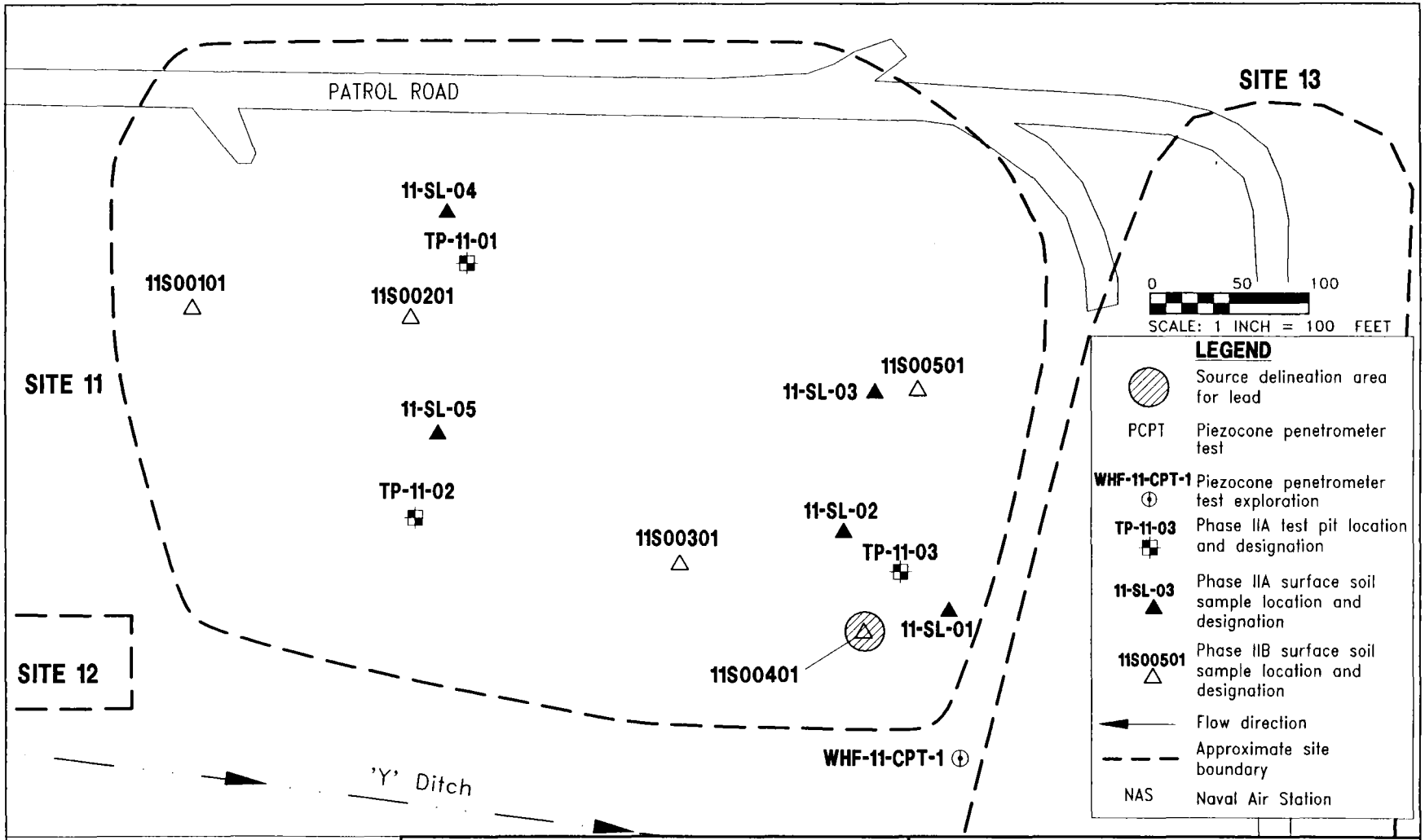

FIGURE 3-2
LOCATION OF SURFACE SOIL SAMPLES, TEST PITS, AND PCPT EXPLORATION

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REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

Five of the thirteen surface soil sample locations (11S00101 through 11S00501) chosen during the Phase IIB RI were selected to obtain an unbiased characterization of on-site surface soil and support both the ERA and the HHRA. Sampling locations were determined using the systematic sampling method where a point is chosen at random along a transect, and then samples are collected at equidistant intervals thereafter (Gilbert, 1987; USEPA, 1989a). Samples (11S00101 through 11S00501) were analyzed for TCL VOCs, SVOCs, pesticides and PCBs, TAL inorganic analytes, and total petroleum hydrocarbons (TPH).

The remaining eight Phase IIB surface soil samples (11S00601 through 11S01301) were collected on a ten-foot-radius around Phase IIA soil sample 11S00401. These samples were collected for source delineation of lead at this location and the samples were analyzed for lead only. After review of the draft RI report, it was noted that the delineation of lead should have been ground surface soil sample 11-SL-02. CH2M Hill conducted additional soil sampling in April 1999 to delineate lead around soil sample 11-SL-02. Results of this sampling event are presented in Appendix J.

All Phase IIB surface soil samples were collected from the land surface to a maximum depth of 12 inches bls using a decontaminated stainless-steel auger. Soil samples were described using the Unified Soil Classification System and recorded in a bound field logbook by HLA personnel.

Background screening criteria were established by collecting background samples across the installation from each U.S. Department of Agriculture (USDA) soil type identified at NAS Whiting Field. These data are presented in Subsection 3.3.1 of the GIR (ABB-ES, 1998). The arithmetic mean of analytes detected in the background soil samples was calculated by summing individual analyte concentrations and then dividing the sum by the number of samples from which the analytes were detected. Samples were then compared to twice the arithmetic mean of analyte concentrations detected in background surface soil samples associated with the Troup loamy sand and Dothan fine sandy loam soil types. The surface soil sampling results are discussed in Section 5.5 of this report.

3.4 SUBSURFACE SOIL ASSESSMENT. Subsurface soil assessment at Site 11 consisted of split-spoon sampling collected during the installation of monitoring wells for both Phase IIA and Phase IIB, and the collection of three soil samples during Phase IIA test pit excavations. The following subsections provide a description of the soil sampling activities associated with both monitoring well installations and the excavation of test pits.

Detailed lithologic descriptions for all monitoring wells and PCPT soundings are presented in Phase I Technical Memorandum No. 1, Geological Assessment (ABB-ES, 1992b) and in Phase IIA Technical Memorandum No. 2, Geological Assessment (ABB-ES, 1995c). A summary of the Site 11 lithology is also presented in Section 5.1 of this report.

3.4.1 Split-Spoon Sampling Lithologic data were recorded during monitoring well installation. Monitoring wells WHF-11-1S and WHF-11-3 were installed during Phase IIA and monitoring well pair WHF-11-4S/WHF-11-4D was installed during Phase IIB. Soil samples were collected using a 2-foot split spoon and visually inspected by an HLA geologist. All data were entered into a bound logbook. Detailed soil descriptions and other pertinent data are presented in the boring logs for the soil boring investigation located in Phase IIA Technical Memorandum No. 2, Geological Assessment (ABB-ES, 1995c). Split-spoon samples were generally

collected at 5-foot intervals during drilling of the monitoring wells. Monitoring well installations were conducted in conjunction with the hydrogeologic and groundwater investigations (summarized in Phase IIA Technical Memoranda Nos. 4 [ABB-ES, 1995a] and 5 [ABB-ES, 1995d], respectively).

3.4.2 Test Pitting Three test pits (TP-11-01, TP-11-02, and TP-11-03) were excavated on October 8, 1992, at Site 11 following the completion of the geophysical survey. UXB International, Inc., from Chantilly, Virginia, was subcontracted by HLA to conduct the test pit excavations.

The test pits were excavated at a location where a geophysical anomaly potentially defined buried materials. The purpose of the test pits was to characterize waste materials, if present, by the description, collection, and chemical analysis of a subsurface soil sample.

Prior to excavating the test pits, the proposed areal dimensions and orientations of the test pits were surveyed by UXB with a hand-held magnetometer, a terrain conductivity meter (FEREX™ 4.021), and a metal detector. Site-specific field activities also included clearing of vegetation.

After each test pit location and orientation had been determined, the four corners of the test pits were staked. The staked locations were referenced to the grid coordinates defined for the geophysical survey. A backhoe was used to excavate rectangular pits. The physical description of each soil layer and waste type was recorded in the field logbook during test pit excavation. A subsurface soil sample was collected directly from the backhoe bucket during the excavation. Following sample collection, the test pit was backfilled with excavated soil.

Three subsurface soil samples (11-SS-01-01, 11-SS-02-02, and 11-SS-03-03) were collected from a depth of 5 to 6 feet bls in the test pits. Soil samples for VOC analyses were collected with a decontaminated stainless-steel spoon directly from the backhoe bucket and placed into a sample jar. Additional sample portions were scooped from the backhoe bucket with a stainless-steel spoon, mixed thoroughly in a glass bowl, and then transferred to the appropriate standard sample containers. The subsurface soil samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, and TAL inorganic analytes. The location of the test pits are presented on Figure 3-2. Sampling results are discussed in Section 5.6 of this report.

3.5 HYDROGEOLOGIC ASSESSMENT. The hydrogeologic assessment of Site 11 included Site 11 and five adjacent sties, including Site 9 (Waste Fuel Disposal Pit), Site 10 (Southeast Open Disposal Area A), Site 12 (Tetraethyl Lead Disposal Area), Site 13 (Sanitary Landfill), and Site 14 (Short-Term Sanitary Landfill). Data from all six sites were combined to provide a larger data set and better understanding of the hydrogeologic conditions.

The hydrogeologic field investigation activities included the collection of water-level data from 15 monitoring wells and conducting slug test analyses on five monitoring wells. Results of the Phase IIA hydrological assessment are presented in Phase IIA Technical Memorandum No. 4, Hydrogeologic Assessment (ABB-ES, 1995a). Monitoring well construction details are presented in Table 3-1. Results of the hydrogeologic assessment are also presented in Section 5.2 of this report.

Table 3-1
Summary of Monitoring Well Construction Details

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	RI Phase of Well Completion	Well Size (inches)	Land Surface Elevation (feet msl)	TOC Elevation (feet msl)	Total Well Depth (feet BTOC)	Approximate Screen Interval (feet BTOC)	Surface Casing Length (feet bls)
Southeast Disposal Area							
Site 9, Waste Fuel Disposal Pit							
WHF-9-1	VS	4	144.66	146.55	118.40	108 to 118	NA
WHF-9-2	I	4	158.11	161.07	124.35	114 to 124	NA
WHF-9-3S	IIA	2	147.92	150.85	108.24	93 to 108	0 to 77
Site 10, Southeast Open Disposal Area (A)							
WHF-10-1	VS	4	144.19	146.73	118.20	108 to 118	NA
WHF-10-2	IIA	2	147.78	150.75	113.14	98 to 113	NA
Site 11, Southeast Open Disposal Area (B)							
WHF-11-1	VS	4	122.48	124.86	128.40	118 to 128	NA
WHF-11-1S	IIA	2	114.91	116.65	54.40	39 to 54	NA
WHF-11-2	I	4	145.19	148.12	125.84	120 to 125	NA
WHF-11-3	IIA	2	114.29	117.19	73.16	58 to 73	0 to 46
WHF-11-4S	IIB	2	126.13	129.43	79.0	64 to 79	NA
WHF-11-4D	IIB	2	125.79	128.94	109	99 to 109	NA
Site 12, Tetraethyl Lead Disposal Area							
WHF-12-1	VS	4	134.20	136.40	113.4	03 to 113	NA
WHF-12-2	IIB	2	132.45	135.56	85	70 to 85	NA
Site 13, Sanitary Landfill							
WHF-13-1	VS	4	100.40	102.66	122.90	112 to 122	NA
WHF-13-1S	IIA	2	104.61	108.97	61.30	46 to 61	NA
WHF-13-1I	IIB	2	NR	109.17	93	83 to 93	NA
WHF-13-2S	IIA	2	99.94	102.86	72.41	57 to 72	0 to 42
WHF-13-3	IIB	2	81.38	81.44	41	26 to 41	NA
WHF-13-4	IIB	2	80.41	80.37	40	25 to 40	NA
Site 14, Short-Term Sanitary Landfill							
WHF-14-1	VS	4	137.83	139.69	153.20	143 to 153	NA
WHF-14-2	IIA	2	142.86	145.80	118.30	103 to 118	0 to 94

Notes: RI = remedial investigation.
msl = mean sea level.
TOC = top of casing.
BTOC = below top of casing.
bls = below land surface.
VS = verification study.
NA = not applicable.
I = remedial investigation Phase I.
IIA = remedial investigation Phase IIA.
IIB = remedial investigation Phase IIB.
NR = not recorded.

3.6 GROUNDWATER ASSESSMENT. Groundwater assessment activities at Site 11 for Phase IIA and Phase IIB RI activities consisted of monitoring well installations and groundwater sampling.During the Phase IIA investigation, two monitoring wells, WHF-11-1S and WHF-11-3, were installed at the site. Both monitoring wells were installed with 15-foot screened sections intersecting the observed water table. WHF-11-1S and WHF-11-3 were completed to depths of 54.42 feet bls and 73.16 feet bls, respectively.

Two additional monitoring wells, WHF-11-4S and WHF-11-4D, were installed at Site 11 during the Phase IIB. The deep monitoring well (WHF-11-4D) was installed with a 10-foot-long screen to a depth of approximately 109 feet bls. The shallow monitoring well (WHF-11-4S) was installed with a 15-foot screen that intersected the water table.

During Phase IIA groundwater samples were collected from monitoring wells WHF-11-1, WHF-11-1S, WHF-11-2, and WHF-11-3 in October 1993. The groundwater samples were collected using a Teflon™ bailer after purging the monitoring wells with either a submersible or bladder pump. The groundwater samples were analyzed for Contract Laboratory Program (CLP) (Naval Energy and Environmental Support Activity [NEESA] Level C) TCL VOCs, SVOCs, pesticides and PCBs, and TAL inorganics.

During Phase IIB of the RI, groundwater samples were collected from all six monitoring wells installed at Site 11 using low-flow sampling techniques. Purging and sampling methodology was followed as presented in Paragraph 2.1.7.2 of the GIR (ABB-ES, 1998). The groundwater samples were analyzed for CLP (NEESA Level D) TCL VOCs, SVOCs, pesticides and PCBs, and TAL inorganic analytes. Samples for TAL inorganic analytes were unfiltered (total analysis) if turbidity was below 10 nephelometric turbidity units (NTUs). If turbidity was greater than 10 NTUs, an additional groundwater sample was collected and filtered (dissolved-phase inorganics) using a 45-micron filter. The purpose of the additional groundwater sample was to assess uncertainty associated with a turbid unfiltered groundwater sample.

Analyses were also conducted to assess secondary water quality parameters and provide data for assessing remedial alternatives in the FS. The analyses included alkalinity, chloride, sulfates, hardness, ammonia nitrates, total Kjeldahl nitrogen, nitrate and nitrite, pH, phosphorous, total dissolved solids, and total organic carbon. Water quality parameter data are presented in Section 5.7 of this report.

CHAPTER 4.0

4.0 SITE-SPECIFIC DATA QUALITY ASSESSMENT

This chapter describes how the data generated during Phase IIB of the RI at Site 11 were managed and evaluated. Section 4.1 describes the analytical program and data management for the RI at Site 11. Section 4.2 summarizes the precision, accuracy, representativeness, completeness, and comparability (PARCCs) report on the data. Section 4.3 presents a summary of the Data Quality Assessment.

The soil and groundwater samples collected during Phase IIA of the RI were qualified according to USEPA functional guidelines for evaluation of organic (USEPA, 1991e) and inorganic analytes (USEPA, 1988) data analyzed using USEPA CLP protocol. The data quality objective (DQO) assessment for the Phase IIA soil samples is presented in detail in RI Phase IIA Technical Memorandum No. 3 (ABB-ES, 1994). The DQO assessment for the Phase IIA groundwater samples is presented in detail in RI Phase IIA Technical Memorandum No. 5 (ABB-ES, 1995d).

4.1 ANALYTICAL PROGRAM. Samples collected during the Phase IIB of the RI at Site 11 were analyzed using off-site laboratory analytical methods. Sampling locations are presented in Chapter 3.0 of this report and sample results are presented in Chapter 5.0 and Appendix C (soil data) and Appendix D (groundwater data).

Environmental samples (surface soil and groundwater) were collected and analyzed by an off-site laboratory using CLP methodology (USEPA, 1986a) for analysis of VOCs, SVOCs, pesticides, PCBs, metals, and cyanide. Some groundwater samples were also analyzed for wet chemistry analyses. The laboratory analytical program is described in more detail in Section 2.2 of the NAS Whiting Field GIR (ABB-ES, 1998).

Analytical results obtained for all environmental samples during the RI sampling events were submitted as NEESA Level D (USEPA Level IV) analytical packages for VOCs, SVOCs, pesticides, PCBs, metals, cyanide, and wet chemistry.

4.2 DATA REVIEW. Data validation is the technical review of individual analytical results relative to the following criteria:

- DQOs and the QAPP in the NAS Whiting Field Workplan (E.C. Jordan Co. Inc., 1990, and ABB-ES, 1995b).
- NEESA guidance document 20.2-047B, Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Program (NEESA, 1988).
- USEPA, CLP National Functional Guidelines for Organic Data Review, February 1994 (USEPA, 1994a).
- USEPA, CLP National Functional Guidelines for Inorganic Data Review, February 1994 (USEPA, 1994b).

The data validation process is described in Section 2.3 of the NAS Whiting Field GIR (ABB-ES, 1998).

The data were reviewed, validated, and evaluated using the PARCC specified in the DQOs. PARCC criteria are described in Section 2.3 of the NAS Whiting Field GIR (ABB-ES, 1998). The Site 11 Phase IIB soil and groundwater analytical data were validated by Laboratory Data Consultants, Inc., of Carlsbad, California, in 1996. The Site 11 Phase IIB data include sample delivery group (SDG) WF11B and WF012 for soil samples and SDG WF028 for groundwater samples. The subsections below summarize the PARCC criteria evaluation of the analytical data.

4.2.1 Precision Precision is a measure of the agreement or repeatability of a set of replicate results (relative percent difference [RPD]) obtained from duplicate laboratory analyses of samples collected from the same location and depth interval. Precision for analytical data collected during the RI sampling events was evaluated using results of field duplicate samples, laboratory duplicate samples, matrix spike and matrix spike duplicate (MS/MSD) samples, and/or consecutive laboratory control samples. The evaluation of precision for the RI sampling event is presented in Table 4-1 and summarized below.

The only exceedance of RPD limits for MS/MSD samples was the semivolatile compound pyrene in SDG WF11B. All other parameters were within MS/MSD RPD limits for the two SDGs.

Soil field duplicate samples from SDG WF11B and SDG WF012 each had a sample with RPD control limit exceedances (RPD greater than 50 percent). Soil field duplicate sample 10S00201 from SDG WF11B had seven organic compounds, (phenanthrene [128 RPD], fluoranthene [90 RPD], pyrene [52 RPD], benzo(a)anthracene [74 RPD], chrysene [59 RPD], bis(2-ethylhexyl)phthalate [183 RPD], benzo(k)fluoranthene [62 RPD]) and two inorganic compounds (calcium [51 RPD] and magnesium [66 RPD]) exceeding the control limits. Field duplicate sample 31S00501 from SDG WF012 had one exceedance of the RPD control limit (magnesium [53 RPD]).

All groundwater MS/MSDs are within the RPD control limits.

Two groundwater field duplicate samples from SDG WF028 had RPD control limit exceedances (RPD greater than 30 percent). Field duplicate sample 12G00101 had a control limit exceedance for the organic compound acetone(67 RPD). Field duplicate sample 11G002201 had five inorganic compounds in exceedance (copper [43 RPD], iron [37 RPD], magnesium [32 RPD], manganese [74 RPD], and zinc [151 RPD]).

Possible causes for RPD exceedances include poor sample heterogeneity, improper sample collection, inconsistent sample preparation, and poor instrument stability. During the validation process, the precision results associated with the exceedances listed above for both soil and groundwater media were considered moderately imprecise. The MS/MSD and field duplicate results indicate an acceptable level of precision was obtained (Appendix B).

4.2.2 Accuracy Accuracy is a measure of the agreement between the true value and the value measured using an analytical method (percent recovery). Accuracy also is evaluated during data validation by assessing initial and continuing calibration data for the analytical instrument. Accuracy for analytical data collected during the RI sampling events was assessed by evaluating percentage recoveries for MS/MSD samples, surrogate recoveries, laboratory control samples, and initial and continuing calibration standard results. The evaluation of recoveries for MS/MSD samples is presented in Table 4-2 and summarized below.

Table 4-1
Precision Summary for Soil and Groundwater Field Duplicate Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	Sample ID	Compound	Sample Concentration	Duplicate Concentration	RPD	Control Limits
Soil						
WF11B						
Organics (μg/kg)	10S00201	Acetone	29	20	37	50
		2-Hexanone	11 U	4	NC	50
		Phenanthrene	68	310	128	50
		Di-*n*-butylphthalate	46	380 U	NC	50
		Fluoranthene	160	420	90	50
		Pyrene	170	290	52	50
		Butylbenzylphthalate	57	380 U	NC	50
		Benzo(a)anthracene	87	190	74	50
		Chrysene	120	220	59	50
		bis(2-Ethylhexyl)phthalate	3,200	140	183	50
		Benzo(a)fluoranthene	150	200	28	50
		Benzo(k)fluoranthene	110	210	62	50
		Benzo(a)pyrene	95	150	45	50
		Indeno(1,2,3-cd)pyrene	58	56	4	50
		Acenaphthene	380 U	40	NC	50
		Anthracene	380 U	54	NC	50
		Carbazole	380 U	84	NC	50
Pesticides and PCB		4,4'-DDT	7.0	8.9	24	50
TAL Metals (mg/kg)		Aroclor-1254	340	390	14	50
		Aluminum	8,960	5,890	41	50
		Arsenic	3.6	2.4	40	50
		Barium	9.2	8.1	13	50
		Beryllium	0.10	0.06	50	50
		Cadmium	1.4	1.3	7	50
		Calcium	1,320	779	51	50
		Chromium	16.0	12.2	27	50
		Cobalt	0.79	0.82	4	50
		Copper	10.8	11.5	6	50
		Iron	9,660	8,650	11	50
		Lead	32.5	29.0	11	50

See notes at end of table.

Table 4-1 (Continued)
Precision Summary for Soil and Groundwater Field Duplicate Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	Sample ID	Compound	Sample Concentration	Duplicate Concentration	RPD	Control Limits
TAL Metals (mg/kg) (Continued)						
		Magnesium	200	100	66	50
		Manganese	39.3	36.4	8	50
		Nickel	2.0	ND	NC	50
		Potassium	69.4	ND	NC	50
		Sodium	181	192	6	50
		Vanadium	24.5	20.8	16	50
		Zinc	50.0	42.9	15	50
		Cyanide	0.20	0.13	42	50
		TRPH	105	66.1	46	50
WF012						
Organics (µg/kg)	31S00501	Acetone	9	8	12	50
TAL Metals (mg/kg)		Aluminum	4,500	6,050	29	50
		Arsenic	1.3	1.2	8	50
		Barium	6.6	8.6	26	50
		Calcium	143	146	2	50
		Chromium	2.8	3.8	30	50
		Cobalt	ND	1.2	NC	50
		Copper	2.2	3.0	31	50
		Iron	2,470	2,840	14	50
		Lead	3.2	2.9	10	50
		Magnesium	80.1	138	53	50
		Manganese	87.0	95.3	9	50
		Nickel	1.9	2.2	15	50
		Potassium	81.9	115	34	50
		Selenium	0.18	ND	NC	50
		Sodium	192	175	9	50
		Vanadium	5.9	7.2	20	50
		Zinc	3.9	5.2	28	50
		Barium,TCLP	0.393	0.574	37	50
		Chromium,TCLP	0.0017 U	0.0018	NC	50
		Selenium,TCLP	0.0217 U	0.2351	NC	50
		Cyanide	0.09	ND	NC	50

See notes at end of table.

Table 4-1 (Continued)
Precision Summary for Soil and Groundwater Field Duplicate Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	Sample ID	Compound	Sample Concentration	Duplicate Concentration	RPD	Control Limits
TAL Metals (μg/ℓ)	11S00601	Lead	19.3	25.0	26	50
Groundwater						
WF028						
Organics (μg/ℓ)	12G00101	Acetone	3	6	67	30
		bis(2-Ethylhexyl)phthalate	2	2	0	30
TAL Metals (μg/ℓ)		Aluminum	14.0	15.1	8	30
		Barium	14.5	14.5	0	30
		Calcium	1,840	1,870	2	30
		Lead	0.60	0.50 U	NC	30
		Magnesium	320	327	2	30
		Manganese	1.0 U	1.4	NC	30
		Potassium	2,220	2,290	3	30
		Sodium	2,310	2,360	2	30
		Thallium	0.70	0.60 U	NC	30
		Zinc	6.7	5.5	20	30
		Cyanide	1.8 U	2.1	NC	30
TAL Metals (μg/ℓ)	11G00201					
		Aluminum	2,770	2,320	18	30
		Arsenic	1.7	2.0	16	30
		Barium	50.3	51.6	3	30
		Beryllium	0.40	0.30 U	NC	30
		Calcium	35,400	41,800	17	30
		Chromium	20.4	19.2	6	30
		Copper	2.0	3.1	43	30
		Iron	232	337	37	30

See notes at end of table.

Table 4-1 (Continued)
Precision Summary for Soil and Groundwater Field Duplicate Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	Sample ID	Compound	Sample Concentration	Duplicate Concentration	RPD	Control Limits
TAL Metals (μg/ℓ) (Continued)						
		Lead	0.50 U	0.90	NC	30
		Magnesium	388	538	32	30
		Manganese	2.2	4.8	74	30
		Potassium	12,900	9,610	29	30
		Sodium	3,420	2,950	15	30
		Vanadium	11.0	11.0	0	30
		Zinc	3.4	24.3	151	30
		Cyanide	1.5 U	3.3	NC	30

Notes: SDG = sample delivery group.
ID = identification.
RPD = relative percent difference.
μg/kg = micrograms per kilogram.
U = compound not detected above detection limit, detection limit is reported.
NC = not calculable.
PCB = polychlorinated biphenyl.
DDT = dichlorodiphenyltrichloroethane.
TAL = target analyte list.
mg/kg = milligrams per kilogram.
ND = nondetect.
TRPH = total recoverable petroleum hydrocarbons.
TCLP = toxicity characteristic leaching procedure.
μg/ℓ = micrograms per liter.
D_1 = sample concentration.
D_2 = duplicate concentration.

$$RPD = 100 \times \frac{|D_1 - D_2|}{0.5\,(D_1 + D_2)} \qquad (1)$$

Table 4-2
Accuracy Summary for MS/MSD Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	MS/MSD Sample	Analyte	% Recovery MS/MSD	Control Limits
WF11B	**Soil**			
	10S00201			
Semivolatile Organic Compounds		Pyrene	39	<36
WF012	31S00501			
Semivolatile Organic Compounds		4-Nitrophenol	120/115	11-114
WF028	**Groundwater**			
	12G00101			
Semivolatile Organic Compounds		4-Nitrophenol	83/-	10-80

Notes: MS/MSD = matrix spike and matrix spike duplicate.
SDG = sample delivery group.
% = percent.
< = less than.

The percent recovery for some of the soil and groundwater samples was above the target range; therefore, some analytical results may be biased low. Some of the analytical results for SVOCs and inorganic analytes were qualified based on the evaluation of percent recovery. The validation process indicates an acceptable level of accuracy was attained (Laboratory Data Consultants, 1996).

A summary of the surrogate spike samples and the surrogate compounds that were outside control limits for the Phase IIB samples collected at Site 11 is presented in Table 4-3. The required control limits were also identified for each surrogate compound. All the samples associated with these surrogates were qualified in accordance with the USEPA functional guidelines as presented in Subsection 3.3.4 of the GIR (ABB-ES, 1998). All data, based on surrogate recoveries, are acceptable for use in conducting the site characterization, risk assessment, and FS.

Table 4-3
Accuracy Summary for Surrogate Recoveries Outside QC Criteria

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG Number	Sample ID	Spiked Analyte	Surrogate Recovery (%R)[1]	QC Limits (percent)
WF11B	12R00101	Decachlorobiphenyl	32/29	60-150
	10S00201	Decachlorobiphenyl	56/55	60-150
	10S00301	Decachlorobiphenyl	45/42	60-150
	11S00201	Decachlorobiphenyl	50/-	60-150
WF012	31R00201	Decachlorobiphenyl	54/43	60-150
	31S00901	Decachlorobiphenyl	45/40	60-150
	31S01201	Decachlorobiphenyl	48/50	60-150
	31S01301	Decachlorobiphenyl	46/-	60-150
WF028	10G00101	Decachlorobiphenyl	50/48	60-150
	11G00101	Decachlorobiphenyl	47/47	60-150
	11G00301	Decachlorobiphenyl	25/24	60-150
	11G00401	Decachlorobiphenyl	29/29	60-150
	11G0020D	Decachlorobiphenyl	59/-	60-150

[1] Reported as value for first column/second column.

Notes: QC = quality control.
SDG = sample delivery group.
ID = identification.
%R = percent recovery.

Initial calibrations are performed to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the volatile TCL. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing a linear calibration curve. Continuing calibrations are performed to ensure that the instrument is capable of producing acceptable qualitative and quantitative data.

Continuing calibration establishes the 12-hour Relative Response Factor on which the quantitations are based and checks satisfactory performance of the instrument on a day-to-day basis. Initial and continuing calibrations for organic analysis are measured by the percent Relative Standard Deviation (%RSD) for initial calibrations and the percent Difference (%D) for continuing calibrations. For inorganic analysis, the initial calibration verification and continuing calibration verification are measured.

Table 4-4 summarizes the initial and continuing calibration details for the soil and groundwater samples collected at Site 11.

The evaluations of the %RSD for the initial calibrations and the %D for the continuing calibrations indicate that the response factors for the system performance check compounds generally met the required criteria for VOCs, SVOCs, pesticides, and PCBs. Samples associated with those SDGs in which certain VOCs, SVOCs, pesticides, and PCBs exhibiting an RRF that does not meet the minimum requirements were qualified as UJ/J.

4.2.3 Representativeness Representativeness is the degree to which the data obtained from an environmental sample accurately reflect the presence or absence of contamination at a site. Field quality control samples (including source water blanks, equipment rinse blanks, and trip blanks) and laboratory quality control samples (including method [organic analyses] and preparation blanks [inorganic analysis]) were used to assess representativeness. Representativeness also is assessed by review of the adherence to extraction and analysis holding times. The evaluation of representativeness in field quality control samples for the RI sampling event is presented in Table 4-5 and summarized below.

Trip Blanks. There were no detections of VOCs above the quantitation limit in the soil trip blanks associated with Site 11. Two groundwater trip blanks (11TO2201 and 10TO2101) both had methylene chloride detected at a concentration of 2 $\mu g/\ell$. Trip blank 11TO2201 also had acetone detected at a concentration of 10 $\mu g/\ell$.

Rinsate Blanks. VOCs, if present, were not detected at concentrations exceeding their detection limits in the rinsate blanks. One SVOC, di-*n*-butylphthalate, was detected in the rinsate blank sample 12R00101 from SDG WF011B at a concentration of 4 $\mu g/\ell$.

Iron, sodium and zinc were detected in both rinse blanks from SDGs WF11B (12R00101) and WF012 (31R00201). SDG WF11B also had barium (0.30 $\mu g/\ell$) and calcium (42.3 $\mu g/\ell$) detected. SDG WF012 had a detection of copper (1.3 $\mu g/\ell$) in the rinse blank 31R00201. SDG WF028 groundwater rinse blank 11R01601 had a detection of acetone (10 $\mu g/\ell$) and di-*n*-butylphthalate (5 $\mu g/\ell$). Groundwater rinse blank11R01601 had calcium, sodium, and cyanide detected at concentrations 62.7, 30.8, and 1.5 $\mu g/\ell$, respectively.

Laboratory Method and Preparation Blanks. Concentrations of styrene (1 $\mu g/\ell$) and xylenes (total)(2 $\mu g/\ell$) were detected in the water method blanks for SDGs WF11B and WF012. Acetone was detected in the soil method blanks for SDGs WF11B and WF012 with concentrations between 4 and 7 $\mu g/\ell$. Di-*n*-butylphthalate was detected in the method blanks for SDG WF11B at a concentration between 69 and 100 $\mu g/\ell$. Bis(2-ethylhexyl)phthalate was

Table 4-4
Summary of Initial and Continuing Calibration for Site 11 Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG[1]	Compound	Initial Calibration	Continuing Calibration	Qualifier
WF11B	Acetone	--	40.0	UJ/J
1/10/96	2-Butanone	--	37.3	UJ
	4-Methyl-2-pentanone	--	37.7	UJ
	2-Hexanone	--	41.0	UJ/J
1/11/96	Trichloroethene	--	27.7	UJ
	2-Hexanone	--	50.9	UJ/J
	1,1,2,2-Tetrachloroethane	--	34.2	UJ
1/12/96	2-Hexanone	--	48.4	UJ/J
1/10/96	Endosulfan	22	--	UJ
WF012	Trichloroethene	--	27.7	UJ
1/11/96	2-Hexanone	--	50.9	UJ
	1,1,2,2-Tetrachloroethane	--	34.2	UJ
1/12/96	2-Hexanone	--	48.4	UJ
1/13/96	Chloromethane	--	27.2	UJ
	Vinyl chloride	--	27.2	UJ
	Acetone	--	68.1	UJ/J
	2-Butanone	--	69.9	UJ
	1,2-Dichloroethane	--	29.6	UJ
	4-Methyl-2-pentanone	--	31.4	UJ
1/15/96	Chloroethane	--	26.3	UJ
	Acetone	--	51.7	UJ/J
	2-Butanone	--	40.8	UJ
	1,2-Dichloroethane	--	35.4	UJ
1/17/96	Endosulfan sulfate	24.0	--	UJ
WF028	Acetone	33.8	--	J
9/2/96	Chloromethane	--	32.4	J
	Chloroethane	--	28.4	J
	Acetone	--	49.2	J
	2-Butanone	--	38.7	J
	4-Methyl-2-pentanone	--	35.7	J
	2-Hexanone	--	38.9	J

See notes at end of table

Table 4-4 (Continued)
Summary of Initial and Continuing Calibration for Site 11 Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

SDG	Compound	Initial Calibration	Continuing Calibration	Qualifier
WF028 (Continued)				
9/3/96	Chloromethane	--	27.4	J
	Acetone	--	34.7	J
	2-Butanone	--	32.6	J
	4-Methyl-2-pentanone	--	32.9	J
	2-Hexanone	--	38.9	J
9/6/96	Chloromethane	--	35.4	J
	Acetone	--	41.0	J
	2-Butanone	--	41.8	J
	1,2-Dichloropropane	--	27.6	J
	4-Methyl-2-pentanone	--	40.5	J
	2-Hexanone	--	43.3	J
	Bromoform	--	26.2	J
	1,1,2,2-Tetrachloroethane	--	26.5	J
9/20/96	3,3-Dichlorobenzidine	--	30.4	J
9/26/96	Benzo(k)fluoranthene	--	28.5	J

Notes: Calibration values expressed as percent recovery.

SDG = sample delivery group.
-- = not detected.
UJ = The analyte was not detected above the reported sample IDL; however, the reported concentration is approximate and may not reliably be presumed to be less than the IDL value.
J = The analyte was positively identified and is reported as an approximate concentration.

Table 4-5
Representativeness Summary for Site 11 Field Quality Control Samples

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	12R00101	31R00201	11R01601	10TO02101	11TO2201
Collect Date:	05-JAN-96	08-JAN-96	28-AUG-96	26-AUG-96	28-AUG-96
Laboratory Sample No.:	RA847012	RA855021	RC044016	RC044001	RC044008
Volatile Organic Compounds (μg/ℓ)					
Acetone	--	--	10 U	--	10 U
Methylene chloride	--	--	--	2	2
Semivolatile Organic Compounds (μg/ℓ)					
Di-*n*-butylphthalate	4	--	5	NA	NA
Pesticides and PCBs (μg/ℓ)					
None detected					
Inorganic Analytes (μg/ℓ)					
Barium	0.30 J	--	--	NA	NA
Calcium	42.3 J	--	67.2 U	NA	NA
Copper	--	1.3 UJ	--	NA	NA
Iron	11.6 UJ	21.2 UJ	--	NA	NA
Sodium	24.6 UJ	40.3 UJ	30.8 U	NA	NA
Zinc	2.2 UJ	3.0 UJ	--	NA	NA
Cyanide	--	--	1.5	NA	NA

Notes: μg/ℓ = micrograms per kilogram.
-- = analyte not detected.
U = compound not detected above detection limit, detection limit is reported.
NA = not analyzed.
PCB = polychlorinated biphenyl.
J = estimated value.

detected in the method blanks associated with SDG WF11B at a concentration of 3 $\mu g/\ell$ for waters and a concentration of 69 $\mu g/\ell$ for soils.

Environmental samples associated with method blanks that contained methylene chloride and acetone with results greater than the instrument detection limit (IDL) but less than 10 times the amount detected in the laboratory preparation blanks were annotated with UJ qualifier (Laboratory Data Consultants, 1996).

Both SDGs WF11B and WF012 had detections of iron, nickel, sodium, zinc, and calcium. SDG WF11B also had a detection of aluminum (2.922 milligrams per kilogram [mg/kg]). SDG WF012 had a detection of barium (0.081 mg/kg). Sample results greater than the IDL but less than 5 times the amount detected in the laboratory preparation blanks were appropriately annotated with a J or UJ qualifier (Laboratory Data Consultants, 1996).

Sampling and analysis holding times for each analytical fraction were met in all samples.

Qualification of the environmental samples was required because of the detection of target analytes in laboratory and field blanks. Qualification of the RI data, based on blank contamination, was performed according to USEPA data validation guidelines (USEPA, 1994a and 1994b).

4.2.4 **Comparability** Comparability is the confidence with which one data set can be compared with another and the degree to which the environmental data from each sampling event are considered equivalent. Comparability of the analytical data was ensured by using standard operating procedures for sample collection, by using standard chemical analytical methods, and by reporting the analytical results in standard units (SU). The sampling, shipment, and analytical protocols were consistent with USEPA standard operation procedures and methodologies described in workplans for NAS Whiting Field throughout the period of the RI.

4.2.5 **Completeness** Completeness is the percentage of useable data reported and validated compared with the total number of measurements made. Useable data are those measurements that were not rejected (qualified with an "R") during the validation process. None of the analytical data were rejected. The goal for analytical completeness for the RI sampling event was 85 percent useable data. The completeness goal of 85 percent was met for all matrices and all parameters.

4.3 **SUMMARY**. Based on the results of the QC sample analyses, the established precision and accuracy goals of the project were achieved (Table 4-6). Some field- and/or laboratory-derived contamination was present in some of the QC samples, which required the results from some of the environmental samples to be amended. QC sample results and data validation criteria indicate a 100 percent completeness was achieved, thus satisfying the 85 percent completeness goal. Standard methods of analyses and units of measure were used throughout the project, thus meeting the QC criteria and the DQOs presented in the workplan.

Overall, the data generated during the sampling event meet established DQOs and are acceptable for use in site characterization, risk assessment, and evaluation of corrective measures.

Table 4-6
Summary of DQO Assessment - PARCC Parameters

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Precision[1]	Accuracy[2]	Representativeness	Completeness (%)	Comparability
Soil and Groundwater Samples					
TCL VOC	Acceptable	Acceptable	Acceptable	100	Acceptable
TCL SVOCs	Acceptable	Acceptable	Acceptable	100	Acceptable
Pesticides and PCBs	Acceptable	Acceptable	Acceptable	100	Acceptable
TAL metals and total cyanides	Acceptable	Acceptable	Acceptable	100	Acceptable

[1] Cumulative of sampling and analytical components.
[2] Analytical component.

Notes: All the units are expressed as the ratio of number of analytes meeting the quality control criteria to the total number of analytes.

DQO = data quality objective.
PARCC = precision, accuracy, reproducibility, completeness, and comparability.
% = percent.
TCL VOCs = target compound list volatile organic compounds.
TCL SVOCs = target compound list semivolatile organic compounds.
PCB = polychlorinated biphenyl.
TAL = target analyte list.

CHAPTER 5.0

5.0 INVESTIGATIVE RESULTS

The Phase IIA RI, at Site 11, consisted of a geophysical survey, surface soil sampling, test pitting and subsurface soil sampling, monitoring well installations, and groundwater sampling. The Phase IIB RI included a soil gas survey, surface soil sampling, monitoring well installations, and groundwater sampling.

The following sections present the results of the geologic, hydrogeologic and geophysical assessment and the analytical results from the soil gas, surface soil, subsurface soil, and groundwater sampling events.

5.1 GEOLOGIC ASSESSMENT. Surface soils encountered during Phase IIA explorations were described as tan to dark brown fine to very fine sand and tan clayey sand. Shallow subsurface soils (two to seven feet bls) were yellow, red, olive, and brown interlayered sand, silt, and clay (ABB-ES, 1994). Test pit excavations encountered crushed and burned debris, bricks, asphalt, concrete, metal cans, and assorted interlayered rubble within the upper 12 feet of soil. At test pit location TP-11-03, in the southeast corner of Site 11, burned debris and a 55-gallon drum were uncovered in the bottom of the excavation at a depth of 12 feet bls (ABB-ES, 1994).

The generalized lithologic sequence of subsurface soils at Site 11 consists of interlayered silty sand, sand, and clay. Throughout most of the site a layer of silty sand was encountered from approximately 10 to 25 feet bls, which was underlain by up to 30 feet of sand. A clay layer (15 to 25 feet thick) was encountered in several soil borings at sites in the southeast area of the facility. In soil borings completed at Site 11 this clay unit was encountered at approximately 60 feet bls. In deeper soil borings, completed below the clay layer, well and poorly graded sand layers were interlayered with clay stringers (ABB-ES, 1995c).

Detailed descriptions can be found in the boring and monitoring well logs presented in the RI Phase IIA Technical Memorandum No. 2 (ABB-ES, 1995c). A general discussion of the geology at NAS Whiting Field is presented in Subsection 1.4.5 of the GIR (ABB-ES, 1998). Site 11 monitoring well boring logs are presented in Appendix G of this report.

5.2 HYDROGEOLOGIC ASSESSMENT. The hydrogeologic assessment included determination of horizontal and vertical hydraulic gradients, hydraulic conductivities, and seepage velocities. The hydrogeologic assessment results are used to characterize the transport of chemicals of potential concern (CPCs) from the site by groundwater flow. Contaminant fate and transport for ecological CPCs at Site 11 is presented in Chapter 8.0 of this report.

Groundwater Flow Direction. Table 5-1 summarizes the results of the water-level measurements for the six RI sites in the southeast disposal area during the RI field program. Facilitywide water table elevation data is provided in Appendix D of the GIR (ABB-ES, 1998). Groundwater flow patterns for the measurement events are similar, and the potentiometric surface maps for depicting the February 8 and 9, 1994, event (Figure 5-1) and the November 7 to 9, 1996, event

Table 5-1
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	September 30 and October 1, 1993		February 8 and 9, 1994	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	86.72	59.83	89.34	57.21
WHF-9-2	161.07	124.35	100.03	61.04	102.69	58.38
WHF-9-3S	150.85	108.24	90.78	60.07	93.35	57.50
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	88.12	58.61	90.62	56.11
WHF-10-2	150.75	113.14	92.04	58.71	94.58	56.17
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	51.08	73.78	63.42	61.44
WHF-11-1S	116.65	54.40	45.50	71.15	45.99	70.66
WHF-11-2	148.12	125.84	93.50	54.62	95.93	52.19
WHF-11-3	117.19	73.16	61.91	55.28	64.22	52.97
WHF-11-4S	129.43	79	--	--	--	--
WHF-11-4I	125.79	109	--	--	--	--
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	80.20	56.20	82.68	53.72
WHF-12-2	135.56	85	--	--	--	--
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	50.62	52.04	52.90	49.76
WHF-13-1S	108.97	61.30	55.25	53.72	57.59	51.38
WHF-13-1I	109.17	93	--	--	--	--
WHF-13-2S	102.86	72.41	51.61	51.25	53.85	49.01
WHF-13-3S	81.81	41	--	--	--	--
WHF-13-4S	80.68	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	88.49	51.20	90.79	48.90
WHF-14-2	145.80	118.30	95.15	50.65	97.45	48.35

See notes at end of table.

Table 5-1 (Continued)
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	June 22 to 24, 1994		October 10 to 13, 1994	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	88.19	58.36	82.20	64.35
WHF-9-2	161.07	124.35	101.95	59.12	95.49	65.58
WHF-9-3S	150.85	108.24	92.28	58.57	86.16	64.69
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	89.60	57.13	83.45	63.28
WHF-10-2	150.75	113.14	93.62	57.13	113.02	37.73
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	62.23	62.63	56.37	68.49
WHF-11-1S	116.65	54.40	44.63	72.02	43.56	73.09
WHF-11-2	148.12	125.84	94.97	53.15	88.79	59.33
WHF-11-3	117.19	73.16	63.08	54.11	57.16	60.03
WHF-11-4S	129.43	79	--	--	--	--
WHF-11-4I	125.79	109	--	--	--	--
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	81.67	54.73	75.41	60.99
WHF-12-2	135.56	85	--	--	--	--
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	51.89	50.77	46.00	56.66
WHF-13-1S	108.97	61.30	56.45	52.52	50.29	58.68
WHF-13-1I	109.17	93	--	--	--	--
WHF-13-2S	102.86	72.41	52.93	49.93	47.00	55.86
WHF-13-3S	81.44	41	--	--	--	--
WHF-13-4S	80.37	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	90.12	49.57	83.88	55.81
WHF-14-2	145.80	118.30	96.86	48.94	90.56	55.24

See notes at end of table.

Table 5-1 (Continued)
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	January 10 to 13, 1995		April 19 and 20, 1995	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	82.82	63.73	82.73	63.82
WHF-9-2	161.07	124.35	95.99	65.08	96.14	64.93
WHF-9-3S	150.85	108.24	86.73	64.12	86.80	64.05
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	83.97	62.76	84.12	62.61
WHF-10-2	150.75	113.14	88.00	62.75	88.10	62.65
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	57.17	67.69	56.92	67.94
WHF-11-1S	116.65	54.40	44.57	72.08	44.03	72.62
WHF-11-2	148.12	125.84	89.22	58.90	89.56	58.56
WHF-11-3	117.19	73.16	57.97	59.22	57.74	59.45
WHF-11-4S	129.43	79	--	--	--	--
WHF-11-4I	125.79	109	--	--	--	--
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	76.06	60.34	76.22	60.18
WHF-12-2	135.56	85	--	--	--	--
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	46.73	55.93	46.61	56.05
WHF-13-1S	108.97	61.30	51.18	57.79	51.02	57.95
WHF-13-1I	--	--	--	--	--	--
WHF-13-2S	102.86	72.41	47.66	55.20	47.64	55.22
WHF-13-3S	81.81	41	--	--	--	--
WHF-13-4S	80.68	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	84.30	55.39	84.67	55.02
WHF-14-2	145.80	118.30	90.93	54.87	91.41	54.39

See notes at end of table.

Table 5-1 (Continued)
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	July 28 and 29, 1995		October 12 to 14, 1995	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	82.01	64.54	82.27	64.28
WHF-9-2	161.07	124.35	95.15	65.92	95.35	65.72
WHF-9-3S	150.85	108.24	85.90	64.95	86.14	64.71
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	83.22	63.51	83.62	63.11
WHF-10-2	150.75	113.14	87.15	63.60	87.55	63.20
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	56.49	68.37	56.96	67.90
WHF-11-1S	116.65	54.40	44.41	72.24	44.18	72.47
WHF-11-2	148.12	125.84	88.73	59.39	89.45	58.67
WHF-11-3	117.19	73.16	57.31	59.88	57.81	59.38
WHF-11-4S	129.43	79	--	--	--	--
WHF-11-4I	125.79	109	--	--	--	--
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	75.38	61.02	75.99	60.41
WHF-12-2	135.56	85	--	--	--	--
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	46.19	56.47	46.93	55.73
WHF-13-1S	108.97	61.30	50.62	58.35	51.34	57.63
WHF-13-1I	--	--	--	--	--	57.72
WHF-13-2S	102.86	72.41	46.09	56.77	47.98	54.88
WHF-13-3S	81.81	41	--	--	--	--
WHF-13-4S	80.68	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	83.90	55.79	84.84	54.85
WHF-14-2	145.80	118.30	90.55	55.25	91.55	54.25

See notes at end of table.

Table 5-1 (Continued)
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	January 19 and 20, 1996		April 25 to 27, 1996	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	76.91	69.64	75.99	70.56
WHF-9-2	161.07	124.35	90.03	71.04	89.13	71.94
WHF-9-3S	150.85	108.24	80.78	70.07	79.96	70.89
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	78.33	68.40	77.49	69.24
WHF-10-2	150.75	113.14	82.25	68.50	81.44	69.31
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	51.85	73.01	50.82	74.04
WHF-11-1S	116.65	54.40	43.26	73.39	43.35	73.30
WHF-11-2	148.12	125.84	84.03	64.09	83.53	64.59
WHF-11-3	117.19	73.16	52.69	64.50	51.68	65.51
WHF-11-4S	129.43	79	--	--	--	61.62
WHF-11-4I	125.79	109	--	61.59	--	57.75
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	70.61	65.79	69.90	66.50
WHF-12-2	135.56	85	--	--	--	--
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	41.87	60.79	41.14	57.48
WHF-13-1S	108.97	61.30	45.92	63.05	45.18	63.79
WHF-13-1I	--	--	--	--	--	--
WHF-13-2S	102.86	72.41	42.91	59.95	42.26	60.60
WHF-13-3S	81.81	41	--	--	--	--
WHF-13-4S	80.68	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	79.60	60.09	79.14	60.55
WHF-14-2	145.80	118.30	86.30	59.50	85.90	59.90

See notes at end of table.

Table 5-1 (Continued)
Summary of Water-Level Elevations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Well TOC Elevation (msl)	Well Depth (ft BTOC)	July 25 to 27, 1996		November 7 to 9, 1996	
			Water Level (ft BTOC)	Water Level (ft msl)	Water Level (ft BTOC)	Water Level (ft msl)
Southeast Disposal Area						
Site 9, Waste Fuel Disposal Pit						
WHF-9-1	146.55	118.40	77.40	69.11	80.95	65.70
WHF-9-2	161.07	124.35	90.27	70.80	93.61	67.46
WHF-9-3S	150.85	108.24	81.30	69.55	84.67	66.18
Site 10, Southeast Open Disposal Area (A)						
WHF-10-1	146.73	118.20	78.82	67.91	82.18	64.55
WHF-10-2	150.75	113.14	82.66	68.09	86.02	64.73
Site 11, Southeast Open Disposal Area (B)						
WHF-11-1	124.86	128.40	52.98	71.88	56.17	68.69
WHF-11-1S	116.65	54.40	44.43	72.22	45.25	71.40
WHF-11-2	148.12	125.84	84.58	63.54	88.01	60.11
WHF-11-3	117.19	73.16	53.78	63.41	57.03	60.16
WHF-11-4S	129.43	79	--	--	67.81	61.62
WHF-11-4I	125.79	109	64.20	61.59	68.04	57.75
Site 12, Tetraethyl Lead Disposal Area						
WHF-12-1	136.40	113.40	71.37	65.03	74.75	61.65
WHF-12-2	135.56	85	--	--	51.45	57.72
Site 13, Sanitary Landfill						
WHF-13-1	102.66	122.90	42.84	55.55	46.17	52.18
WHF-13-1S	108.97	61.30	47.11	61.86	50.48	58.49
WHF-13-1I	109.17	93	--	--	51.45	57.72
WHF-13-2S	102.86	72.41	43.88	58.98	47.13	55.73
WHF-13-3S	81.44	41	--	--	--	--
WHF-13-4S	80.37	40	--	--	--	--
Site 14, Short-Term Sanitary Landfill						
WHF-14-1	139.69	153.20	80.19	59.50	63.65	76.04
WHF-14-2	145.80	118.30	86.83	58.97	90.33	55.47

Notes: TOC = top of casing.
msl = mean sea level.
ft BTOC = feet below top of casing.
ft msl = feet above mean sea level.
-- = no water level was recorded for this round of sampling.

Figure 5-1 Potentiometric Surface Map of the Water Table Zone in the Sand-and-Gravel Aquifer, Southeast Disposal Area, February 1994

11 x 17

Figure 5-2 Potentiometric Surface Map of the Water Table Zone in the Sand-and-Gravel Aquifer, Southeast Disposal Area, November 1996

11 x 17

(Figure 5-2) are included in the body of this report. Groundwater elevations for monitoring wells WHF-11-1 and WHF-11-1S were not used in the potentiometric surface maps. Monitoring well WHF-11-1S is screened in a perched groundwater layer and anomalous groundwater elevations were recorded for well WHF-11-1. The data from the measurement events indicate a groundwater flow direction to the southeast.

Three intermediate depth wells (WHF-11-1, WHF-13-1, and WHF-14-1) were completed at depths generally 10 to 30 feet deeper than the shallow zone monitoring wells (Table 3-1). Data from these three wells suggests a groundwater flow pattern to the southeast, similar to the flow pattern for the shallow water table zone.

Horizontal Hydraulic Gradients. Table 5-2 provides a summary of the horizontal hydraulic gradients calculated for sites in the Southeast Disposal Area from October 1993 to November 1996. The horizontal hydraulic gradients for all sites in the southeast disposal area ranged from a low of 0.0021 feet per foot (ft/ft) to a maximum of 0.0036 ft/ft. The average horizontal hydraulic gradient for all sites in the southeast disposal area ranged from 0.0026 ft/ft for February 1994 to 0.0033 ft/ft for April 1996. The overall average horizontal hydraulic gradient for all measurement events from 1993 through 1996 was 0.0029 ft/ft.

Vertical Hydraulic Gradients. Table 5-3 presents a summary of the vertical hydraulic gradients calculated for the Site 11 sites in the southeast disposal area. The vertical hydraulic gradients have been calculated for the site since 1993 using wells WHF-14-1 and WHF-14-2. With installation of two additional well clusters during the Phase IIB at Site 11 (WHF-11-4S/WHF-11-4D) and Site 13 (WHF-13-1S/WHF-13-1I), vertical gradients were also calculated at these sites using November 1996 data.

A downward vertical gradient was measured at both Site 11 and Site 13 during the November 1996 measurement period. The downward gradient is in contrast to the consistently upward gradient measured at Site 14. Typically, the upward gradient at well cluster WHF-14-1/WHF-14-2 ranged from 0.013 ft/ft to 0.015 ft/ft. The November 1996 measurements in the Site 14 well cluster indicate a 20-foot difference in water levels between the two wells. The average water-level difference between these wells previously was approximately 0.6 feet. This variation in the reading suggest a potential measurement error rather than a dramatic change in the site hydrogeology.

Hydraulic Conductivity. Slug tests were conducted at five shallow monitoring wells in the southeast disposal area during the RI. Table 5-4 summarizes the hydraulic conductivity values and geometric mean calculated for monitoring wells in the southeast disposal area. As shown in Table 5-4, all slug test trials on monitoring well WHF-11-2 were rejected because data were extremely varied. In addition, hydraulic conductivity data from monitoring well WHF-10-2 was rejected because it exceeded a 20 percent variance. A discussion of hydraulic conductivity data is presented in Section 2.3 and Table 2-2 of Technical Memorandum No. 4, Hydrogeologic Assessment, January 1995 (ABB-ES, 1995d).

Average hydraulic conductivity values for individual monitoring wells in the southeast disposal area ranged from 4.73 feet per day (ft/day) (1.67×10^{-3} centimeters per second [cm/sec]) for WHF-11-3 to 14.55 ft/day (5.13×10^{-3} cm/sec) for WHF-13-2S. Monitoring wells selected from the area were screened within well-graded to poorly-graded sand between 27 to 59 feet above msl. The geometric mean for the hydraulic conductivity data of monitoring wells in the area was 8.38 ft/day (2.96×10^{-3} cm/sec).

Table 5-2
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	September 30 to October 1, 1993		February 8 and 9, 1994	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	60.07	0.0026	57.50	0.0025
WHF-10-2		58.71		56.17	
WHF-9-1	460	59.83	0.0027	57.21	0.0024
WHF-10-1		58.61		56.11	
WHF-9-2	842	61.04	0.0028	58.38	0.0026
WHF-10-2		58.71		56.17	
WHF-11-3	1,381	55.28	0.0029	52.97	0.0029
WHF-13-2		51.25		49.01	
WHF-11-2	1,123	54.62	0.0031	52.19	0.0029
WHF-14-1		51.20		48.90	
WHF-9-2	3,547	61.04	0.0029	58.38	0.0028
WHF-14-2		50.65		48.35	
		Average Gradient	0.0028		0.0026

See notes at end of table.

Table 5-2 (Continued)
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	June 22 to 24, 1994		October 10 to 13, 1994	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	58.57	0.0027	64.69	**
WHF-10-2		57.13		37.73	
WHF-9-1	460	58.36	0.0027	64.35	0.0023
WHF-10-1		57.13		63.28	
WHF-9-2	842	59.12	0.0024	65.58	**
WHF-10-2		57.13		37.73	
WHF-11-3	1,381	54.11	0.0030	60.03	0.0030
WHF-13-2		49.93		55.86	
WHF-11-2	1,123	53.15	0.0032	59.33	0.0031
WHF-14-1		49.57		55.81	
WHF-9-2	3,547	59.12	0.0029	65.58	0.0029
WHF-14-2		48.94		55.24	
	Average Gradient		0.0028		0.0028

See notes at end of table.

Table 5-2 (Continued)
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	January 10 to 13, 1995		April 19 and 20, 1995	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	64.12	0.0026	64.05	0.0027
WHF-10-2		62.75		62.65	
WHF-9-1	460	63.73	0.0021	63.82	0.0026
WHF-10-1		62.76		62.61	
WHF-9-2	842	65.08	0.0028	64.93	0.0027
WHF-10-2		62.75		62.65	
WHF-11-3	1,381	59.22	0.0029	59.45	0.0031
WHF-13-2		55.20		55.22	
WHF-11-2	1,123	58.90	0.0031	58.56	0.0032
WHF-14-1		55.39		55.02	
WHF-9-2	3,547	65.08	0.0029	64.93	0.0030
WHF-14-2		54.87		54.39	
	Average Gradient		0.0027		0.0029

See notes at end of table.

Table 5-2 (Continued)
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	July 28 and 29, 1995		October 12 to 14, 1995	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	64.95	0.0026	64.71	0.0029
WHF-10-2		63.60		63.20	
WHF-9-1	460	64.54	0.0022	64.28	0.0025
WHF-10-1		63.51		63.11	
WHF-9-2	842	65.92	0.0028	65.72	0.0030
WHF-10-2		63.60		63.20	
WHF-11-3	1,381	59.88	0.0023	59.38	0.0033
WHF-13-2		56.77		54.88	
WHF-11-2	1,123	59.39	0.0032	58.67	0.0034
WHF-14-1		55.79		54.85	
WHF-9-2	3,547	65.92	0.0030	65.72	0.0032
WHF-14-2		55.25		54.25	
	Average Gradient		0.0027		0.0031

See notes at end of table.

Table 5-2 (Continued)
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	January 19 and 20, 1996		April 25 to 27, 1996	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	70.07	0.0030	70.89	0.0030
WHF-10-2		68.50		69.31	
WHF-9-1	460	69.64	0.0027	70.56	0.0029
WHF-10-1		68.40		69.24	
WHF-9-2	842	71.04	0.0030	71.94	0.0031
WHF-10-2		68.50		69.31	
WHF-11-3	1,381	64,50	0.0033	65.51	0.0036
WHF-13-2		59.95		60.60	
WHF-11-2	1,123	64.09	0.0036	64.59	0.0036
WHF-14-1		60.09		60.55	
WHF-9-2	3,547	71.04	0.0033	71.94	0.0034
WHF-14-2		59.50		59.90	
	Average Gradient		0.0032		0.0033

See notes at end of table.

Table 5-2 (Continued)
Summary of Horizontal Hydraulic Gradients

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Designation	Distance Between Wells (feet)	July 25 to 27, 1996		November 7 to 9, 1996	
		Water Level (msl)	Horizontal Gradient (ft/ft)	Water Level (msl)	Horizontal Gradient (ft/ft)
Southeast Disposal Area					
WHF-9-3S	526	69.55	0.0028	66.18	0.0028
WHF-10-2		68.09		64.73	
WHF-9-1	460	69.11	0.0026	65.70	0.0025
WHF-10-1		67.91		64.55	
WHF-9-2	842	70.80	0.0032	67.46	0.0032
WHF-10-2		68.09		64.73	
WHF-11-3	1,381	63.41	0.0032	60.16	0.0032
WHF-13-2		58.98		55.73	
WHF-11-2	1,123	63.54	0.0036	60.11	0.014*
WHF-14-1		59.50		76.04	
WHF-9-2	3,547	70.80	0.0033	67.46	0.0034
WHF-14-2		58.97		55.47	
	Average Gradient		0.0031		0.0031

Notes: msl = mean sea level.
ft/ft = feet per foot.
* = anomalous horizontal gradient, not included in average hydraulic gradient calculation.

Table 5-3
Summary of Vertical Hydraulic Gradients, Southeast Disposal Area

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Number	Bottom of Well Elevation (msl)	Vertical Distance Between Well Screens (feet)	Groundwater Elevation (msl)	Vertical Gradient (ft/ft)	Vertical Flow Direction
September 30 and October 1, 1993					
WHF-14-2	27.5	41.01	50.65	0.0134	Upward
WHF-14-1	-13.51		51.20		
February 8 and 9, 1994					
WHF-14-2	27.5	41.01	48.35	0.0134	Upward
WHF-14-1	-13.51		48.90		
June 22 to 24, 1994					
WHF-14-2	27.5	41.01	48.94	0.0154	Upward
WHF-14-1	-13.51		49.57		
October 10 to 13, 1994					
WHF-14-2	27.5	41.01	55.24	0.0139	Upward
WHF-14-1	-13.51		55.81		
January 10 to 13, 1995					
WHF-14-2	27.5	41.01	54.87	0.0127	Upward
WHF-14-1	-13.51		55.39		
April 19 and 20, 1995					
WHF-14-2	27.5	41.01	54.39	0.0154	Upward
WHF-14-1	-13.51		55.02		
July 28 and 29, 1995					
WHF-14-2	27.5	41.01	55.25	0.0132	Upward
WHF-14-1	-13.51		55.79		
October 12 and 14, 1995					
WHF-14-2	27.5	41.01	54.25	0.0146	Upward
WHF-14-1	-13.51		54.85		
January 19 and 20, 1995					
WHF-14-2	27.5	41.01	59.50	0.0144	Upward
WHF-14-1	-13.51		60.09		
April 25 to 27, 1996					
WHF-14-2	27.5	41.01	59.90	0.0158	Upward
WHF-14-1	-13.51		60.55		

See notes at end of table.

Table 5-3 (Continued)
Summary of Vertical Hydraulic Gradients, Southeast Disposal Area

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Number	Bottom of Well Elevation (msl)	Vertical Distance Between Well Screens (feet)	Groundwater Elevation (msl)	Vertical Gradient (ft/ft)	Vertical Flow Direction
July 25 to 27, 1996					
WHF-14-2	27.5	41.01	58.97	0.0129	Upward
WHF-14-1	-13.51		59.50		
November 7 to 9, 1996					
WHF-14-2	27.5	41.01	55.47	*	*
WHF-14-1	-13.51		76.04		
WHF-13-1S	47.67	31.5	58.49	0.0244	Downward
WHF-13-1I	16.17		57.72		
WHF-11-4S	50.43	30.49	61.62	0.0236	Downward
WHF-11-4D	19.94		60.90		

Notes: msl = mean sea level.
ft/ft = feet per foot.
* = vertical gradient not calculated due to anomaly in water-level data.

Table 5-4
Summary of Hydraulic Conductivity (K) Data from Slug Tests

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Well Number	Range of K (ft/day)	Number of Usable Runs	Average K (ft/min)	Average K (ft/day)	Average K (cm/sec)
Southeast Disposal Area					
Site 10, Southeast Open Disposal Area (A)					
WHF-10-2	R	R	R	R	R
Site 11, Southeast Open Disposal Area (B)					
WHF-11-2	R	R	R	R	R
WHF-11-3	4.41 to 5.23	3	0.0033	4.73	1.67×10^{-3}
Site 13, Sanitary Landfill					
WHF-13-2S	13.23 to 15.51	6	0.0101	14.55	5.13×10^{-3}
Site 14, Short-Term Sanitary Landfill					
WHF-14-2	8.53 to 8.57	2	0.0059	8.55	3.02×10^{-3}
			Geometric Mean	8.38	2.96×10^{-3}

Notes: Average is the arithmetic mean.

ft/day = feet per day.
ft/min = feet per minute.
cm/sec = centimeters per second.
R = data rejected.

Seepage Velocity. The seepage velocity was calculated by multiplying the hydraulic conductivity (K) by the hydraulic gradient and dividing by the effective porosity (n). Table 5-5 summarizes the average linear pore water velocity (i.e., seepage velocity) for the water table zone of the sand and gravel aquifer for sites in the southeast disposal area. The calculations are based on an assumed effective porosity (n) of 0.35 for the site soil. The effective porosity (n) value represents silty through poorly graded sands (Fetter, 1988). Seepage velocities ranged from 0.069 ft/day at Sites 9, 10, 11, 13, and 14 to 0.079 ft/day at Sites 11 and 13. The average of the seepage velocity values for the sites in the southeast disposal area was 0.074 ft/day (27 feet per year [ft/yr]).

Table 5-5
Summary of Phase II Seepage Velocities

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Investigation Area	Sites	Monitoring Well Pair	Horizontal[1] Gradient (ft/ft)	K (ft/day)	Effective Porosity (n)	Seepage Velocity (ft/day)
Southeast Disposal Area	11 and 13	WHF-11-3 and WHF-13-2	0.0029	[2]9.65	0.35	0.079
	9, 10, 11, 13, and 14	WHF-9-2 and WHF-14-2	0.0029	[3]8.37	0.35	0.069
					Arithmetic average	0.074

[1] Horizontal gradients based on groundwater measurements from September 1993 through November 1996.
[2] The K is averaged where values are available for both wells in the well pair.
[3] Geometric mean for the area.

Notes: ft/ft = feet per foot.
K is hydraulic conductivity (ft/day).
ft/day = feet per day.

5.3 GEOPHYSICAL SURVEY Interpretation of the geophysical data including total magnetic, EM-31 conductivity, and EM-31 inphase data sets indicated a single well-defined landfill boundary and three smaller total magnetic anomalies located outside the interpreted landfill area. The three anomalies located outside the interpreted landfill boundary are believed to be caused by ferromagnetic metal lying at or near the ground surface.

5.4 SOIL GAS ASSESSMENT Thirty-one of the 48 proposed soil gas sample locations were sampled at Site 11. The sample locations are shown on Figure 3-1. The soil gas locations not sampled were several grid spacings beyond locations with positive detections.

The analytical results from the soil gas survey are presented in Table 5-6. Total VOCs (TVOCs) and methane were detected in two samples (sample locations 45 and 46) along the northeast corner of the site. At both locations the detections were in the sample from 3 feet bls. TVOC concentrations were 600 ppm and 1,100 ppm for locations 45 and 46, respectively. Methane concentrations were 350 ppm and 1,100 ppm, accounting for 58 percent and 100 percent of the TVOC concentrations in the two samples. Based upon the soil gas survey, it was concluded that off-site migration of soil gas was unlikely (ABB-ES, 1995e).

Table 5-6
Summary of Active Soil Gas Survey, July 15, 16, and 17, 1995

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample ID	Depth (feet bls)	Total VOC (ppm)	Methane (ppm)	Methane/VOC (percent)	Rinsate Blank (ppm)
9	1.5	0	0	NA	1
	3.0	0	0	NA	1
10	1.5	0	0	NA	1
	3.0	0	0	NA	1
11	1.5	NR	NR	NA	1
	3.0	0	0	NA	1
12	1.5	0	0	NA	1
	3.0	0	0	NA	1
13	1.5	0	0	NA	0
	3.0	0	0	NA	0
16	1.5	0	0	NA	2
	3.0	0	0	NA	2
17	1.5	0	0	NA	1
	3.0	0	0	NA	1
18	1.5	0	0	NA	1
	3.0	0	0	NA	1
19	1.5	0	0	NA	0
	3.0	0	0	NA	0
20	1.5	0	0	NA	0
	3.0	0	0	NA	0
23	1.5	0	0	NA	0
	3.0	0	0	NA	0
24	1.5	0	0	NA	0
	3.0	0	0	NA	0
25	1.5	0	0	NA	0
	3.0	0	0	NA	0
26	1.5	0	0	NA	0
	3.0	0	0	NA	0
27	1.5	0	0	NA	0
	3.0	0	0	NA	0
30	1.5	0	0	NA	1
	3.0	0	0	NA	1
31	1.5	0	0	NA	0
	3.0	0	0	NA	0
32	1.5	0	0	NA	0
	3.0	0	0	NA	0

See notes at end of table.

Table 5-6 (Continued)
Summary of Active Soil Gas Survey, July 15, 16, and 17, 1995

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample ID	Depth (feet bls)	Total VOC (ppm)	Methane (ppm)	Methane/VOC (percent)	Rinsate Blank (ppm)
32D	1.5	0	0	NA	0
	3.0	0	0	NA	0
33	1.5	0	0	NA	0
	3.0	0	0	NA	0
34	1.5	0	0	NA	0
	3.0	0	0	NA	0
37	1.5	0	0	NA	0
	3.0	0	0	NA	0
38	1.5	0	0	NA	0
	3.0	0	0	NA	0
39	1.5	0	0	NA	0
	3.0	0	0	NA	0
40	1.5	0	0	NA	0
	3.0	0	0	NA	0
41	1.5	0	0	NA	0
	3.0	0	0	NA	0
43	1.5	0	0	NA	0
	3.0	0	0	NA	0
44	1.5	0	0	NA	0
	3.0	0	0	NA	0
45	1.5	0	0	NA	1
	3.0	600	350	58	1
46	1.5	0	0	NA	0
	3.0	1,100	1,100	100	0
47	1.5	0	0	NA	0
	3.0	0	0	NA	0
48	1.5	0	0	NA	0
	3.0	0	0	NA	0

Notes: ID = identification.
bls = below land surface.
VOC = volatile organic compounds.
ppm = parts per million.
NA = not applicable.
NR = sample was not recovered.
D = duplicate.

5.5 SURFACE SOIL ASSESSMENT. Table 5-7 summarizes the analytical results for organic compounds detected in surface soil samples at Site 11. Table 5-8 summarizes the analytical results for the inorganic analytes detected in the surface soil samples and Table 5-9 summarizes the results of the additional sampling for lead at the site. The sample locations are shown on Figure 3-2 and analytical results are summarized on Figure 5-3. Table 5-10 summarizes the frequency of detection, range of detection limits, range of detection concentrations, mean of detected concentrations, and background screening values for the combined background samples of the Troup loamy sand and Dothan fine sandy loam found at Site 11. This table also presents the USEPA Region III Risk-Based Concentrations (RBCs) for soils and the Soil Cleanup Target Levels for Florida (FDEP, 1999).

TCL VOCs. One VOC (acetone) was detected at an estimated concentration of 100 micrograms per kilogram (μg/kg) in surface soil sample (11-SL-02). The detected concentration was below the Florida residential soil cleanup target level of 260,000 μg/kg.

TPH. TPH analysis was performed on five surface soil samples (11S00101 through 11S00501) at Site 11. All five samples contained TPH at concentrations ranging from 7 to 53.1 μg/kg which are below the Florida cleanup target level of 350 mg/kg.

TCL SVOCs. Fourteen SVOCs were detected in the surface soil samples from Site 11. Thirteen of the compounds were only detected in surface soil sample 11-SL-04. Benzo(a)pyrene, detected at a concentration of 910 μg/kg, exceeded the FDEP residential and industrial cleanup target levels and the USEPA Region III RBCs for residential and industrial soil. Benzo(a)anthracene (1,800 μg/kg) also exceeded the FDEP residential soil cleanup target level (1,400 μg/kg) and the USEPA Region III RBC for residential soil.

The location of surface soil sample 11-SL-04 was excavated in June 1999 as part of a source removal conducted by CH2M Hill. Confirmation samples collected from the bottom of the excavation indicated contaminant concentrations were below State and Federal screening criteria (Appendix J).

Pesticides and PCBs. Nine pesticide compounds were detected in the soil samples collected at the site. At least one pesticide was detected in 8 of the 10 samples collected at Site 11. However, only one of the pesticide compounds (dieldrin) was detected at concentrations exceeding the Florida soil cleanup target levels and USEPA Region III RBCs. Dieldrin was detected in sample 11-SL-02 (estimated concentration of 210 μg/kg) at a concentration exceeding the Florida residential soil cleanup target level and USEPA Region III RBC of 70 μg/kg and 40 μg/kg, respectively. The Florida leachability cleanup target level of 4 μg/kg was also exceeded by all eight of the dieldrin detections at Site 11.

TAL Inorganic Analytes. Twenty-three inorganic analytes were detected in the surface soil samples at Site 11. Twelve of the analytes (aluminum, arsenic, barium, calcium, chromium, iron, lead, magnesium, manganese, sodium, vanadium,

Table 5-7
Summary of Analytical Results for Organic Compounds Detected in Surface Soil at Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	11-SL-01	11-SL-01A Duplicate Sample	11-SL-02	11-SL-03	11-SL-04	11-SL-05
Collect Date:	08/18/92	08/18/92	08/18/92	08/18/92	08/18/92	08/18/92
Volatile Organic Compounds (µg/kg)						
Acetone	--	--	100 J	--	--	--
Total Petroleum Hydrocarbons (mg/kg)	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compounds (µg/kg)						
2-Methylnaphthalene	--	--	--	--	49 J	--
Acenaphthylene	--	--	--	--	110 J	--
Anthracene	--	--	--	--	280 J	--
Benzo(a)anthracene	--	--	--	--	1,800	--
Benzo(a)pyrene	--	--	--	--	910	--
Benzo(b)fluoranthene	--	--	--	--	710	--
Benzo(g,h,i)perylene	--	--	--	--	310 J	--
Benzo(k)fluoranthene	--	--	--	--	870	--
Chrysene	--	--	--	--	2,500	--
Fluoranthene	--	--	--	--	1,300	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	230 J	--
Phenanthrene	--	--	--	--	2,100	--
Pyrene	--	--	--	--	3,400	--
bis(2-Ethylhexyl)phthalate	--	--	--	--	540	--
Pesticides and PCBs (µg/kg)						
4,4'-DDD	--	--	140 J	--	--	--
4,4'-DDE	--	--	88 J	2.5 J	4.9 J	64 J
4,4'-DDT	--	--	530 J	30 J	6.7 J	45 J
Aldrin	--	--	--	--	--	--
Dieldrin	--	--	210 J	5.1 J	4.9 J	44 J
Heptachlor	--	--	--	--	--	--
Heptachlor epoxide	--	--	--	--	--	--
alpha-Chlordane	--	--	62 J	--	39 J	310 J
gamma-Chlordane	--	--	54 J	--	29 J	260 J

See notes at end of table.

Table 5-7 (Continued)
Summary of Analytical Results for Organic Compounds Detected in Surface Soil at Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	11S00101	11S00201	11S00301	11S00401	11S00501
Collect Date:	01/06/96	01/06/96	01/07/96	01/07/96	01/06/96
Volatile Organic Compounds (μg/kg)					
Acetone	--	--	--	--	--
Total Petroleum Hydrocarbons (mg/kg)	7	53.1	9.3	8.6	11.6
Semivolatile Organic Compounds (μg/kg)					
2-Methylnaphthalene	--	--	--	--	--
Acenaphthylene	--	--	--	--	--
Anthracene	--	--	--	--	--
Benzo(a)anthracene	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--
Benzo(b)fluoranthene	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--
Chrysene	--	--	--	--	--
Fluoranthene	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	--
Phenanthrene	--	--	--	--	--
Pyrene	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	130 J	71 J	52 J	81 J
Pesticides and PCBs (μg/kg)					
4,4-DDD	--	--	--	--	--
4,4-DDE	--	19 J	5.3	--	2.1
4,4-DDT	--	27 J	6.8	6.8	2.3
Aldrin	--	0.96 J	--	--	--
Dieldrin	--	20 J	23	23	13
Heptachlor	--	4.8 J	--	--	--
Heptachlor epoxide	--	8.8 J	--	--	--
alpha-Chlordane	--	--	--	--	--
gamma-Chlordane	--	100 J	--	--	--

Notes: μg/kg = micrograms per kilogram.
-- = compound if present was not detected above instrument detection limits
J = estimated value.
mg/kg = milligrams per kilogram.
NA = not analyzed.
PCBs = polychlorinated biphenyls.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.

Table 5-8
Summary of Analytical Results for Inorganic Analytes Detected in Surface Soil at Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	11-SL-01	11-SL-01A	11-SL-02	11-SL-03	11-SL-04	11-SL-05
Collect Date:	08/18/92	08/18/92	08/18/92	08/18/92	08/18/92	08/18/92
Inorganic Analytes (mg/kg)						
Aluminum	9,790	10,800	10,800	9,380	6,100	2,110
Antimony	--	--	3.5 J	--	--	--
Arsenic	2 J	1.6 J	3.8	2.1 J	1.5 J	0.93 J
Barium	16.4 J	17.8 J	96	13.1 J	6.3 J	6.2 J
Beryllium	0.13 J	0.1 J	0.14 J	--	--	--
Cadmium	--	--	--	--	--	--
Calcium	183 J	186 J	1,790	375 J	248 J	331 J
Chromium	6.9	7.4	19.6	--	7.7	4.5
Cobalt	1.2 J	1.6 J	3.4 J	--	1.2 J	0.35 J
Copper	5.2 J	5.1 J	19.4	--	5.3 J	4 J
Cyanide	--	--	--	--	--	--
Iron	5,810	5,860	11,700	--	5,500	3,540
Lead	5.7	5.5	2,230	--	22.3	7.8
Magnesium	108 J	142 J	1,260	--	99.7 J	82.7 J
Manganese	275	285	230	--	182	39.4
Mercury	0.05 J	0.05 J	0.06 J	--	0.04 J	0.04 J
Nickel	--	--	10	--	--	--
Potassium	--	139 J	166 J	--	--	--
Selenium	--	--	--	--	--	--
Silver	1.2 J	0.67 J	1.9 J	--	0.55 J	0.93 J
Sodium	177 J	169 J	307 J	--	184 J	189 J
Vanadium	14.9	15.7	20.3	--	14.6	9.5 J
Zinc	8.8 J	9.9 J	260	--	47.8	9.4 J

See notes at end of table..

Table 5-8 (Continued)
Summary of Analytical Results for Inorganic Analytes Detected in Surface Soil at Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	11S00101	11S00201	11S00301	11S00401	11S00501
Collect Date:	01/06/96	01/06/96	01/07/96	01/07/96	01/06/96
Inorganic Analytes (mg/kg)					
Aluminum	9,660	5,670	5,070	5,070	10,700
Antimony	--	--	--	--	--
Arsenic	2.1 J	1.6 J	2.2 J	2.2 J	2.7
Barium	15.3 J	8.6 J	4.6 J	12.8 J	11.7 J
Beryllium	0.1 J	0.08 J	0.05 J	0.05 J	0.09 J
Cadmium	--	0.28 J	--	--	0.24 J
Calcium	206 J	332 J	249 J	249 J	483 J
Chromium	2.7	5	6	7.8	11.8
Cobalt	--	0.94 J	--	--	--
Copper	8.1	5.5	--	--	6.3
Cyanide	--	0.19 J	0.13 J	0.09 J	0.09 J
Iron	1,500	3,480	4,310	4,310	6,690
Lead	8.6	25.2	40.3	40.3	16.5
Magnesium	65.1 J	122 J	54.2 J	54.2 J	139 J
Manganese	31.4	46.7	34.2	97.3	122
Mercury	0.05 J	--	--	--	0.08
Nickel	--	1.8 J	--	--	2 J
Potassium	133 J	109 J	108 J	62.1 J	90.3 J
Selenium	--	--	--	--	--
Silver	0.79 J	--	--	--	--
Sodium	177 J	173 J	168 J	168 J	160 J
Vanadium	4.4 J	9.3 J	11.9	11.9	17.8
Zinc	21.5	23.8	8	8	11.2

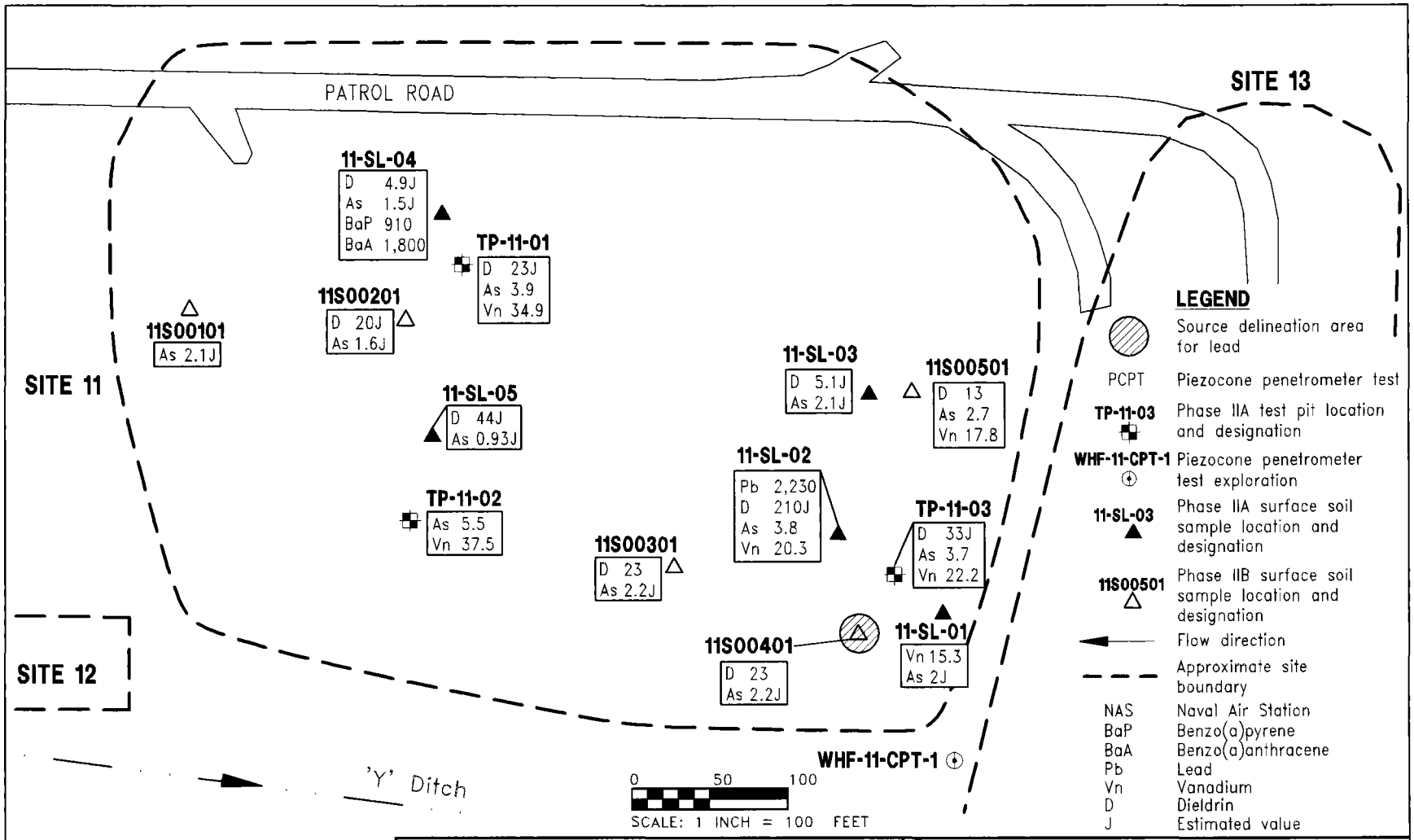
Notes: mg/kg = milligrams per kilogram.
-- compound, if present, was not detected above instrument detection limits.
J = estimated value.

Table 5-9
Summary of Analytical Results for Additional Lead Analysis of Surface Soils at Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Sample Identifier:	11500601	11S00601D	11S00701	11S00801	11S00901	11S01001	11S01101	11S01201	11S01301
Collect Date:	01/07/96	01/07/96	01/07/96	01/07/96	01/07/96	01/07/96	01/07/96	01/07/96	01/07/96
Inorganic Analytes (mg/kg)									
Lead	19.3 J	25	18.7 J	16.5 J	16.8 J	23.3 J	16.2 J	74.8	43.5

Notes: mg/kg = milligrams per kilogram.
J = estimated value.



NOTES:
1. Only compounds with detections above Florida cleanup target levels are shown.
2. Organic concentration are in micrograms per kilogram.
3. Inorganic concentrations are in milligrams per kilograms.

FIGURE 5-3
SURFACE AND SUBSURFACE SOIL ANALYTICAL RESULTS

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

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Table 5-10
Summary of Surface Soil Analytical Results

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Background Screening Concentration[3]	USEPA Region III RBCs Residential/ Industrial[4]	Soil Cleanup Target Levels for Florida Residential/Industrial/ Leachability[5]
Volatile Organic Compounds (µg/kg)						
Acetone	1/10	11 to 13	53.3*	NA	[7]780,000/20,000,000	780,000/5,500,000/2,800
Semivolatile Organic Compounds (µg/kg)						
2-Methylnaphthalene	1/10	350 to 4,000	49	NA	[7]160,000/4,100,000	80,000/560,000/6,100
Acenaphthylene	1/10	350 to 4,000	110	NA	[7]470,000/12,000,000	1,100,000/11,000,000/27,000
Anthracene	1/10	350 to 4,000	280	NA	[7]2,300,000/61,000,000	18,000,000/260,000,000/2,500,000
Benzo(a)anthracene	1/10	350 to 4,000	1,800	NA	[6]870/7,800	1,400/5,000/3,200
Benzo(a)pyrene	1/10	350 to 4,000	910	NA	[6]87/780	100/500/8,000
Benzo(b)fluoranthene	1/10	350 to 4,000	710	NA	[6]870/7,800	1,400/4,800/10,000
Benzo(g,h,i)perylene	1/10	350 to 4,000	310	NA	--/--	2,300,000/41,000,000/32,000,000
Benzo(k)fluoranthene	1/10	350 to 4,000	870	NA	[6]8,700/78,000	15,000/52,000/25,000
bis(2-Ethylhexyl)phthalate	5/10	350 to 4,000	52 to 540	NA	[6]46,000/410,000	76,000/280,000/3,600,000
Chrysene	1/10	350 to 4,000	2,500	NA	[6]87,000/780,000	140,000/450,000/77,000
Fluoranthene	1/10	350 to 4,000	1,300	NA	[7]310,000/8,200,000	2,900,000/48,000/1,200,000
Indeno(1,2,3-cd)pyrene	1/10	350 to 4,000	230	NA	[6]870/7,800	1,500/5,300/28,000
Phenanthrene	1/10	350 to 4,000	2,100	NA	--/--	2,000,000/30,000,000/250,000
Pyrene	1/10	350 to 4,000	3,400	NA	[7]230,000/6,100,000	2,200,000/37,000,000/880,000
Pesticides and PCBs (µg/kg)						
4,4'-DDD	1/10	3.6 to 980	140	NA	[6]2,700/24,000	4,600/18,000/4,000
4,4'-DDE	7/10	3.7 to 980	2.1 to 88	NA	[6]1,900/17,000	3,300/13,000/18,000

See notes at end of table.

Table 5-10 (Continued)
Summary of Surface Soil Analytical Results

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Background Screening Concentration[3]	USEPA Region III RBCs Residential/ Industrial[4]	Soil Cleanup Target Levels for Florida Residential/Industrial/ Leachability[5]
Pesticides and PCBs (μg/kg) (Continued)						
4,4'-DDT	8/10	3.7 to 980	2.3 to 530	NA	[6]1,900/17,000	3,300/13,000/11,000
Aldrin	1/10	1.9 to 490	0.96	NA	[6]38/340	70/300/500
Dieldrin	8/10	3.7 to 980	4.9 to 210	NA	[6]40/360	70/300/4
Heptachlor	1/10	1.9 to 490	4.8	NA	[6]140/1,300	200/900/23,000
Heptachlor epoxide	1/10	1.9 to 490	8.8	NA	[6]70/630	100/400/600
alpha-Chlordane	4/10	1.9 to 4,900	39 to 310	NA	[6]1,800/16,000	3,100/12,000/9,600
gamma-Chlordane	4/10	1.9 to 4,900	29 to 260	NA	[6]1,800/16,000	3,100/12,000/9,600
Inorganic Analytes (mg/kg)						
Aluminum	10/10	40	2,110 to 10,800	15,314	[7]7,800/200,000	72,000/--/SPLP[11]
Antimony	1/10	2.6 to 12	3.5	8	[7]3.1/82	26/240/5
Arsenic	10/10	2	0.93 to 3.8	3.0	[6]0.43/3.8	0.8/[12]4.62/29
Barium	10/10	40	4.6 to 96	23.8	[7]550/14,000	110/87,000/1,600
Beryllium	7/10	0.05 to 1	0.05 to 0.14	0.36	[7]16/410	120/800/63
Cadmium	2/10	0.58 to 1	0.24 to 0.28	0.58	[7]3.9/100	75/1,300/8
Calcium	10/10	1,000	185 to 1,790	402	--/--	--/--/--
Chromium[9]	10/10	2	2.7 to 19.6	10.8	[7]23/610	210/420/38
Cobalt	6/10	0.33 to 10	0.35 to 3.4	3	[7]470/12,000	4,700/110,000/SPLP[11]

See notes at end of table.

Table 5-10 (Continued)
Summary of Surface Soil Analytical Results

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Background Screening Concentration[3]	USEPA Region III RBCs Residential/ Industrial[4]	Soil Cleanup Target Levels for Florida Residential/Industrial/ Leachability[5]
Inorganic Analytes (mg/kg) (Continued)						
Copper	8/10	5	3.7 to 19.4	9.4	[7]310/8,200	110/76,000/SPLP[11]
Cyanide	5/10	0.23 to 0.5	0.09 to 0.19	0.26	[7,10]160/4,100	30/28,000/40
Iron	10/10	20	1,500 to 11,700	8,588	[7]2,300/61,000	23,000/480,000/SPLP[11]
Lead	18/18	0.60 to 1	5.2 to 2,230	11.4	[8]400	400/920/SPLP[11]
Magnesium	10/10	1,000	54.2 to 1,260	258	--/--	--/--/--
Manganese	10/10	3	31.4 to 280*	404	160/4,100	1,600/22,000/SPLP[11]
Mercury	6/10	0.1	0.04 to 0.08	0.12	[7]2.3/61	3.4/26/2.1
Nickel	4/10	2.3 to 8	1.6 to 10	7.2	[7]160/4,100	110/28,000/130
Potassium	8/10	128 to 1,000	62.1 to 166	177	--/--	--/--/--
Selenium	1/10	0.44 to 1	0.16	0.44	[7]39/1,000	390/10,000/5
Silver	5/10	2	0.55 to 1.9	0.7	[7]39/1,000	390/9,100/17
Sodium	10/10	1,000	160 to 307	388	--/--	--/--/--
Vanadium	10/10	10	4.4 to 20.3	21.2	[7]55/1,400	15/7,400/980
Zinc	10/10	4	5.7 to 260	15.4	[7]2,300/61,000	23,000/560,000/6,000
Others (mg/kg)						
Total petroleum hydrocarbon	5/5	1.8 to 1.9	7 to 53.1	ND	--/--	340/2,500/340

See notes at end of table.

Table 5-10 (Continued)
Summary of Surface Soil Analytical Results

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] A value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect, one-half of the contract-required quantification limit/contract-required detection limit is used as a surrogate concentration for the nondetect.
[3] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentration (RBC) Table (October 1998).
[5] Chapter 62-777, Florida Administrative Code, June 1999.
[6] The values correspond to a human cancer risk level of 1 in 1,000,000.
[7] The calculated values correspond to a noncancer hazard quotient of 0.1.
[8] Lead value is from the Revised Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (Office of Solid Waste and Emergency Response Directive 9355.4-12).
[9] Values are for hexavalent chromium.
[10] Values are for hydrogen cyanide.
[11] Leachability values may be derived using SPLP test to calculate site-specific target levels or may be determined using toxicity characteristic leaching procedure in the event oily wastes are present.
[12] Value is a Florida Department of Environmental Protection approved site-specific soil cleanup goal for arsenic at covered landfill sites, Naval Air Station, Whiting Field (Appendix H).

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: 11-SL-01 through 11-SL-05, 11S00101 through 11S00501, and 11SS0101 through 11SS303.
Background samples: BKG-SL-02, BKG-SL-06, BKG-SL-07, BKG-SL-04, BKS00101, BKS00201, BKS00301, BKS00401, and BKS00501.
Background duplicate sample: BKS00201D.

* = average of a sample and its duplicate.
μg/kg = micrograms per kilogram.
Bold indicates analyte exceeded screening criteria.
NA = not applicable.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.
NSC = no screening criteria available.

and zinc) were detected in every sample. Nine soil samples contained one or more detected metals at concentrations exceeding the FDEP soil cleanup target levels and/or the USEPA RBCs. In five samples (11-SL-01, 11-SL-02, 11-SL-03, 11S00101, and 11S00501), concentrations of aluminum exceeded the Region III residential RBC of 7,800 mg/kg; however, all detections of aluminum (maximum of 10,800 mg/kg) were below the established background concentration of 15,450 mg/kg. In sample 11-SL-02, the detected concentration of arsenic (3.8 mg/kg) exceeded both the background concentration of 3.2 mg/kg and the Florida residential and industrial soil cleanup target levels of 0.8 mg/kg and 3.7 mg/kg, respectively. Detected concentrations of iron exceeded the USEPA residential RBC of 2,300 mg/kg in nine of the ten samples in which it was analyzed. However, sample 11-SL-02, with an iron concentration of 11,700 mg/kg, was the only sample that exceeded the background iron concentration of 8,830 mg/kg.

Lead was analyzed for and detected at all 18 surface soil sampling locations. The only exceedance of the OSWER Federal value of 400 mg/kg and the Florida residential and industrial soil cleanup goals of 400 mg/kg and 920 mg/kg, respectively, was in sample 11-SL-02, in which lead was detected at 2,230 mg/kg. Thirteen of the eighteen surface soil samples contained lead at concentrations exceeding the background screening concentration of 11.4 mg/kg. All eight samples (11S00601 through 11S01301), collected around location 11S00401 for source delineation, contained lead concentrations in excess of the background screening concentration. After review of the draft RI report, it was noted that the delineation of lead should have been around surface soil sample 11-SL-02. CH2M Hill conducted additional soil sampling in April 1999 to delineate lead around soil sample 11-SL-02. Only one of the 25 samples collected had a lead concentration (666 mg/kg in sample 11S03801) greater than the Florida residential cleanup target level and the Federal OSWER level of 400 mg/kg. Results of this sampling event are presented in Appendix J.

In one sample, 11-SL-01, the detected concentration of manganese (275 and 285 mg/kg for duplicate sample) exceeded the USEPA Region III residential RBC of 160 mg/kg, but not the USEPA industrial RBC, the Florida soil cleanup target levels, or the background screening concentration.

Vanadium was detected above the FDEP residential cleanup target level of 15 mg/kg but all detections were below the background screening concentration of 21.2 mg/kg.

5.6 SUBSURFACE SOIL ASSESSMENT. Table 5-11 summarizes the analytical results for organic and inorganic analytes detected in the three subsurface soil samples collected from the Phase IIA test pit excavations at Site 11. The sample locations are shown on Figure 3-1.

Table 5-12 summarizes the frequency of detection, range of detection limits, range of detection concentrations, mean of detected concentrations, and background screening values for Site 11 subsurface soil samples.

TCL VOCs. Three VOCs were detected in the three subsurface soil samples collected at Site 11. Acetone was detected in samples 11SS0101 and 11SS0303 at estimated concentrations of 100 μg/kg and 80 μg/kg, respectively. Toluene was detected in sample 11SS0101 at an estimated concentration of 4 μg/kg, and total xylenes were detected in all samples at estimated concentrations of 4 μg/kg (11SS0101 and 11SS0202) and 8 μg/kg (11SS0303). All detections of acetone, toluene, and xylene were below USEPA Region III RBCs and Florida cleanup target levels.

Table 5-11
Summary of Analytical Results, Site 11
Subsurface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Test Pit Identifier:	TP-11-01	TP-11-02	TP-11-03
Sample Identifier:	11SS0101	11SS0202	11SS0303
Collect Date:	10/08/92	10/08/92	10/08/92
Volatile Organic Compounds (µg/kg)			
Acetone	100 J	--	80 J
Toluene	4 J	--	--
Xylenes (total)	4 J	4 J	8 J
Semivolatile Organic Compounds (µg/kg)			
bis(2-Ethylhexyl)phthalate	100 J	--	--
Pesticides and PCBs (µg/kg)			
4,4'-DDD	22 J	--	120
4,4'-DDE	5 J	27	22 J
4,4'-DDT	--	8.4	28 J
Aldrin	7 J	--	--
Aroclor-1254	260 J	--	--
Aroclor-1260	62 J	--	--
Dieldrin	23 J	2 J	33 J
Inorganic Analytes (mg/kg)			
Aluminum	17,100	19,400	11,300
Arsenic	3.9	5.5	3.7
Barium	14.6 J	10.7 J	28.5 J
Beryllium	0.18 J	0.21 J	0.12 J
Cadmium	5	--	6.5
Calcium	601 J	766 J	12,100
Chromium	19.5	17.2	11.4
Cobalt	1.2 J	1.1 J	1.7 J
Copper	17.2	5.9	6.7
Iron	16,800	15,600	7,780
Lead	64.4	7.4	109
Magnesium	85.2 J	97 J	311 J
Manganese	20.6	41	188
Mercury	0.11	0.08 J	0.2 J
Nickel	3.7 J	3.5 J	3.9 J
Selenium	--	0.56 J	--
Sodium	176 J	167 J	189 J
Vanadium	34.9	37.5	22.2
Zinc	298	12.8 J	100

Notes: µg/kg = micrograms per kilogram.
J = estimated value.
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.

Table 5-12
Comparison of Analytes Detected in Site 11 Subsurface Soil Samples to Background Screening Values and Benchmark Concentrations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentrations	Background Screening Concentration[2]	USEPA Region III RBC Industrial[3]	Florida Soil Cleanup Target Levels Residential/Industrial/Leachability[4]
Volatile Organic Compounds (µg/kg)						
Acetone	2/3	11 to 19	80 to 100	NA	[6]20,000,000	780,000/5,500,000/2,800
Toluene	1/3	11 to 12	4	NA	[6]41,000,000	380,000/2,600,000/500
Xylenes (total)	3/3	11 to 12	4 to 8	NA	[6]410,000,000	5,900,000/40,00,000/200
Semivolatile Organic Compounds (µg/kg)						
bis(2-Ethylhexyl)phthalate	1/3	370 to 4,000	100	NA	[5]410,000	76,000/280,000/3,600,000
Pesticides and PCBs (µg/kg)						
4,4'-DDD	2/3	3.7 to 40	22 to 120	NA	[5]24,000	4,600/18,000/4,000
4,4'-DDE	2/3	4 to 40	5 to 27	NA	[5]17,000	3,300/13,000/18,000
4,4'-DDT	1/3	4 to 40	8.4 to 28	NA	[5]17,000	3,300/13,000/11,000
Aldrin	1/3	1.9 to 21	7	NA	[5]340	70/300/500
Aroclor-1254	1/3	37 to 400	260	NA	[5]2,900	500/2,100/17,000
Aroclor-1260	1/3	37 to 400	62	NA	[5]2,900	500/2,100/17,000
Dieldrin	1/3	4 to 40	2 to 33	NA	[5]360	70/300/4
Inorganic Analytes (mg/kg)						
Aluminum	3/3	40	11,300 to 19,400	27,800	[6]200,000	72,000/--/SPLP[9]
Arsenic	3/3	2	3.7 to 5.5	6.2	[5]3.8	0.8/[10]4.62/29
Barium	3/3	40	10.7 to 28.5	15.8	[6]14,000	110/87,000/1,600
Beryllium	3/3	1	0.12 to 0.21	0.26	[5]410	120/800/63
Cadmium	1/3	0.67 to 1	5 to 6.5	0.92	[6]100	75/1,300/8

See notes at end of table.

Table 5-12 (Continued)
Comparison of Analytes Detected in Site 11 Subsurface Soil Samples to Background Screening Values and Benchmark Concentrations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentrations	Background Screening Concentration[2]	USEPA Region III RBC Industrial[3]	Florida Soil Cleanup Target Levels Residential/Industrial/Leachability[4]
Inorganic Analytes (mg/kg) (Continued)						
Calcium	2/3	1,000	601 to 12,100	444	--	--/--/--
Chromium[8]	3/3	2	11.4 to 19.5	22.8	[6]610	210/420/38
Cobalt	1/3	10	1.1 to 1.7	1.48	[6]12,000	4,700/110,000/SPLP[9]
Copper	3/3	5	5.9 to 17.2	8.8	[6]8,200	110/76,000/SPLP[9]
Iron	3/3	20	7,780 to 16,800	18,100	[6]61,000	23,000/480,000/SPLP[9]
Lead	3/3	1	7.4 to 109	8.4	[7]400	400/920/SPLP[9]
Magnesium	3/3	1,000	85.2 to 311	270	--	--/--/--
Manganese	3/3	3	20.6 to 188	42.6	[6]4,100	1,600/22,000/SPLP[9]
Mercury	2/3	0.1	0.08 to 0.12	ND	[6]61	3.4/26/2.1
Nickel	2/3	8	0.08 to 0.2	5	[6]4,100	110/28,000/130
Selenium	1/3	0.48 to 1	3.5 to 3.9	0.3	[6]1,000	390/10,000/5
Sodium	2/3	1,000	167 to 189	ND	--	--/--/--
Vanadium	3/3	10	22.2 to 37.5	45	[6]1,400	15/7,400/980
Zinc	3/3	4	12.8 to 298	15.6	[6]61,000	23,000/560,000/6,000

See notes at end of table.

Table 5-12 (Continued)
Comparison of Analytes Detected in Site 11 Subsurface Soil Samples to Background Screening Values and Benchmark Concentrations

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[3] U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentration (RBC) Table (October 1998).
[4] Soil Cleanup Target Levels, Chapter 62-777, Florida Administrative Code (FDEP, 1999).
[5] The values correspond to a human cancer risk level of 1 in 1,000,000.
[6] The calculated values correspond to a noncancer hazard quotient of 0.1.
[7] Lead value is from the Revised Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (Office of Solid Waste and Emergency Response Directive 9355.4-12).
[8] Values based on hexavalent form of chromium.
[9] Leachability values may be derived using SPLP test to calculate site-specific target levels or may be determined using toxicity characteristic leaching procedure in the event oily wastes are present.
[10] Value is a Florida Department of Environmental Protection approved site-specific soil cleanup goal for arsenic at covered landfill sites, Naval Air Station, Whiting Field (Appendix H).

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: 10SS0101, 10SS0202, 10SS0303.
Background samples: BKB00101, BKB00102, BKB201, BKB00202, BKB00301, BKB00302, BKB00401, BKB00402, BKB00501, BKB00502, BKB00601, BKB00602, BKB00701, BKB00702.
Background duplicate samples: BKB00401D and BKB00602D.

μg/kg = micrograms per kilogram.
NA = not applicable.
NSC = no screening criteria available.
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
DDT = dichlorodiphenyltrichloroethane.
DDE = dichlorodiphenyldichloroethene.
mg/kg = milligrams per kilogram.
Bold indicates analyte exceeded screening criteria.

TCL SVOCs. Bis(2-ethylhexyl) phthalate was detected in subsurface soil sample 11SS0101 at an estimated concentration of 100 μg/kg. The detected concentration did not exceed Federal or Florida soil screening criteria.

Pesticides and PCBs. Five pesticides (4,4'-dichlorodiphenyldichloroethane [DDD], 4,4'-dichlorodiphenyldichloroethene [DDE], 4,4'-dichlorodiphenyltrichloroethane [DDT], aldrin, and dieldrin) and two PCBs (Aroclor-1254 and Aroclor-1260) were detected in subsurface soil samples collected at Site 11. Dieldrin and 4,4'-DDE were detected in all three samples. The PCBs were only detected in sample 11SS0101 from test pit TP-11-01. None of the detected pesticides or PCBs exceeded the respective screening values with the exception of dieldrin. Dieldrin was detected in sample 11SS0101 at a concentration of 33 μg/kg which exceeded the Florida leachability cleanup target level of 4 μg/kg.

TAL Metals and (Total) Cyanide. Nineteen inorganic analytes were detected in the subsurface soil samples at Site 11. Seventeen of the analytes (aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, sodium, vanadium, and zinc) were detected in every sample.

The detected arsenic concentrations, ranging from 3.7 mg/kg to 5.5 mg/kg, exceeded the Florida and Federal Screening Criteria for residential and industrial use soils but did not exceed the background screening concentration of 6.2 mg/kg. The detected concentrations of iron exceeded the background screening criteria, but were less than the USEPA and Florida screening criteria. In one sample (11SS0303) the concentration of manganese exceeded the background screening concentration. Manganese was not detected in any of the subsurface samples at concentrations in excess of the USEPA industrial RBC, or the Florida industrial soil cleanup target level. Vanadium was detected above the Florida residential cleanup target level in all three samples but was below the background screening concentration of 45 mg/kg.

5.7 GROUNDWATER ASSESSMENT. The groundwater assessment at Site 11 consisted of the collection of groundwater samples from four onsite wells during Phase IIA and six onsite wells during Phase IIB. The results of groundwater sampling events are discussed separately because of differences in sampling methodology.

5.7.1 Phase II Groundwater Samples Table 5-13 presents field parameter data collected during the Phase IIB sampling and Table 5-14 presents the analytical results for groundwater samples collected at Site 11 during the Phase IIA and IIB sampling events.

Field Parameters. Representative measurements of the field parameters obtained during the purging of the monitoring wells at Site 11 are presented in Table 5-11. The pH values for groundwater samples collected at Site 11 ranged from 5.21 to 11.9 SUs. All of the pH values, with the exception of one sample (monitoring well WHF-11-3, October 28, 1993) were outside the range for the Florida secondary drinking water requirements of 6.5 to 8.5 SUs. Monitoring well WHF-11-2 was sampled on two occasions (October 28, 1993 and August 28, 1996). During each sampling event, pH was measured to be 11.9 SU and 11.63 SU, respectively. The pH of monitoring well WHF-11-2 is considerably higher than the other monitoring wells at Site 11 and is the only well not within the range of values observed in background groundwater samples collected for NAS Whiting Field.

Table 5-13
Summary of Groundwater Field Parameters

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Monitoring Well Designation	Date Sampled	pH (SU)	Temperature (°C)	Specific Conductance (μmhos/cm)	Turbidity (NTU)
Phase IIA					
WHF-11-1	10-29-93	6.04	19.9	111	2.77
WHF-11-1S	10-28-93	5.70	--	--	607
WHF-11-2	10-28-93	11.9	20.8	2,060	168
WHF-11-3	10-28-93	7.12	19	37	799
Phase IIB					
WHF-11-1	8-27-96	5.39	21.9	12	1
WHF-11-1S	8-28-96	6.36	31	520	3.2
WHF-11-2	8-28-96	11.63	26.9	1,270	1
WHF-11-3	8-28-96	5.21	26.7	14	1
WHF-11-4S	8-27-96	6.20	25.5	445	1.5
WHF-11-4D	8-26-96	6.08	23.4	75	1

Notes: SU = standard unit.
°C = degrees Celsius.
μmhos/cm = micromhos per centimeter.
NTU = nephelometric turbidity unit.
-- = not recorded.

Table 5-14
Summary of Analytical Results for Organic Parameters Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase II A Sampling Event					Phase II B Sampling Event
Well Identifier:	WHF-11-1	WHF-11-1S	WHF-11-2	WHF-11-3	WHF-11-3	WHF-11-1
Sample Identifier:	WHF-11-1	WHF-11-1B	WHF11-2	WHF-11-3	WHF11-3A Duplicate	11G00102
Collect Date:	10/29/93	10/28/93	10/28/93	10/28/93	10/28/93	8/27/96
Volatile Organic Compounds (µg/ℓ)						
1,2-Dichloroethene (total)	--	9 J	--	--	--	--
Acetone	--	--	94 J	--	--	--
Benzene	--	--	--	--	--	--
Carbon disulfide	--	--	--	--	--	--
Vinyl chloride	--	--	--	--	--	--
Semivolatile Organic Compounds (µg/ℓ)						
Di-n-octylphthalate	17 J*	--	5 J*	--	--	--
Phenol	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	--	--	--	--	--
Pesticides and PCBs (µg/ℓ)						
None detected						

See notes at end of table.

Table 5-14 (Continued)
Summary of Analytical Results for Organic Parameters Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase II B Sampling Event					
Well Identifier:	WHF-11-1S	WHF-11-2	WHF-11-2	WHF-11-3	WHF-11-4S	WHF-11-4D
Sample Identifier:	11G00101	11G00201	11G00201 Duplicate	11G00301	11G00401	11G00401
Collect Date:	8/28/96	8/28/96	8/28/96	8/28/96	8/27/96	8/267/96
Volatile Organic Compounds (μg/ℓ)						
1,2-Dichloroethene (total)	6 J	--	--	2 J	--	--
Acetone	--	--	--	--	--	--
Benzene	2 J	--	--	--	--	--
Carbon disulfide	--	--	--	--	1 J	2 J
Vinyl chloride	2 J	--	--	--	--	--
Semivolatile Organic Compounds (μg/ℓ)						
Di-n-octylphthalate	--	--	--	--	--	--
Phenol	--	4 J	6 J	--	--	--
bis(2-Ethylhexyl)phthalate	--	5 J	4 J	6 J	--	--
Pesticides and PCBs (μg/ℓ)						
None detected						

Notes: μg/ℓ = micrograms per liter.
-- = not analyzed or not detected.
* = concentration is a result of sample reanalysis.
J = estimated value.
PCB = polychlorinated biphenyl.

Temperature measurements ranged from 19 to 31 degrees Celsius, and the specific conductance ranged from 12 to 2,060 micromhos per centimeter. Turbidity measurements for Phase IIA groundwater samples ranged from 2.77 to 799 NTUs. Turbidity measurements for Phase IIB groundwater samples, collected using low-flow sampling methods, ranged from 1 to 3.2 NTUs. All of the Phase IIB groundwater samples had turbidity measurements below the Florida public water supply treatment technique criteria of 5 NTUs.

Phase IIA Sampling Event. Tables 5-14 and 5-15 summarize the analytical results for organic and inorganic analytes, respectively, detected in four groundwater samples at Site 11. The sample locations are shown on Figure 3-1. No VOCs were detected in groundwater samples collected from the shallow monitoring wells at concentrations exceeding Federal or State MCLs. In samples from well WHF-11-1S, 1,2-dichloroethene (DCE) was detected at an estimated concentration of 9 $\mu g/\ell$, which is below the Federal and State MCL of 70 $\mu g/\ell$. Acetone was detected in one groundwater sample from an intermediate depth monitoring well (WHF-11-2) at an estimated concentration of 94 $\mu g/\ell$. The reported concentration did not exceed the Florida groundwater cleanup target level of 700 $\mu g/\ell$.

Di-*n*-octylphthalate was detected in groundwater samples collected from monitoring wells WHF-11-1 and WHF-11-2 at Site 11. Currently, no Federal or State standards exist for di-*n*-octylphthalate.

Seventeen inorganic analytes were detected in the groundwater samples collected from monitoring wells at Site 11. Thirteen inorganic analytes (aluminum, barium, beryllium, calcium, chromium, copper, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc) were detected at concentrations exceeding the background screening criteria. Five of the analytes, including aluminum, iron, lead, manganese, and vanadium, were detected at concentrations exceeding either the Federal or State regulatory limits.

Phase IIB Sampling Event. Tables 5-14 and 5-15 summarize the analytical results for organic and inorganic analytes detected in six groundwater samples at Site 11 during Phase IIB of the RI investigation. The sample locations are shown on Figure 3-1 and analytical results are summarized on Figure 5-4. Table 5-16 shows statistical summary information for the Phase IIB groundwater sampling event.

Four VOCs (benzene, 1,2-DCE, carbon disulfide, and vinyl chloride) were detected in groundwater samples from monitoring wells at Site 11. Vinyl chloride (estimated concentration of 2 $\mu g/\ell$), benzene (estimated concentration of 2 $\mu g/\ell$), and 1,2-DCE (estimated concentration of 6 $\mu g/\ell$) were detected in monitoring well WHF-11-1S, which is located directly downgradient of the site. The detected concentrations of both vinyl chloride and benzene in this well exceed the Florida groundwater cleanup target level of 1 $\mu g/\ell$ for these two compounds. Carbon disulfide was detected in monitoring wells WHF-11-4S and WHF-11-4D at estimated concentrations of 1 $\mu g/\ell$ and 2 $\mu g/\ell$, respectively. 1,2-DCE was also detected in monitoring well WHF-11-3 at an estimated concentration of 2 $\mu g/\ell$.

One SVOC, bis(2-ethylhexyl)phthalate, was detected in monitoring well WHF-11-3 at a concentration that exceeded the Federal MCL and Florida groundwater cleanup target level. Phenol, detected in the groundwater sample (and duplicate)

Table 5-15
Summary of Analytical Results for Inorganic Analytes Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase IIA Sampling Event					Phase IIB Sampling Event	
Well Identifier:	WHF-11-1	WHF-11-1S	WHF-11-2	WHF-11-3	WHF-11-3	WHF-11-1	WHF-11-1S
Sample Identifier:	WHF-11-1	WHF-11-1B	WHF11-2	WHF-11-3	WHF11-3A Duplicate	11G00102	11G00101
Collect Date:	10/29/93	10/28/93	10/28/93	10/28/93	10/28/93	8/27/96	8/28/96
Inorganic Analytes (μg/ℓ)							
Aluminum	69.8 J	16,400	5,860	24,000	22,300	--	--
Arsenic	--	--	--	--	--	--	0.6 J
Barium	33.8 J	97.1 J	63.6 J	153 J	150 J	34.1 J	102 J
Beryllium	--	0.2	--	--	1.2 J	--	--
Cadmium	--	--	--	--	--	--	--
Calcium	6,830	49,800	67,700	9,570	9,520	3,520 J	80,800
Chromium	--	20.3	44.4	54.3	55.2	--	--
Cobalt	--	--	--	6.1 J	5.9 J	--	--
Copper	5.4 J	8.4 J	6.4 J	34	27.5	--	--
Cyanide	--	--	--	--	--	--	--
Iron	142	23,000	2,280	37,800	36,700	--	6,690
Lead	6	5.4	2.1 J	21.9	19 J	--	9.8
Magnesium	304 J	5,220	567 J	3,570 J	3,450	238 J	7,660
Manganese	2.5 J	272	14.5 J	374	369	--	385
Mercury	--	--	--	--	0.22 J	--	--
Nickel	--	13.3	--	16.7 J	13.9 J	--	--
Potassium	747 J	1,980 J	9,960	3,060 J	2,940 J	9,760	3,100 J
Sodium	1,800 J	25,300 J	2,940 J	12,800	12,800	4,790 J	2,870 J
Thallium	--	--	--	--	--	0.7 J	--
Vanadium	--	49.8 J	--	61.8	60.6	--	--
Zinc	37.5	32.5 J	15.8 J	80.8	81.5	--	6.4 J
Secondary Water Quality Parameters							
Alkalinity as CaCO3	NA	NA	NA	NA	NA	30	178
Ammonia-N	NA	NA	NA	NA	NA	--	0.8

See notes at end of table.

Table 5-15 (Continued)
Summary of Analytical Results for Inorganic Analytes Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase IIA Sampling Event					Phase IIB Sampling Event	
Well Identifier:	WHF-11-1	WHF-11-1S	WHF-11-2	WHF-11-3	WHF-11-3	WHF-11-1	WHF-11-1S
Sample Identifier:	WHF-11-1	WHF-11-1B	WHF11-2	WHF-11-3	WHF11-3A Duplicate	11G00102	11G00101
Collect Date:	10/29/93	10/28/93	10/28/93	10/28/93	10/28/93	8/27/96	8/28/96
Secondary Water Quality Parameters (Continued)							
Hardness as CaCO3	NA	NA	NA	NA	NA	14	211
Nitrate-Nitrite	NA	NA	NA	NA	NA	0.34	--
Phosphorous-P, (total)	NA	NA	NA	NA	NA	--	--
Sulfate	NA	NA	NA	NA	NA	0.57	43.4
Total dissolved solids	NA	NA	NA	NA	NA	30	245
Total Kjeldahl Nitrogen	NA	NA	NA	NA	NA	--	1
Total organic carbon	NA	NA	NA	NA	NA	--	--

See notes at end of table.

Table 5-15 (Continued)
Summary of Analytical Results for Inorganic Analytes Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase IIB Sampling Event						
Well Identifier:	WHF-11-2	WHF-11-2	WHF-11-2(F)	WHF-11-3	WHF-11-3(F)	WHF-11-4S	WHF-11-4D
Sample Identifier:	11G00201	11G00201D	11G00201F	11G00301	11G00301F	11G00401	11G00402
Collect Date:	8/28/96	8/28/96	8/28/96	8/28/96	8/28/96	8/27/96	8/26/96
Inorganic Analytes $\mu g/\ell$							
Aluminum	2,770	2,320	1,930	913	--	--	270
Arsenic	1.7 J	2 J	1.1 J	--	--	3.3 J	--
Barium	50.3 J	51.6 J	26.4 J	35 J	15.6 J	96.2 J	18 J
Beryllium	0.4 J	--	--	--	--	--	--
Cadmium	--	--	--	1.2 J	--	--	--
Calcium	35,400	41,800	17,800	2,640 J	1,840 J	69,900	8,900
Chromium	20.4	19.2	14.1	10	--	--	--
Cobalt	--	--	--	--	--	--	--
Copper	2 J	3.1 J	--	4.5 J	--	--	1.6 J
Cyanide	--	--	0	--	0	--	--
Iron	232	337	7.4 J	4,560	--	8,810	271
Lead	--	0.9 J	1.1 J	1.8 J	--	3.1	1.5 J
Magnesium	388 J	538 J	378 J	485 J	379 J	4,290 J	963 J
Manganese	2.2 J	4.8 J	--	33.6	18.9	193	193
Mercury	--	--	--	--	--	--	--
Nickel	--	--	--	--	--	--	--
Potassium	12,900	9,610	9,970	2,540 J	--	--	--
Sodium	3,420 J	2,950 J	2,950 J	4,840 J	4,230 J	1,780 J	12,900
Thallium	--	--	--	--	--	--	--
Vanadium	11 J	11 J	8.4 J	4.5 J	--	--	--
Zinc	--	24.3	--	60.6	74.1	--	144
Secondary Water Quality Parameters							
Alkalinity as CaCO3	84	NA	NA	--	NA	168	35
Ammonia-N	--	NA	NA	--	NA	0.3	--

See notes at end of table.

Table 5-15 (Continued)
Summary of Analytical Results for Inorganic Analytes Detected in Groundwater Samples, Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

	Phase IIB Sampling Event						
Well Identifier:	WHF-11-2	WHF-11-2	WHF-11-2(F)	WHF-11-3	WHF-11-3(F)	WHF-11-4S	WHF-11-4D
Sample Identifier:	11G00201	11G00201D	11G00201F	11G00301	11G00301F	11G00401	11G00402 Duplicate
Collect Date:	8/28/96	8/28/96	8/28/96	8/28/96	8/28/96	8/27/96	8/26/96
Secondary Water Quality Parameters							
Hardness as CaCO3	113	NA	NA	NA	NA	196	22
Nitrate-Nitrite	0.9	NA	NA	NA	NA	--	--
Phosphorous-P (total)	--	NA	NA	0.11	NA	--	--
Sulfate	10.6	NA	NA	0.53	NA	44	9.12
Total dissolved solids	52	NA	NA	33	NA	215	33
Total Kjeldahl Nitrogen	--	NA	NA	--	NA	0.5	--
Total organic carbon	--	NA	NA	--	NA	2.7	--

Notes: $CaCo_3$ = calcium carbonate.
-- = compound, if present, was not detected above instrument detection limits.
$\mu g/\ell$ = micrograms per liter.
J = estimated value.
NA = compound was not analyzed.

Figure 5-4 Groundwater Analytical Results

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Table 5-16
Summary of Analytes Detected in Site 11 Groundwater Samples Collected During the Phase IIB Remedial Investigation

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentrations Range[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Federal MCLs[5]	Florida Groundwater Cleanup Target Level[6]
Volatile Organic Compounds (µg/ℓ)							
1,2-Dichloroethene (total)	2/6	10	2 to 6	4	ND	70	70
Benzene	1/6	10	2	2	ND	5	1
Carbon disulfide	2/6	10	1 to 2	1.5	ND	NA	700
Vinyl chloride	1/6	10	2	2	ND	2	1
Semivolatile Organic Compounds (µg/ℓ)							
bis(2-Ethylhexyl)phthalate	2/6	10	4.5* to 6	5.3	ND	6	6
Phenol	1/6	10	5*	5	ND	NA	10
Inorganic Analytes (µg/ℓ)							
Aluminum	3/6	14.6 to 50	270 to 2,550	1,240	654	[8]200	200
Arsenic	3/6	0.5	0.6 to 3.3	1.9	ND	50	50
Barium	6/6	NR	18 to 102	56	72.6	2,000	2,000
Beryllium	1/6	0.15 to 0.3	0.28*	0.28	0.58	4	4
Cadmium	1/6	1.2	1.2	1.2	4.4	5	5
Calcium	6/6	NR	2,640 to 80,800	34,100	3,320	NA	NA
Chromium	2/6	2	10 to 19.8*	14.9	30	100	100
Copper	3/6	1.1	1.6 to 4.5	2.9	10.7	1,000	1,000
Iron	5/6	5	271 to 8,810	4,123	964	300	300
Lead	5/6	0.25 to 0.5	0.575* to 9.8	3.4	ND	[7]15	15
Magnesium	6/6	NR	238 to 7,660	2,350	2,430	NA	NA
Manganese	5/6	1	3.5* to 385	162	42.8	50	50
Potassium	4/6	1,100 to 1,580	2,540 to 11,300*	6,660	1,530	NA	NA

See notes at end of table.

Table 5-16 (Continued)
Summary of Analytes Detected in Site 11 Groundwater Samples Collected During the Phase IIB Remedial Investigation

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentrations Range[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Federal MCLs[5]	Florida Groundwater Cleanup Target Level[6]
Inorganic Analytes (μg/ℓ) (Continued)							
Sodium	6/6	NR	1,780 to 12,900	5,060	4,770	NA	160,000
Thallium	1/6	0.6	0.7	0.7	ND	2	2
Vanadium	2/6	1.2	4.5 to 11*	7.8	3.8	NA	49
Zinc	4/6	1.6 to 2.6	6.4 to 144	56	200	5,000	5,000

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] A value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect, one-half of the contract-required quantification limit/contract-required detection limit is used as a surrogate concentration for the nondetect.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[5] Federal MCLs are maximum permissible concentrations of contaminants in the water that are delivered to a user by a public water system. USEPA Drinking Water Regulations and Health Advisories, February 1996.
[6] Florida Groundwater Cleanup Target Levels, Chapter 62-777, Florida Administrative Code (FDEP, 1999).
[7] Value is a treatment technique.
[8] Value is a secondary MCL.

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: 11G00101, 11G00102,11G00201, 11G00301, 11G00401, 11G00402.
Duplicate sample: 11G00201D.
Background samples: BKG00101 through BKG00103, BKG00201 through BKG00203, BKG00301 through BKG00303.
Background duplicate sample: BKG00101D.

ARARs = applicable or relevant and appropriate requirement.
MCL = maximum contaminant level.
μg/ℓ = micrograms per liter.
* = average of sample and duplicate.
ND = not detected in any background samples.
NA = not applicable.
NR = not reported.
Bold indicates analyte exceeded screening criteria.

collected from monitoring well WHF-11-2, was the only other SVOC detected in the Site 11 groundwater.

Seventeen inorganic analytes were detected in the Phase IIB groundwater samples. Twelve of the analytes (aluminum, arsenic, barium, calcium, iron, lead, magnesium, manganese, potassium, sodium, thallium, and vanadium) were detected at concentrations exceeding the background screening concentration. Only three inorganic analytes (aluminum, iron, and manganese) were detected at levels that exceeded their respective Florida groundwater cleanup target level and Federal MCLs. Aluminum was detected above the Florida and Federal standard of 200 $\mu g/\ell$ in three monitoring wells: WHF-11-2, WHF-11-3, and WHF-11-4D. Groundwater samples from monitoring wells WHF-11-1S, WHF-11-3, and WHF-11-4S each contained concentrations of iron that exceeded the Florida and Federal standard of 300 $\mu g/\ell$. Manganese was detected in groundwater samples from monitoring wells WHF-11-1S, WHF-11-4S, and WHF-11-4D at concentrations exceeding the Federal and Florida regulatory limit of 50 $\mu g/\ell$.

CHAPTER 6.0

6.0 HUMAN HEALTH RISK ASSESSMENT

An HHRA has been conducted as part of the RI for Site 11 at NAS Whiting Field. The purpose of the HHRA is to characterize the risks associated with the hypothetical exposures to site-related chemicals. This HHRA is conducted in accordance with the following guidance documents:

- USEPA's Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) (USEPA, 1989b),
- Guidance for Data Useability in Risk Assessment (Part A), Final (USEPA, 1992a), and
- Region IV Risk Assessment Guidance (USEPA, 1995a).

Additionally the HHRA will consider FDEP regulations:

- Soil and Groundwater Cleanup Target Levels for Florida (FDEP, 1999)

The methodology for the HHRA is described in Chapter 2.0 of the GIR (ABB-ES, 1998). The HHRA methodology presented in the GIR (ABB-ES, 1998) consists of the following steps:

- data evaluation,
- selection of chemicals of potential concern,
- exposure assessment,
- toxicity assessment, and
- risk characterization.

Site 11 is located in the southeast area of the facility. The location, physical description, and history associated with Site 11 are described in Chapter 1.0 of this report. During the RI, surface soil, subsurface soil, and groundwater were collected from Site 11. Sampling locations and the sampling rationale are presented in Chapters 3.0 and 5.0 of this report.

6.1 DATA EVALUATION. The data evaluation involves numerous activities, including sorting data by medium, evaluating quantitation limits, and evaluating quality of data with respect to qualifiers.

The data for Site 11 were categorized into surface soil, subsurface soil, groundwater, and background for each medium.

Sample Quantitation Limits (SQLs) are compared to USEPA Region III Risk-Based Concentrations (RBCs) (USEPA, 1998), and Florida Cleanup Target Levels (FDEP 1999). Surface soil and subsurface soil SQLs were compared to Region III RBCs for residential and industrial, respectively (USEPA, 1997a) and Soil Cleanup Target Levels for Florida (FDEP, 1999). Groundwater SQLs were compared to Florida Groundwater Cleanup Target Levels (FDEP, 1999) and Region III Tap Water RBCs (USEPA, 1998). Analyte-specific SQLs that are above RBCs and Federal and State screening values are identified and discussed in the uncertainty analysis.

The quality of the data was evaluated with respect to the data qualifiers. Only data of sufficient quality were retained for evaluation in the HHRA. The HHRA considers data with "J", "U", and "UJ" qualifiers, as well as data with no qualifier.

6.2 SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN (HHCPCs). The HHCPCs were selected per the methodology described in Section 2.5 of the GIR (ABB-ES, 1998). This HHCPC selection methodology considers 1) frequency of detection, 2) consistency with background conditions, 3) comparison with regulatory and risk-based screening values (screening values are presented in Appendix E, Tables E-1 through E-3), and 4) comparison with essential nutrient levels.

In selecting HHCPCs, USEPA Region IV criteria will be used (USEPA, 1995a). For each medium, the following criteria will be employed to exclude detected analytes from the list of HHCPCs. Each criterion by itself is justification for excluding the analyte.

Less than 5 Percent Frequency of Detection. If an analyte has a frequency of detection (number of samples in which the analyte is detected divided by the number of samples analyzed for that analyte) less than 5 percent (USEPA, 1995a) and is not selected as a HHCPC in another medium, it is not selected as a HHCPC. This criterion is not used if there are less than 20 environmental samples for a specific medium, and was not applicable in this HHRA.

Less than Background Screening Concentrations. If the maximum detected concentration of an analyte is less than twice the arithmetic mean of the background concentration (inorganics only), the analyte is not selected as a HHCPC (USEPA, 1995a). Development of background screening values for surface soil, groundwater, and subsurface soil are discussed below.

- A representative surface soil background data set consisting of Troup loamy sand and Dothan fine sandy loam soil types is used for background screening of Site 11 surface soil samples. Sample locations are identified on Figure 3-10 and are discussed in Subsection 3.3.1 of the GIR (ABB-ES, 1998). The background surface soil data used for screening Site 11 surface soils are presented in Tables 3-8 and 3-14 of the GIR (ABB-ES, 1998).

- Subsurface soil locations are identified on Figure 3-11 and are discussed in Subsection 3.3.2 of the GIR (ABB-ES, 1998). Tables 3-15 through 3-17 in the GIR report present background sample data for various types of subsurface soil. Table 3-18 of the GIR (ABB-ES, 1998) presents summary statistics and background screening data value used in the Site 11 HHRA subsurface soil evaluation.

- Background groundwater sample locations are identified on Figure 3-12 and discussed in Subsection 3.3.3 of the GIR (ABB-ES, 1998). Tables 3-21 through 3-23 of the GIR (ABB-ES, 1998) presents background screening data for groundwater. Table 3-24 of the GIR (ABB-ES, 1998) presents the summary statistics used for screening the groundwater at Site 11.

Less than Risk-Based Screening Concentrations, Standards, and Guidelines. If the maximum detected concentration of the analyte in a medium is less than its corresponding adjusted USEPA Region III RBC (USEPA, 1998), and less than USEPA and Florida standards, the analyte is not selected as a HHCPC (USEPA, 1995a). The target hazard quotient (HQ) in the USEPA Region III RBC table is 1 and the target cancer risk is 1×10^{-6}. All RBCs based on noncarcinogenic effects are adjusted for a target HQ of 0.1 per Region IV guidance (USEPA, 1995a).

The residential soil RBCs are used for surface soil. The industrial soil RBCs are used for subsurface soil. No RBC is available for lead in soil due to a lack of toxicity data. Based on an USEPA recommendation, a screening level of 400 mg/kg for lead under residential land use is used as the RBC for lead in soil (USEPA, 1994c). No RBC is available for TPH. Therefore, the FDEP Cleanup Target Level was used for screening (FDEP, 1999). The maximum detected concentrations of analytes in surface soil and subsurface soil are also compared to residential and industrial Florida soil cleanup target levels, respectively. The maximum detected concentration of any organic analyte in surface soil that was also detected in groundwater (above a standard or guideline) is compared to the Florida Leaching Cleanup Target Level for that analyte.

Tap water RBCs (USEPA, 1997a), Federal MCLs (USEPA, 1996b) and Florida Groundwater Cleanup Target Levels (FDEP, 1999) are used for screening HHCPCs in groundwater.

Less than Essential Nutrient Screening Values. If the maximum detected concentration of an essential nutrient (i.e., sodium, potassium, magnesium, and calcium) in a medium is below a toxic level and consistent with or only slightly above its background concentration, the essential nutrient is not selected as an HHCPC. The derivation of essential nutrient screening values is presented in the GIR (ABB-ES, 1998).

HHCPCs were not screened using the essential nutrient value for iron; the RBC for iron was used instead. However, if iron is determined to be a risk driver, a comparison of the exposure point concentrations (EPCs) against the essential nutrient level for iron will be presented in the uncertainty analysis section for that medium.

If the analyte meets any of the above criteria, is not a member of the same chemical class as other HHCPCs in the medium, and is not a breakdown product of other HHCPCs in the medium, then the analyte is not selected as an HHCPC. In situations where multiple screening values are available, a chemical is excluded only if its maximum screening concentration is less than all of the corresponding screening values. Appendix E presents the RBCs, regulatory guidance values, and applicable or relevant and appropriate requirements that are used in HHCPC selection. After applying these criteria with professional judgment, HHCPCs are identified for each medium. HHCPC selection for each media is presented below in Subsections 6.2.1 through 6.2.3.

6.2.1 Surface Soil

6.2.1.1 Site 11 Surface Soil Ten samples including 11-SL-01 through 11-SL-05, 11S00101, 11S00201, 11S00301, 11-SL-02RE, 11S00201DL, and two duplicates 11-SL-01A and 11S00601D were considered in the Site 11 HHRA. Sample 11-SL-02RE only had data for VOCs, which were averaged with the original sample 11-SL-02. Sample 11S00201DL only had data for pesticides. However, all of the data were rejected, except for alpha chlordane. Sample 11S002001 had data for every class of constituents except alpha chlordane. Therefore, the alpha-chlordane data for sample 11S00201DL were combined into sample 11SS00201. Samples 11S00601 through 11S01301 and duplicate 11S00601D were analyzed only for lead. TPH was analyzed only in samples 11S00101 through 11S00501. VOCs, SVOCs, pesticides, PCBs, inorganic analytes, and TPH data from all of these samples are evaluated in this HHRA. Table 5-7 presents the analytes detected and the concentrations in surface soil. Table 6-1 presents summary statistics for the HHRA and identifies six polynuclear aromatic hydrocarbons (PAHs) (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene), one pesticide compound (dieldrin), and three inorganic analytes (arsenic, iron, and lead) as the HHCPCs for surface soil at Site 11.

6.2.1.2 Site 11 Subsurface Soil Three samples (11SS0101, 11SS0202, and 11SS0303) were collected from Site 11 (Figure 3-2). VOCs, SVOCs, pesticides, PCBs and inorganic analyte data from all of these samples are evaluated in this HHRA (Table 5-11). Table 6-2 presents the HHCPCs selection for subsurface soil at Site 11. No analytes were selected as HHCPCs in the subsurface soil.

6.2.1.3 Groundwater Six groundwater samples (11G00101, 11G00102, 11G00201, 11G00301, 11G00401, 11G00402) and the duplicate sample for 11G00201D) were collected from Site 11 (Figure 3-3). VOCs, SVOCs, pesticides, PCBs, and inorganic analyte data from these samples are evaluated in this HHRA (Table 5-14 and 5-15). Table 6-3 presents the summary statistics for the detected concentrations and identifies 1,2-dichloroethene, benzene, vinyl chloride, bis(2-ethylhexyl)phthalate, and five inorganics (aluminum, arsenic, iron, manganese, and thallium) as HHCPCs for groundwater at Site 11.

6.3 EXPOSURE ASSESSMENT. The exposure assessment methodology is described in Section 2.5.3 of the GIR (ABB-ES, 1998). This process involves the following several steps:

- characterization of the exposure setting in terms of physical characteristics and the populations that may hypothetically be exposed to site-related chemicals;
- identification of potential exposure pathways and receptors; and
- quantification of exposure for each population in terms of the amount of chemical either ingested, inhaled, or absorbed through the skin from all complete or hypothetically complete (potential future) exposure pathways.

Summaries of hypothetical exposure pathways to chemicals detected at Site 11 are presented on Figure 6-1.

Table 6-1
Selection of Human Health Chemicals of Potential Concern for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (μg/kg)								
Acetone	1/10	11 to 13	53.3*	53.3	ND	780,000	No	S
Semivolatile Organic Compounds (μg/kg)								
2-Methylnaphthalene	1/10	350 to 4,000	49	49	ND	80,000	No	S
Acenaphthylene	1/10	350 to 4,000	110	110	ND	470,000	No	S
Anthracene	1/10	350 to 4,000	280	280	ND	2,300,000	No	S
Benzo(a)anthracene	1/10	350 to 4,000	1,800	1,800	ND	870	Yes	
Benzo(a)pyrene	1/10	350 to 4,000	910	910	ND	87	Yes	
Benzo(b)fluoranthene	1/10	350 to 4,000	710	710	ND	870	Yes	C
Benzo(g,h,i)perylene	1/10	350 to 4,000	310	310	ND	230,000	No	S
Benzo(k)fluoranthene	1/10	350 to 4,000	870	870	ND	8,700	Yes	C
bis(2-Ethylhexyl)phthalate	5/10	350 to 4,000	52 to 540	175	ND	46,000	No	S
Chrysene	1/10	350 to 4,000	2,500	2,500	ND	87,000	Yes	C
Fluoranthene	1/10	350 to 4,000	1,300	1,300	ND	310,000	No	S
Indeno(1,2,3-cd)pyrene	1/10	350 to 4,000	230	230	ND	870	Yes	C
Phenanthrene	1/10	350 to 4,000	2,100	2,100	ND	230,000	No	S
Pyrene	1/10	350 to 4,000	3,400	3,400	ND	230,000	No	S

See notes at end of table.

Table 6-1 (Continued)
Selection of Human Health Chemicals of Potential Concern for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Pesticides and PCBs (μg/kg)								
4,4'-DDD	1/10	3.6 to 980	140	140	ND	2,700	No	S
4,4'-DDE	7/10	3.7 to 980	2.1 to 88	26.5	ND	1,900	No	S
4,4'-DDT	8/10	3.7 to 980	2.3 to 530	81.8	ND	1,900	No	S
Aldrin	1/10	1.9 to 490	0.96	0.96	ND	38	No	S
Dieldrin	8/10	3.7 to 980	4.9 to 210	42.9	ND	40	Yes	
Heptachlor	1/10	1.9 to 490	4.8	4.8	ND	140	No	S
Heptachlor epoxide	1/10	1.9 to 490	8.8	8.8	ND	70	No	S
alpha-Chlordane	4/10	1.9 to 4,900	39 to 310	140	ND	1,800	No	S
gamma-Chlordane	4/10	1.9 to 4,900	29 to 260	111	ND	1,800	No	S
Inorganic Analytes (mg/kg)								
Aluminum	10/10	40	2,110 to 10,800	7,490	15,314	7,800	No	B
Antimony	1/10	2.6 to 12	3.5	3.5	8	3.1	No	B
Arsenic	10/10	2	0.93 to 3.8	2.1	3.0	0.43	Yes	
Barium	10/10	40	4.6 to 96	19.2	23.8	110	No	S
Beryllium	7/10	0.05 to 1	0.05 to 0.14	0.09	0.36	16	No	B, S

See notes at end of table.

Table 6-1 (Continued)
Selection of Human Health Chemicals of Potential Concern for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Inorganic Analytes (mg/kg) (Continued)								
Cadmium	2/10	0.58 to 1	0.24 to 0.28	0.26	0.58	3.9	No	B, S
Calcium	10/10	1,000	185 * to 1,790	445	402	1,000,000	No	S
Chromium	10/10	2	2.7 to 19.6	7.9	10.8	23	No	S
Cobalt	6/10	0.33 to 10	0.35 to 3.4	1.5	3	470	No	S
Copper	8/10	5	3.7 to 19.4	7.2	9.4	110	No	S
Cyanide	5/10	0.23 to 0.5	0.09 to 0.19	0.12	0.26	30	No	B, S
Iron	10/1	20	1,500 to 11,700	5,250	8,588	2,300	Yes	
Lead	18/18	0.6 to 1	5.2 to 2,230	146	11.4	400	Yes	
Magnesium	10/10	6,000	54.2 to 1,260	214	258	460,468	No	S
Manganese	10/10	3	31.4 to 280*	126	404	160	No	B
Mercury	6/10	0.1	0.04 to 0.08	0.05	0.12	2.3	No	B, S
Nickel	4/10	2.3 to 8	1.6 to 10	3.9	7.2	110	No	S
Potassium	8/10	128 to 1,000	62.1 to 166	111	177	1,000,000	No	B, S
Selenium	1/10	0.44 to 1	0.16	0.16	0.44	39	No	B, S
Silver	5/10	2	0.55 to 1.9	1	0.7	39	No	S
Sodium	10/10	1,000	160 to 307	188	388	1,000,000	No	B, S
Vanadium	10/10	10	4.4 to 20.3	12.9	21.2	15	No	B, S
Zinc	10/10	4	5.7 to 260	40.5	15.4	2,300	No	S

See notes at end of table.

Table 6-1 (Continued)
Selection of Human Health Chemicals of Potential Concern for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limits	Range of Detected Concentrations[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Others (mg/kg)								
Total petroleum hydrocarbons	5/5	1.8 to 1.9	7 to 53.1	17.9	NA	380	No	S

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] A value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect, one-half of the contract-required quantification limit/contract-required detection limit is used as a surrogate concentration for the nondetect.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[5] For all chemicals except the essential nutrients (calcium, magnesium, potassium, and sodium), the lesser of the U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentration (RBC) table for residential soil exposure per January 1993 guidance ("Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening, "EPA/903/R-93-001 [USEPA, 1993a]) or the Florida Soil Cleanup Target Levels (FDEP, 1999) was used for screening. Values from the USEPA Region III RBC Tables, dated October 1998, are based on an excess lifetime cancer risk of 6×10^{-6} or an adjusted hazard quotient of 0.1. For the essential nutrients, screening values were derived based on recommended daily allowances. Lead value is from the Revised Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (Office of Solid Waste and Emergency Response Directive 9355.4-12).
[6] Analyte was included or excluded from the risk assessment for the following reasons:
B = the maximum detected concentration did not exceed the background screening concentration; therefore, the analyte will not be considered further.
S = the maximum detected concentration did not exceed the screening concentration; therefore, the analyte will not be considered further.
C = the analyte is a carcinogenic PAH and was selected as an HHCPC because one or more other carcinogenic PAHs were selected.

The average of a sample and its duplicate is used for all table calculations.
Samples: 11-SL-01 through 11-SL-05, 11S00101 through 11S01501, 11S00101 through 11S01301 (for lead only), 11S00101 through 11SS0501 (only analyzed TPH data).
Sample Duplicates: 11-SL-01A and 11S00601D.
Background samples: BKG-SL-02, BKG-SL-06, BKG-SL-07, BKG-SL-08, BKS00101, BKS00201, BK50301, BKS00401, and BKS00501.
Background duplicate sample: BKS00201D.

Notes: HHCPC = human health chemical of potential concern.
μg/kg = micrograms per kilogram.
* = average of sample and duplicate.
ND = not detected in any background sample.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.
NA = not applicable.

Table 6-2
Selection of Human Health Chemicals of Potential Concern for Subsurface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Background Screening Concentration[3]	Selected Screening Concentration[4]	Analyte HHCPC? (Yes/No)	Reason[5]
Volatile Organic Compounds (µg/kg)								
Acetone	2/3	11 to 19	80 to 100	90	NA	5,500,000	No	S
Toluene	1/3	11 to 12	4	4	NA	2,600,000	No	S
Xylenes (total)	3/3	NA	4 to 8	5.3	NA	40,000,000	No	S
Semivolatile Organic Compounds (µg/kg)								
bis(2-Ethylhexyl)phthalate	1/3	370 to 4,000	100	100	NA	280,000	No	S
Pesticides and PCBs (µg/kg)								
4,4'-DDD	2/3	3.7 to 40	22 to 120	71	NA	18,000	No	S
4,4'-DDE	3/3	NA	5 to 27	18	NA	13,000	No	S
4,4'-DDT	2/3	4 to 40	8.4 to 28	18.2	NA	13,000	No	S
Aldrin	1/3	1.9 to 21	7	7	NA	300	No	S
Aroclor-1254	1/3	37 to 400	260	260	NA	2,100	No	S
Aroclor-1260	1/3	37 to 400	62	62	NA	2,100	No	S
Dieldrin	3/3	NA	2 to 33	19.3	NA	300	No	S
Inorganic Analytes (mg/kg)								
Aluminum	3/3	NA	11,300 to 19,400	15,900	27,800	200,000	No	B, S
Arsenic	3/3	NA	3.7 to 5.5	4.4	6.2	3.7	No	B
Barium	3/3	NA	10.7 to 28.5	17.9	15.8	14,000	No	S

See notes at end of table.

Table 6-2 (Continued)
Selection of Human Health Chemicals of Potential Concern for Subsurface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Background Screening Concentration[3]	Selected Screening Concentration[4]	Analyte HHCPC? (Yes/No)	Reason[5]
Inorganic Analytes (mg/kg) (Continued)								
Beryllium	3/3	NA	0.12 to 0.21	0.17	0.26	410	No	B, S
Cadmium	2/3	0.67 to 1	5 to 6.5	5.8	0.92	100	No	S
Calcium	3/3	NA	601 to 12,100	4,490	444	1,000,000	No	S
Chromium	3/3	NA	11.4 to 19.5	16	22.8	420	No	B, S
Cobalt	3/3	NA	1.1 to 1.7	1.3	1.5	12,000	No	S
Copper	3/3	NA	5.9 to 17.2	9.9	8.8	8,200	No	S
Iron	3/3	NA	7,780 to 16,800	13,400	18,100	61,000	No	B, S
Lead	3/3	NA	7.4 to 109	60.3	8.4	400	No	S
Magnesium	3/3	NA	85.2 to 311	164	272	460,468	No	S
Manganese	3/3	NA	20.6 to 188	83.2	42.6	4,100	No	S
Mercury	3/3	NA	0.08 to 0.2	0.13	ND	26	No	S
Nickel	3/3	NA	3.5 to 3.9	3.7	5	4,100	No	B, S
Selenium	1/3	0.48 to 1	0.56	0.56	0.3	1,000	No	S
Sodium	3/3	NA	167 to 189	177	ND	1,000,000	No	S
Vanadium	3/3	NA	22.2 to 37.5	31.5	45	1,400	No	B, S
Zinc	3/3	NA	12.8 to 298	137	15.6	61,000	No	S

See notes at end of table.

Table 6-2 (Continued)
Selection of Human Health Chemicals of Potential Concern for Subsurface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[3] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[4] The lesser of the U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentration (RBC) table for industrial soil exposure per January 1993 guidance ("Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA/903/R-93-001 [USEPA, 1993a]) or Florida Soil Cleanup Target Levels (Florida Department of Environmental Protection, 1999) were used for screening. Actual values are taken from the USEPA Region III RBC Tables dated October 1998, and are based on an excess lifetime cancer risk of 1×10^{-6} or an adjusted hazard quotient of 0.1.
[5] Analyte was included or excluded from the risk assessment for the following reasons:
B = the maximum detected concentration did not exceed the background; therefore, the analyte will not be considered further.
S = the maximum detected concentration did not exceed the screening concentration; therefore, the analyte will not be considered further.

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: 11SS0101, 11SS0202, 11SS0303.
Background samples: BKB00101, BKB00102, BKB00201, BKB00202, BKB00301, BKB00302, BKB00401, BKB00402, BKB00501, BKB00502, BKB00601, BKB00602, BKB00701, BKB00702.
Background duplicate samples: BKB00401D and BKB00602D.

HHCPC = human health chemical of potential concern.
μg/kg = micrograms per kilogram.
NA = not applicable.
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.

Table 6-3
Selection of Human Health Chemicals of Potential Concern for Unfiltered Groundwater

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florid

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentrations Range[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
1,2-Dichloroethene (total)	2/6	10	2 to 6	4	NA	5.5	Yes	
Benzene	1/6	10	2	2	NA	0.36	Yes	
Carbon disulfide	2/6	10	1 to 2	1.5	NA	100	No	S
Vinyl chloride	1/6	10	2	2	NA	0.019	Yes	
Semivolatile Organic Compounds (µg/ℓ)								
bis(2-Ethylhexyl)phthalate	2/6	10	4.5* to 6	5.3	NA	4.8	Yes	
Phenol	1/6	10	5 *	5	NA	10	No	S
Inorganic Analytes (µg/ℓ)								
Aluminum	3/6	14.6 to 50	270 to 2,550 *	1,240	654	50	Yes	
Arsenic	3/6	0.5	0.6 to 3.3	1.9	ND	0.045	Yes	
Barium	6/6	NA	18 to 102	56	72.6	260	No	S
Beryllium	1/6	0.15 to 0.3	0.28 *	0.28	0.58	4	No	B
Cadmium	1/6	1.2	1.2	1.2	4.4	1.8	No	B, S
Calcium	6/6	NA	2,640 to 80,800	34,100	3,320	1,060,000	No	S
Chromium	2/6	2	10 to 19.8 *	14.9	30	11	No	B
Copper	3/6	1.1	1.6 to 4.5	2.9	10.7	150	No	B, S
Iron	5/6	5	271 to 8,810	4,120	964	300	Yes	
Lead	5/6	0.25 to 0.5	0.58* to 9.8	3.4	ND	15	No	S
Magnesium	6/6	NA	238 to 7,660	2,350	2,430	118,807	No	S
Manganese	5/6	1	3.5 * to 385	162	42.8	50	Yes	

See notes at end of table.

Table 6-3 (Continued)
Selection of Human Health Chemicals of Potential Concern for Unfiltered Groundwater

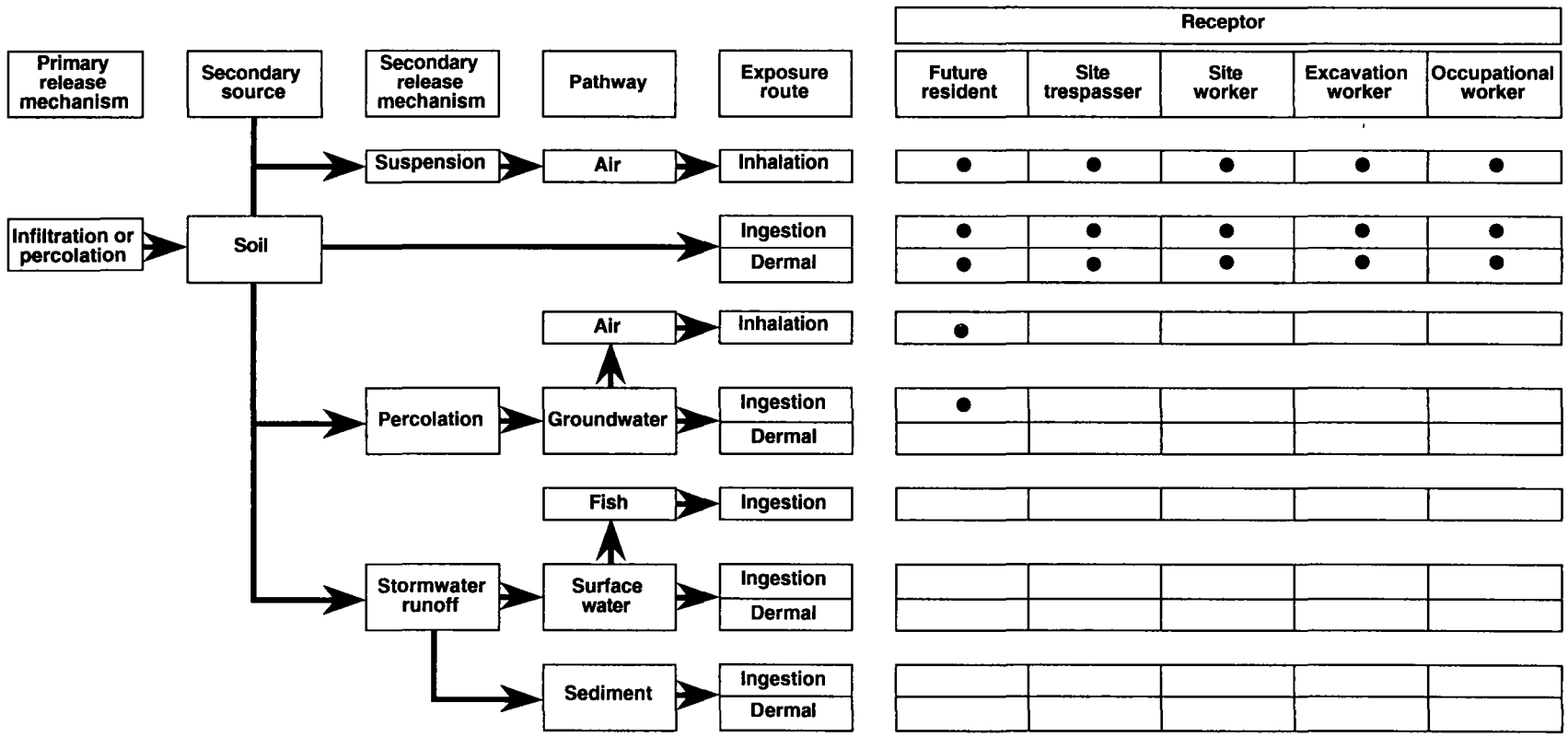
Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentrations Range[2]	Mean of Detected Concentrations[3]	Background Screening Concentration[4]	Selected Screening Concentration[5]	Analyte HHCPC? (Yes/No)	Reason[6]
Inorganic Analytes (μg/ℓ) (Continued)								
Potassium	4/6	1,100 to 1,580	2,540 to 11,300 *	6,660	1,530	297,016	No	S
Sodium	6/6	NA	1,780 to 12,900	5,060	4,770	160,000	No	S
Thallium	1/6	0.6	0.7	0.7	ND	0.29	Yes	
Vanadium	2/6	1.2	4.5 to 11 *	7.8	3.8	26	No	S
Zinc	4/6	1.6 to 2.6	6.4 to 144	56	200	1,100	No	B, S

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] A value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect, one-half of the contract-required quantification limit/contract-required detection limit is used as a surrogate concentration for the nondetect.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples.
[5] For all chemicals except the essential nutrients (calcium, magnesium, potassium, and sodium), the lesser of the U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentration (RBC) table for tap water exposure per January 1993 guidance ("Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA/903/R-93-001 [USEPA, 1993a]) or the Florida Groundwater Cleanup Target Levels (Florida Department of Environmental Protection, 1999) was used for screening. Actual values are taken from the USEPA Region III RBC Tables dated October 1998, and are based on a excess lifetime cancer risk of 1×10^{-6} or an adjusted hazard quotient of 0.1. For the essential nutrients, screening values were derived based on recommended daily allowances.
[6] Analyte was included or excluded from the risk assessment for the following reasons:
B = the maximum detected concentration did not exceed the background screening concentration; therefore, the analyte will not be considered further.
S = the maximum detected concentration did not exceed the screening concentration; therefore, the analyte will not be considered further.

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: 11G00101, 11G00102,11G00201, 11G00301, 11G00401, 11G00402.
Duplicate sample: 11G00201D
Background samples: BKG00101 through BKG00103, BKG00201 through BKG00203, and BKG00301
Background duplicate sample: BKG00101D

HHCPC = human health chemical of potential concern.
μg/ℓ = micrograms per liter.
NA = not applicable.
* = average of sample and duplicate.
ND = not detected in any background samples.



NOTE:
NAS = Naval Air Station

FIGURE 6-1
SITE 11, COMPLETE EXPOSURE PATHWAYS FOR HUMAN RECEPTORS

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

2534-09 WHITING SITE 11 FIG 6-1 FINAL 040198HAS

The hypothetical pathways including medium and route of exposure, the hypothetical exposed population, and the rationale for pathway selection or exclusion are provided in Table 6-4, and are described in more detail in Subsections 6.3.1through 6.3.3. Receptor-specific exposure parameters for each exposure scenario are presented in Appendix C to the GIR (ABB-ES, 1998). Risk calculation spreadsheets in Appendix E of this RI report also contain the assumed exposure parameters and quantitation of exposures.

6.3.1 Surface Soil No humans currently reside or work at Site 11. Site 11 may be developed eventually for residential land use; therefore, the residential receptor will be evaluated as part of the hypothetical future land-use scenario.

Currently there are no buildings present at the site; therefore, exposure of occupational workers will be only considered as part of the future land-use scenario. Other possible future exposure scenarios include excavation activities, such as installation of utility lines, and site maintenance, such as mowing the grass. Exposures of hypothetical future residents (adult and child), hypothetical future occupational workers, current and future site maintenance workers, future excavation workers, and current and future trespassers (adult and child) to surface soil contaminants through ingestion, dermal contact, and inhalation of particulates are evaluated in this HHRA.

6.3.2 Subsurface Soil There are no current exposures to subsurface soil because no excavation or construction activities are ongoing at Site 11. Therefore, subsurface soil exposure pathways are not evaluated in this HHRA. Also, there were no HHCPCs identified.

6.3.3 Groundwater Currently, groundwater at Site 11 is not used for any potable or nonpotable purpose. There are no plans to use the water resource in the foreseeable future. However, in the event that Site 11 or areas hydraulically downgradient of Site 11 are developed for residential use, the exposure pathway to chemicals in groundwater could become complete. Therefore, hypothetical future domestic use of the surficial aquifer is evaluated in this HHRA as a worst-case estimate of future potential exposures to groundwater. Exposure routes evaluated include ingestion of groundwater as tap water, and inhalation of volatiles during bathing (showering). The tap water ingestion and volatile inhalation exposure pathways are considered to be the most significant exposure pathways associated with potable use of water. Dermal exposure to groundwater during potable use is considered to be insignificant relative to tap water ingestion and volatile inhalation exposure pathways, and separate quantitative evaluation is not required by USEPA Region IV (USEPA, 1995).

6.3.4 Exposure Point Concentrations EPCs for all HHCPCs in surface soil and groundwater were calculated according to Subsection 2.5.3.3 of the GIR (ABB-ES, 1998). This quantification process involves developing assumptions regarding exposure conditions and exposure scenarios for each receptor to estimate the total amount of contaminants that a hypothetical receptor may ingest, dermally absorb, or inhale from each exposure pathway. The ultimate goal of this step, as defined in the USEPA guidance, is to identify the combination of these exposure variables or parameters that result in the most intense level of exposure that may "reasonably" be expected to occur under current and future site conditions (USEPA, 1989b). The EPCs for HHCPCs in surface soil for Site 11 are presented in Table 6-5. The EPCs for HHCPCs in groundwater for Site 11 are

Table 6-4
Summary of Potential Exposure Pathways

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Medium of Exposure	Route of Exposure	Potentially Exposed Population	Selected for Evaluation ?	Reason for Selection or Evaluation
Current Land Use				
Surface soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Resident (adult and child) Trespasser (adult and adolescent) Occupational worker (adult) Site maintenance worker (adult) Excavation worker (adult)	No Yes No Yes No	No humans currently reside at Site 11. Adolescents and adults may be exposed to contaminants in the surface soil while trespassing. The site maintenance workers may be exposed to contaminants in surface soil while performing routine site activities.
Subsurface soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Excavation worker (adult)	No	An excavation worker could be exposed to soil during excavation activities, but no excavation activities are ongoing. Additionally, there were no HHCPCs selected for subsurface soil at Site 11.
Groundwater	Ingestion of groundwater as drinking water	Resident (adult)	No	There are no current exposures to groundwater.
Future Land Use				
Surface soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Resident (child and adult) Trespasser (adolescent and adult) Occupational worker (adult) Site maintenance worker (adult) Excavation worker (adult)	Yes Yes Yes Yes Yes	If Site 11 is developed for residential use, residents could be exposed to chemicals in surface soil. Exposure of trespassers, occupational workers, site maintenance workers and excavation workers to chemicals in surface soil is possible.
Subsurface soil	Dermal contact with soil, ingestion of soil, and inhalation of fugitive dust.	Excavation worker (adult)	No	An excavation worker could be exposed to subsurface soil during utility work or construction activities; however, there were no human health chemical of potential concerns selected for subsurface soil at Site 11.
Groundwater	Ingestion of groundwater as drinking water and inhalation of volatiles while showering	Resident (adult and child)	No	If Site 11 is developed for residential use, drinking water wells in the surficial aquifer could be influenced by contaminants in the groundwater associated with Site 11.

Table 6-5
Exposure Point Concentrations for Human Health Chemicals of Potential Concern for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Maximum Detected Concentration	95% UCL[2]	Exposure Point Concentration[3]
Semivolatile Organic Compounds (μg/kg)				
Benzo(a)anthracene	1/10	1,800	976	976
Benzo(a)pyrene	1/10	910	806	806
Benzo(b)fluoranthene	1/10	710	777	710
Benzo(k)fluoranthene	1/10	870	800	800
Chrysene	1/10	2,500	1,140	1,140
Indeno(1,2,3-cd)pyrene	1/10	230	608	203
Pesticides and PCBs (μg/kg)				
Dieldrin	8/10	210	74	74
Inorganic Analytes (mg/kg)				
Arsenic	10/10	3.8	2.7	2.7
Iron	10/10	11,700	6,930	6,930
Lead	18/18	2,230	166	166

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] 95% UCL of the arithmetic mean is calculated using all samples. One-half the contract-required quantitation limit/contract-required detection limit is used as a surrogate for nondetects. The UCL is not calculated when there are less than 10 total samples.
[3] Exposure point concentration is the lower of either the 95% UCL concentration or maximum detected concentration.

Notes: % = percent.
mg/kg = milligrams per kilogram.
UCL = upper confidence limit
μg/kg = micrograms per kilogram.
PCB = polychlorinated biphenyl.

presented in Table 6-6. The EPCs were used with receptor-specific exposure parameters to quantify exposures to the HHCPCs, as shown in the risk calculation spreadsheets in Appendix E of this report.

6.4 TOXICITY ASSESSMENT. The toxicity assessment methodology is described in Subsection 2.5.4 of the GIR (ABB-ES, 1998). The toxicity assessment evaluates the available evidence on the hypothetical adverse effects associated with exposure to each HHCPC. This information is used to develop a relationship between the extent of exposure and the likelihood or severity of adverse human health effects. Two steps are typically associated with toxicity assessment: hazard identification and dose-response assessment.

- Hazard identification is the process of determining if exposure to an agent can cause a particular adverse health effect and, more importantly, if that effect will occur in humans. The objectives of the hazard identification in the HHRA are to (1) identify which of the contaminants detected at the site are hypothetical hazards, and (2) summarize their potential toxicity in brief nontechnical language.

- A dose-response assessment is conducted to characterize and quantify the relationship between intake, or dose, of a HHCPC and the likelihood of a toxic effect or response. There are two categories of toxic effects evaluated in this HHRA: carcinogenic and noncarcinogenic. Following USEPA guidance for HHRAs (USEPA, 1989b), these two endpoints (cancer and noncancer) are evaluated separately. As a result of the dose-response assessment, identified toxicity values are used to estimate the incidence of adverse effects as a function of human exposure to a chemical.

Appendix C to this report contains brief toxicity profiles for HHCPCs identified in surface soil and groundwater at Site 11. Appendix E of this report also contains toxicity information for the HHCPCs (Tables E-4 through E-9). Toxicity values used in this HHRA were current as of November 1997 for Integrated Risk Information System (IRIS) (USEPA, 1997b) and July 1997 for Health Effects Assessment Summary Tables (USEPA, 1997c).

6.5 RISK CHARACTERIZATION. Risk characterization is the final step in the risk assessment process. This step involves the integration of the exposure and toxicity assessments into a qualitative or quantitative expression of potential human health risks associated with contaminant exposure. Quantitative estimates of both carcinogenic and noncarcinogenic risks are made for each HHCPC and each complete exposure pathway identified in the exposure assessment. The risk characterization methodology is described in Subsection 2.5.5 of the GIR (ABB-ES, 1998).

Risk estimates for hypothetical exposures to surface soil and groundwater under current and hypothetical future land use scenarios are discussed below. These risk estimates are then compared to USEPA and FDEP carcinogenic and noncarcinogenic target levels.

The USEPA guidelines, established in the NCP, indicate that the total excess lifetime cancer risk (ELCR) due to exposure to the HHCPCs at a site should not

Table 6-6
Exposure Point Concentrations for Human Health Chemicals of Potential Concern, Groundwater

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Maximum Detected Concentration	Arithmetic Mean[2]	Exposure Point Concentration[3]
Volatile Organics (μg/ℓ)				
1,2-Dichloroethene (total)	2/6	6	4.7	4.7
Benzene	1/6	2	4.5	2
Vinyl chloride	1/6	2	4.5	2
Semivolatile Organics (μg/ℓ)				
bis(2-Ethylhexyl)phthalate	2/6	6	5.1	5.1
Inorganic Analytes (μg/ℓ)				
Aluminum	3/6	2,550	628	628
Arsenic	3/6	3.3	1.1	1.1
Iron	5/6	8,810	3,440	3,440
Manganese	5/6	385	135	135
Thallium	1/6	0.7	0.37	0.37

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] Arithmetic mean of all samples calculated using one-half the contract-required quantitation limit and contract-required detection limit for nondetects.
[3] Exposure point concentration is the lower of either the mean concentration or maximum detected concentration.

Note: μg/ℓ = micrograms per liter.

exceed a range of 1 in 1,000,000 ($1x10^{-6}$) to 1 in 10,000 ($1x10^{-4}$) (USEPA, 1990). FDEP has indicated that chemical-specific risks greater than one in one million ($1x10^{-6}$) warrant further consideration.

A HQ less than 1 indicates that noncarcinogenic toxic effects are not expected to occur due to HHCPC exposure. Hazard indices (HIs) greater than 1 may be indicative of possible noncarcinogenic toxic effects, but the circumstances must be evaluated on a case-by-case basis (USEPA, 1989a). As the HI increases, so does the likelihood that adverse effects might be associated with exposure. Both USEPA and FDEP consider that chemicals with HIs greater than 1 warrant further evaluation and require an evaluation of the noncarcinogenic effects.

Table 6-7 summarizes the cancer and noncancer risk under a current land-use scenario for Site 11. Table 6-8 summarizes the cancer and noncancer risk under a hypothetical future land-use scenario for Site 11.

6.5.1 Surface Soil The risk calculations for surface soil exposure are shown in Tables E-10 through E-23 in Appendix E of this report. For the current land-use scenario, the cancer risks associated with exposure to surface soil (ingestion, dermal contact, and fugitive dust inhalation) are 3×10^{-6} for an aggregate (combined adult and adolescent) trespasser, and 1×10^{-6} for a site maintenance worker. Both receptors cancer risk values are below the USEPA acceptable cancer risk range of 1 in 10,000 to 1 in 1,000,000. The noncancer risks associated with surface soil ingestion, dermal contact, and fugitive dust inhalation under current land use (adolescent trespasser, adult trespasser, and site worker) are below USEPA's and FDEP's target HI of 1. Figures 6-2 and 6-3 present summaries of cancer risks and HIs, respectively, associated with exposure scenarios under potential current land-use exposure scenario.

The cancer risks associated with exposure to surface soil ingestion, dermal contact, and fugitive dust inhalation under hypothetical future land use are 7×10^{-5} for an aggregate resident (combined adult and child), 3×10^{-6} for an aggregate trespasser (combined adult and adolescent), 2×10^{-6} for an occupational worker, 1×10^{-6} for a site maintenance worker, and 5×10^{-8} for an excavation worker under hypothetical future land use.

Figure 6-4 presents a summary of cancer risk associated with exposure scenarios under future land use. All of these hypothetical future receptor risks are within or below the USEPA acceptable cancer risk range; however, the hypothetical future residential risk exceeds the FDEP level of concern of 1×10^{-6} (mainly to benzo(a)pyrene and arsenic).

The noncancer risks associated with surface soil ingestion, dermal contact, and fugitive dust inhalation under future land use for all receptors are below USEPA's target HI of 1. Figure 6-5 presents a summary of HIs associated with exposure scenarios under future land use.

6.5.2 Groundwater The risk calculations for groundwater exposure are shown in Tables E-24 through E-27 in Appendix E of this report. Currently, there are no potable supply wells at the site; thus, there is no human exposure to groundwater. Therefore, risk was not evaluated for the current land-use scenario.

The cancer risks associated with exposure to groundwater via ingestion of tap water, and inhalation of volatiles while showering, under hypothetical future

Table 6-7
Risk Summary Current Land Use

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Land Use		Exposure Route	HI	ELCR
Current Land Use				
Surface Soil:				
	Adult Trespasser:	Incidental ingestion	0.006	4×10^{-7}
		Dermal contact	0.01	3×10^{-7}
		Inhalation of particulates	ND	6×10^{-11}
		Total Adult Trespasser:	0.02	7×10^{-7}
	Adolescent Trespasser:	Incidental ingestion	0.009	2×10^{-6}
		Dermal contact	0.01	2×10^{-7}
		Inhalation of particulates	ND	4×10^{-11}
		Total Adolescent Trespasser:	0.02	2×10^{-6}
		Total Risk to Trespasser (Adult and Adolescent) Exposed to Surface Soil:	NC	3×10^{-6}
	Site Maintenance Worker:	Incidental ingestion	0.002	1×10^{-6}
		Dermal contact	0.008	3×10^{-7}
		Inhalation of particulates	ND	3×10^{-10}
		Total Site Maintenance Worker:	0.01	1×10^{-6}

Notes: HI = hazard index.
ELCR = excess lifetime cancer risk.
ND = not detected.
NC = not calculated because child and adult HIs are not additive.

Table 6-8
Risk Summary Future Land Use

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Land Use		Exposure Route	HI *	ELCR *
Future Land Use				
Surface Soil:				
	Adult Trespasser:	Incidental ingestion	0.006	4×10^{-7}
		Dermal contact	0.01	3×10^{-7}
		Inhalation of particulates	ND	6×10^{-11}
		Total Adult Trespasser:	0.02	7×10^{-7}
	Adolescent Trespasser:	Incidental ingestion	0.009	2×10^{-6}
		Dermal contact	0.01	2×10^{-7}
		Inhalation of particulates	ND	4×10^{-11}
		Total Adolescent Trespasser:	0.02	2×10^{-6}
		Total Risk to Trespasser (Adult and Adolescent) Exposed to Surface Soil:	NC	3×10^{-6}
	Adult Resident:	Incidental ingestion	0.05	4×10^{-6}
		Dermal contact	0.09	3×10^{-6}
		Inhalation of particulates	ND	2×10^{-9}
		Total Adult Resident:	0.1	7×10^{-6}
	Child Resident:	Incidental ingestion	0.4	6×10^{-5}
		Dermal contact	0.1	1×10^{-6}
		Inhalation of particulates	ND	3×10^{-9}
		Total Child Resident:	0.5	6×10^{-5}
		Total Risk to Resident (Adult and Child) Exposed to Surface Soil:	NC	7×10^{-5}
	Occupational Worker:	Incidental ingestion	0.09	1×10^{-6}
		Dermal contact	0.005	6×10^{-7}
		Inhalation of particulates	ND	8×10^{-10}
		Total Occupational Worker:	0.09	2×10^{-6}

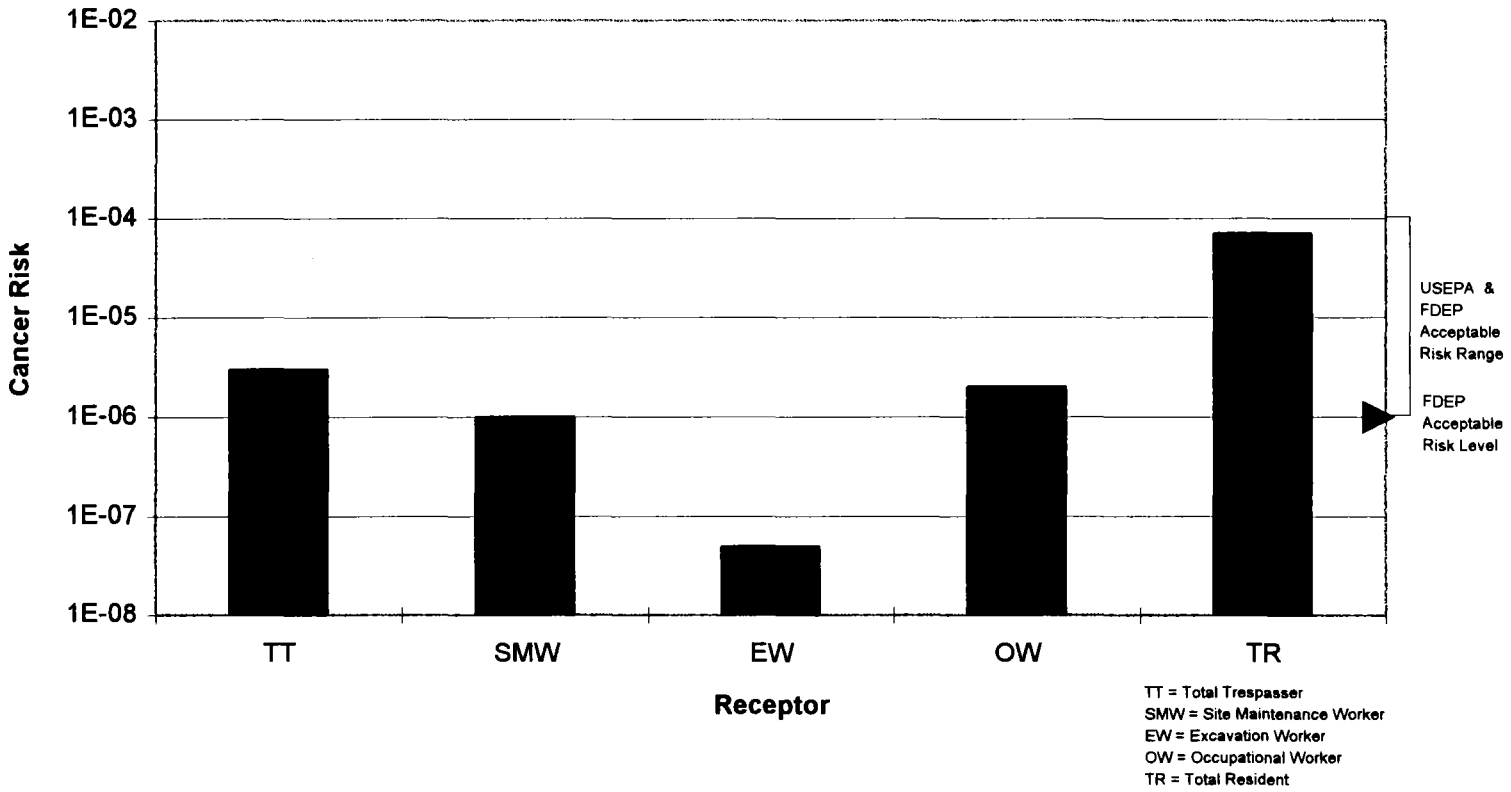
See notes at end of table.

Table 6-8 (Continued)
Risk Summary Future Land Use

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Land Use		Exposure Route	HI *	ELCR *
Future Land Use (Continued)				
	Site Maintenance Worker:	Incidental ingestion	0.002	1×10^{-6}
		Dermal contact	0.008	3×10^{-7}
		Inhalation of particulates	ND	3×10^{-10}
		Total Site Maintenance Worker:	0.01	1×10^{-6}
	Excavation Worker:	Incidental ingestion	0.02	5×10^{-8}
		Dermal contact	0.008	6×10^{-10}
		Inhalation of particulates	ND	1×10^{-11}
		Total Excavation Worker:	0.03	5×10^{-8}
Groundwater				
	Adult Resident			
		Ingestion of groundwater as drinking water	1	5×10^{-5}
		Inhalation of volatiles while showering	ND	3×10^{-6}
		Total Adult Resident:	1	5×10^{-5}
	Child Resident			
		Ingestion of groundwater as drinking water	1	3×10^{-5}
		Total Child Resident:	1	3×10^{-5}
		Total Risk to Resident (Adult and Child) Exposed to Groundwater:	NC	8×10^{-5}
		Total Risk to Resident (Adult and Child) Exposed to Surface Soil and Groundwater:	NC	1×10^{-4}

Notes: HI = hazard index.
* = receptor totals may vary for spreadsheets due to rounding algorithm.
ELCR = excess lifetime cancer risk
ND = No dose-response data for this exposure route were available for human health chemicals of potential concern in this medium.
NC = Not calculated because child and adult HIs are not additive.



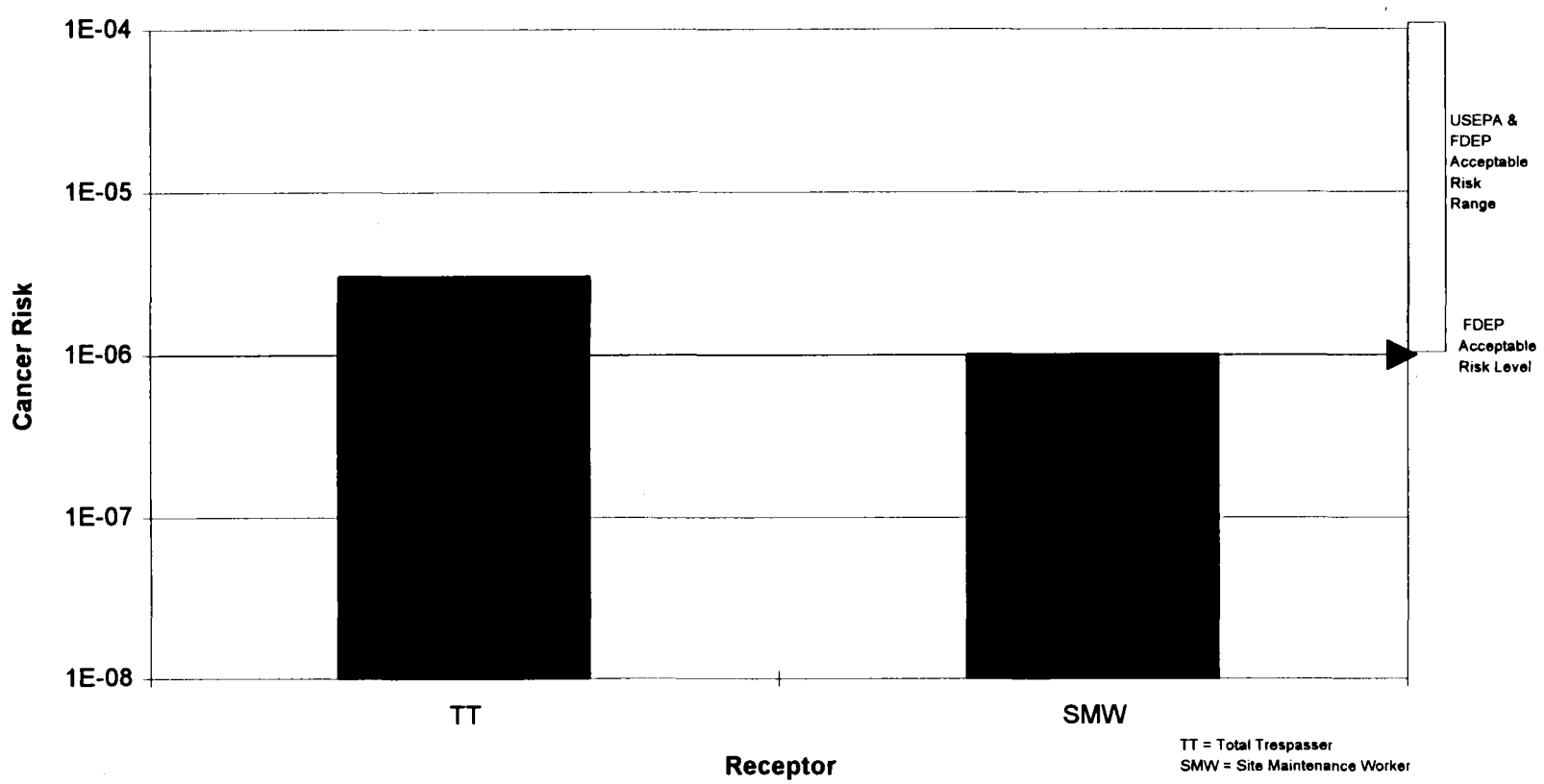
NOTES:
NAS = Naval Air Station
USEPA = U.S. Environmental Protection Agency
FDEP = Florida Department of Environmental Protection

FIGURE 6-2
CANCER RISK SUMMARY
CURRENT LAND USE FOR SURFACE SOIL AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

H:\HEID\WHITING\SITE11\FIG6-2.PM5, FIGS11B.XLS 040198HAS



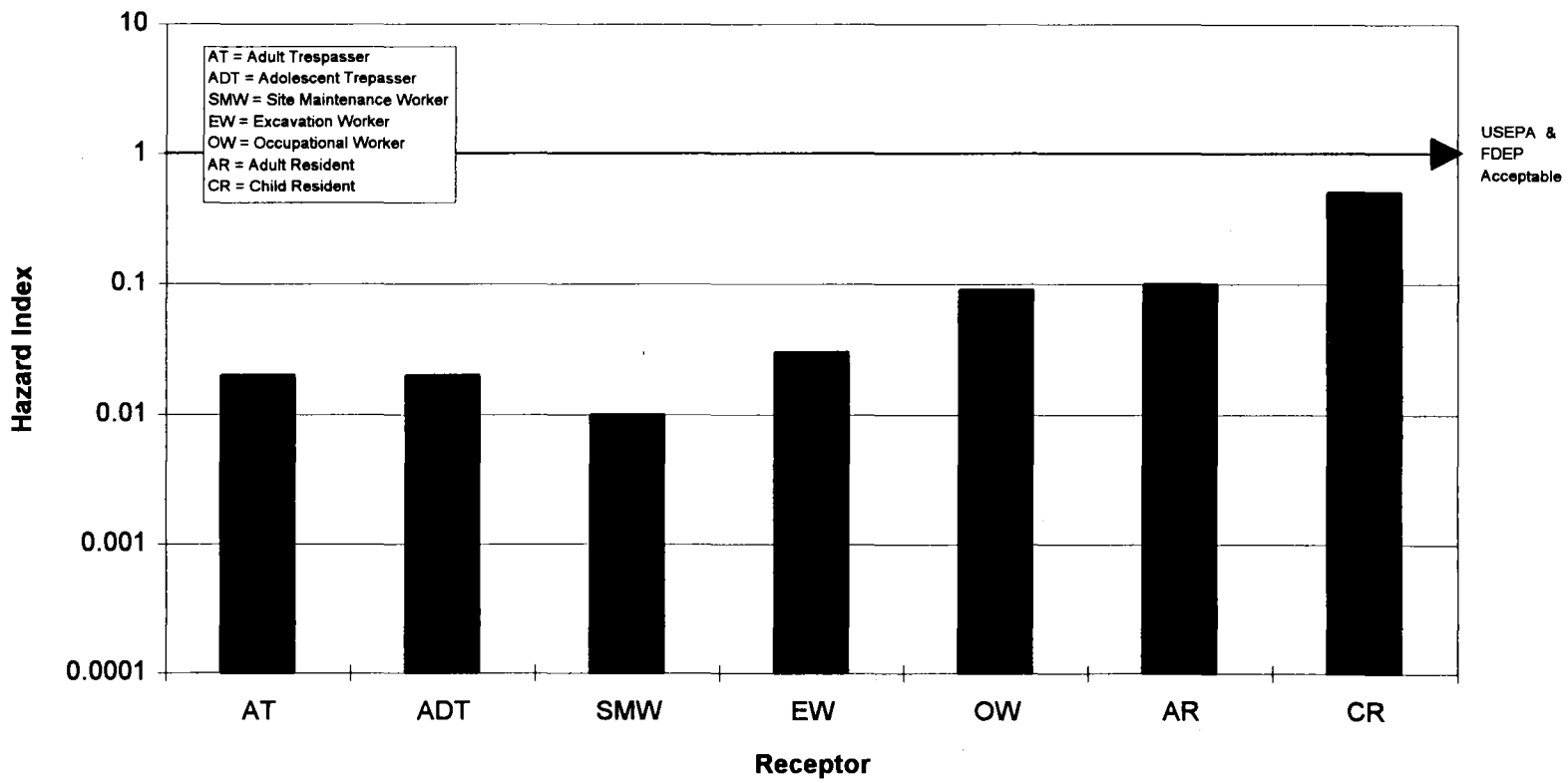
NOTES:
NAS = Naval Air Station
USEPA = U.S. Environmental Protection Agency
FDEP = Florida Department of Environmental Protection

FIGURE 6-3
NONCANCER RISK SUMMARY
CURRENT LAND USE FOR SURFACE SOIL AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

H:\HEID\WHITING\SITE11\FIG6-3.PM5, FIGS11B.XLS 040198HAS



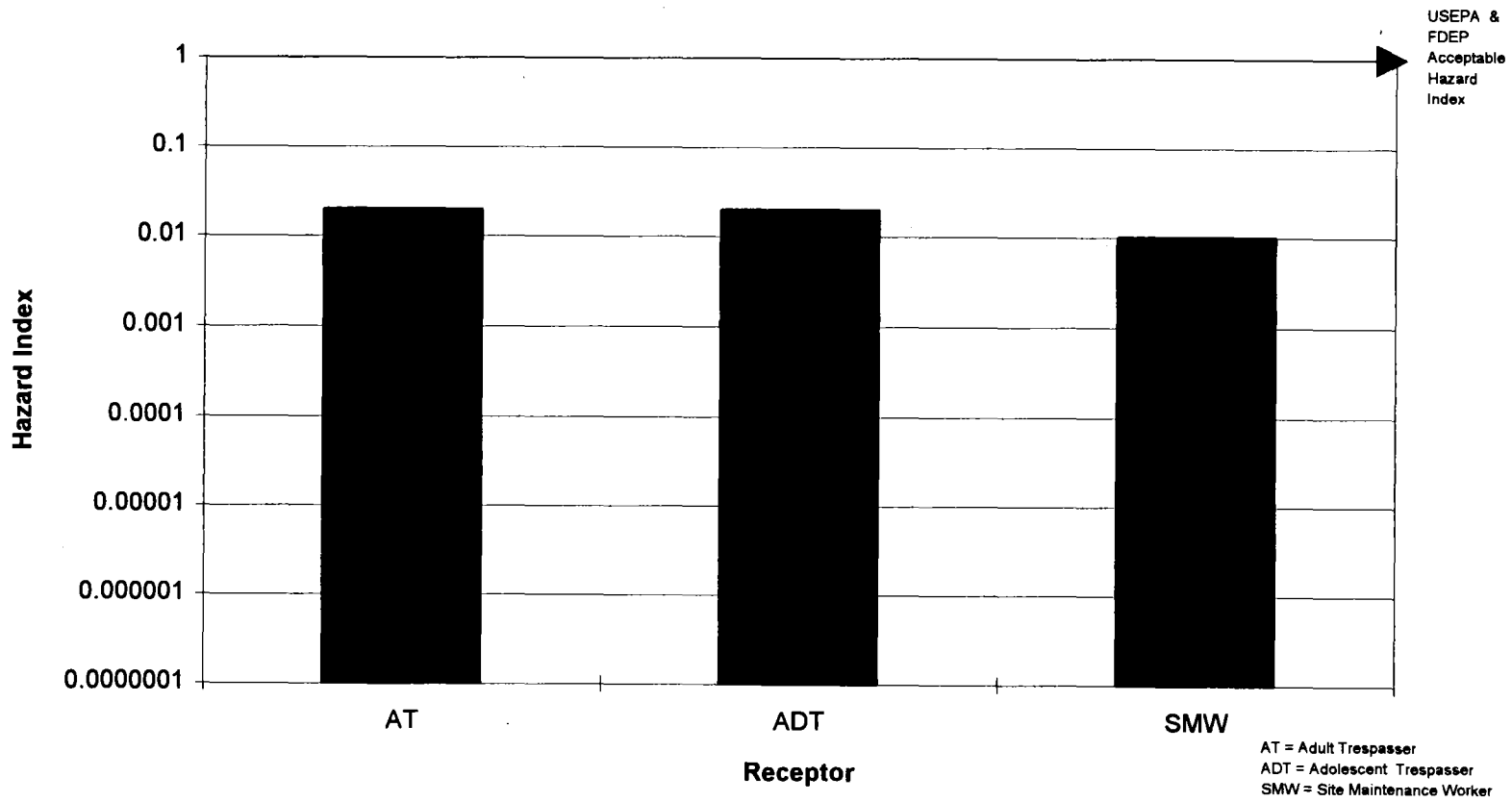
NOTES:
NAS = Naval Air Station
USEPA = U.S. Environmental Protection Agency
FDEP = Florida Department of Environmental Protection

FIGURE 6-4
CANCER RISK SUMMARY
FUTURE LAND USE FOR SURFACE
SOIL AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN
DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

H:\HEID\WHITING\SITE11\FIG6-4.PM5, FIGS11B.XLS 040198HAS



NOTES:
NAS = Naval Air Station
USEPA = U.S. Environmental Protection Agency
FDEP = Florida Department of Environmental Protection

FIGURE 6-5
NONCANCER RISK SUMMARY
FUTURE LAND USE FOR SURFACE SOIL AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

H:\HEIDI\WHITING\SITE11\FIG6-5.PM5, FIGS11B.XLS 040198HAS

land use are 8×10^{-5} for an aggregate resident (combined adult and child). Figure 6-6 presents a summary of cancer risk associated with exposure scenarios under future land use. The hypothetical future receptor risk is within the USEPA acceptable cancer risk range but exceeds the FDEP level of concern of 1×10^{-6} due to vinyl chloride and arsenic.

Under hypothetical future land use, the noncancer risks associated with groundwater ingestion are 1 for both the adult resident and child resident. Both of these HIs do not exceed USEPA's target HI of 1. Figure 6-7 present a summary of the noncancer risk to potential future residents.

6.6 UNCERTAINTY ANALYSIS. General uncertainties associated with the collection, analysis, and evaluation of data; exposure assessment; toxicity assessment; and the risk estimation process are discussed in Subsection 2.5.5.1 of the GIR (ABB-ES, 1998). Site-specific uncertainties that are important for the interpretation of the calculated risk estimates for surface soil and groundwater at Site 11 are discussed below.

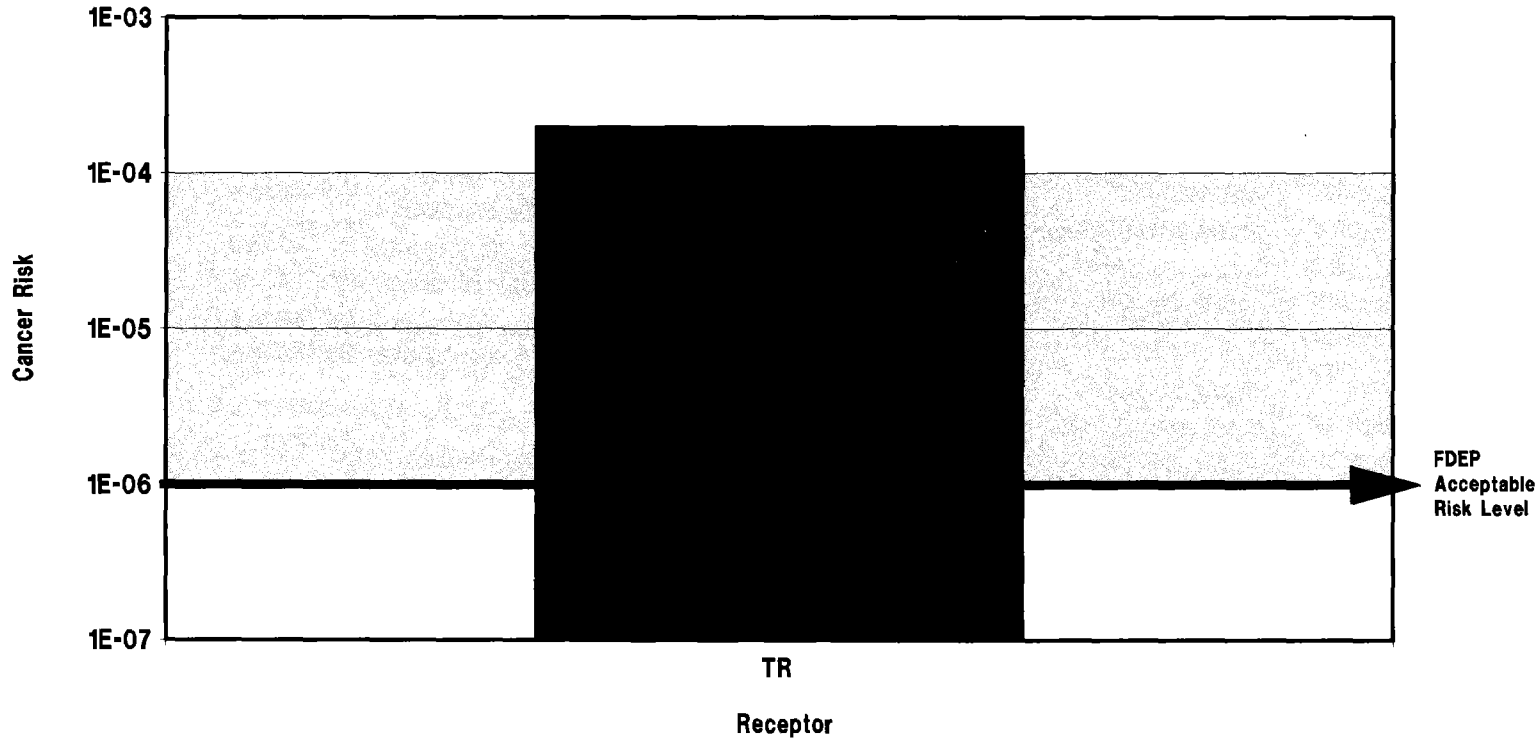
- The lack of inhalation reference doses for the HHCPCs in surface soil may have resulted in underestimates of the HIs associated with exposure to surface soil at Site 11; however, these noncancer risks are not likely to be significant when compared to oral and dermal risks that are fully characterized.

- One of the main contributors to surface soil carcinogenic risk at Site 11 is arsenic, a naturally occurring metal. It is uncertain whether or not this risk to hypothetical future residents is actually due to past site operations. Detected arsenic concentrations may actually be at naturally occurring levels or due to other anthropogenic activities such as pesticides application. This is especially noteworthy because the risk from arsenic at background conditions is 7×10^{-6}. Therefore, the risks from arsenic at Site 11 are likely to be overestimates.

- The SQLs were compared to the risk-based screening criteria and FDEP guidelines for all analytes not selected as HHCPCs to assess whether or not the detection limits were adequate to detect analytes at levels of concern (SQLs of analytes with 100 percent frequency of detection were not evaluated). These analytes with SQLs that exceed their screening criteria are aldrin, heptachlor, heptachlor epoxide, and chlordane in surface soil.

  Although these analyte SQLs exceeded the screening criteria, the detected concentrations were less than the SQLs. Since the laboratory equipment was able to detect the SQL, it was assumed that the SQL for aldrin, heptachlor, heptachlor epoxide, and chlordane was adequate for this HHRA.

- According to the methodology described in the GIR (ABB-ES, 1998) (Subsection 2.5.3.3), central tendency carcinogenic risk was evaluated for receptors that have an ELCR exceeding FDEP or USEPA levels of concern. The central tendency evaluation is designed to provide a probable risk level (USEPA, 1992a).



LEGEND

USEPA acceptable risk range

USEPA U.S. Environmental Protection Agency
FDEP Florida Department of Environmental Protection
TR Total resident

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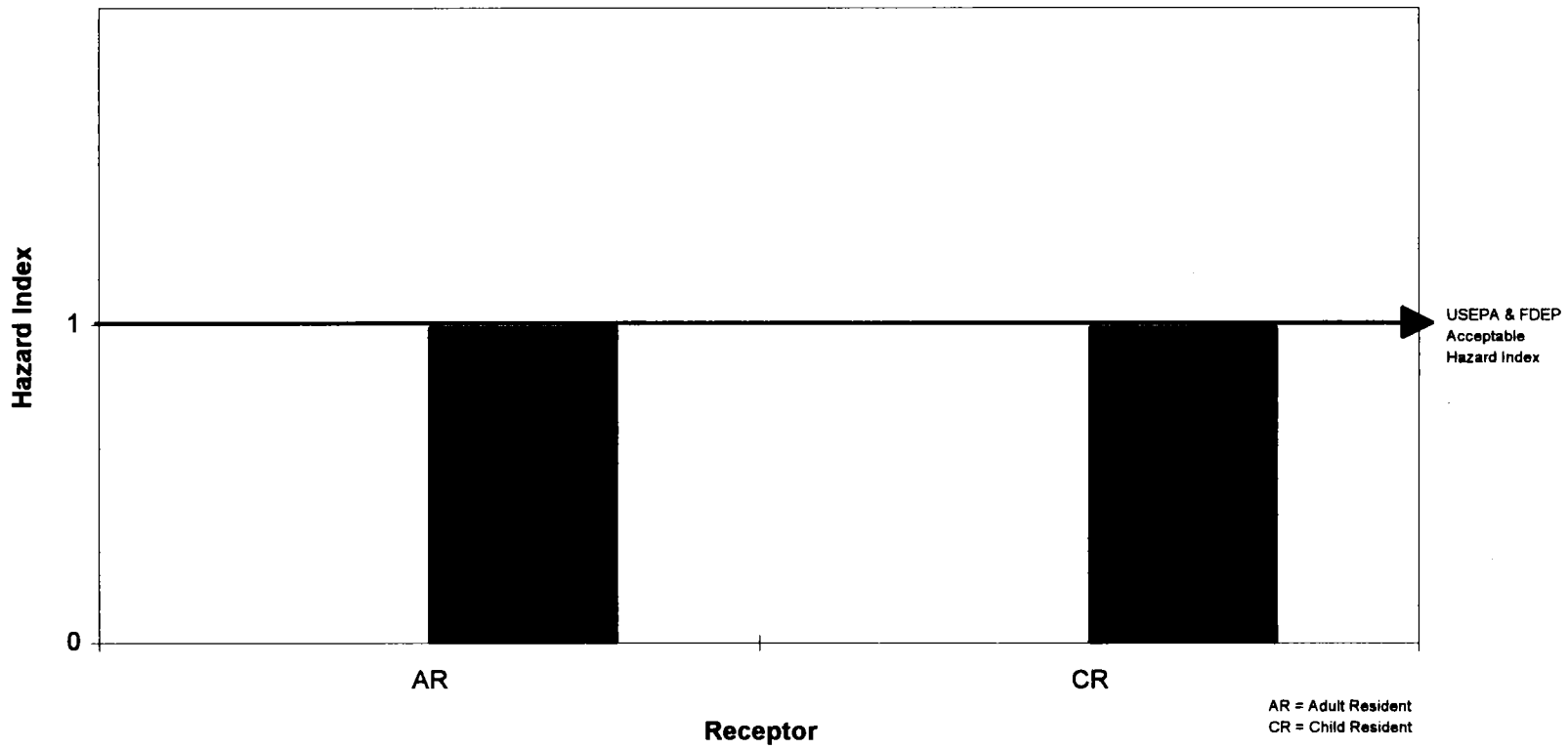
FIGURE 6-6
CANCER RISK SUMMARY
FUTURE LAND USE FOR GROUNDWATER
AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN
DISPOSAL AREA

NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA



NOTES:
NAS = Naval Air Station
USEPA = U.S. Environmental Protection Agency
FDEP = Florida Department of Environmental Protection

FIGURE 6-7
NONCANCER RISK SUMMARY
FUTURE LAND USE FOR GROUNDWATER
AT SITE 11

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN
DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

H:\HEIDI\WHITING\SITE11\FIG8-7.PM5, GW11B.XLS 040398HAS

The hypothetical reasonable maximum exposure (RME) carcinogenic risk for the future resident exceeded target risk level of 1×10^{-6}. The central tendency carcinogenic risk for hypothetical trespasser, future residential, and occupational worker are presented in Table E-28 through E-34 in Appendix E of this report. Calculated central tendency risk was characterized only for ingestion and dermal exposures because the contribution from inhalation was insignificant compared to other risk pathways. The central tendency risk from exposure to surface soil is 1×10^{-5} for the future resident, 3×10^{-7} for the aggregate trespasser, and 5×10^{-7} for the occupational worker.

The central tendency risk aggregate residential exposed to groundwater is 2×10^{-5}, which exceeds the Florida target level.

The risk range 7×10^{-5} to 1×10^{-5} presented by the RME and central tendency risk exposure scenarios for the hypothetical future aggregate resident to surface soil are useful information to provide perspective for the risk manager and compliance with Agency guidance (USEPA, 1995b).

6.7 REMEDIAL GOAL OPTIONS. Remedial goal option (RGO) tables are presented for each medium with a total ELCR greater than 1×10^{-6} or an HI greater than 1 per USEPA guidance, and for media with chemicals whose EPCs exceed Florida standards. The RGO concentrations are calculated using the scenario representing the highest estimated risk for a given medium. Based on the above criteria, RGOs are developed for each chemical with a total ELCR greater than 1×10^{-6} or an HQ greater than 0.1. Because the HI for all receptors is at or below 1, RGOs were not calculated based on noncancer risk. Analytes whose EPCs exceed Florida standards are also presented in the RGO tables.

RGOs and available Federal regulatory and FDEP risk-based criteria are intended to provide the basis for the development of remedial alternatives in the FS. The RGO values are not actual or proposed cleanup levels, but are provided to assist risk-management decision making in the FS.

Table 6-9 presents the RGOs for surface soil for four analytes. RGOs are presented for benzo(a)pyrene, dieldrin, and arsenic based on cancer risks for the adult and child resident at Site 11. Benzo(a)anthracene is presented in the RGO table because the EPC exceeds the FDEP Cleanup Target Level.

Table 6-10 presents the RGOs for groundwater for four analytes. RGOs are presented for benzene, vinyl chloride, and arsenic. Iron is presented in the RGO table because the EPC exceeded the FDEP Groundwater Target Level.

6.8 SUMMARY OF HHRA FOR SITE 11. HHCPCs were identified and risks were estimated for surface soil and groundwater associated with Site 11. No HHCPCs were identified for subsurface soil; therefore, no additional evaluations were performed. The conclusions below were drawn based on this HHRA.

- The HHCPCs detected in surface soil, subsurface soil, and groundwater do not pose unacceptable carcinogenic risks to the evaluated receptors based on USEPA target risk range of 1×10^{-4} to 1×10^{-6}.

Table 6-9
Summary of Remedial Goal Options for Surface Soil

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Range of Detected Concentrations	Exposure Point Concentration	Total Excess Lifetime Cancer Risk (Based on risk to resident [adult and child])			Total Hazard Index (Based on risk to child resident)			Florida Soil Cleanup Target Level (Residential)[1]	Florida Soil Cleanup Target Level (Leaching)[1]	Background Screening Concentration
			10^{-4}	10^{-5}	10^{-6}	3	1	0.1			
Semivolatile Organic Compounds (µg/kg)											
Benzo(a)anthracene	1,800	976	NA	NA	NA	NA	NA	NA	1,400	3,200	NA
Benzo(a)pyrene	910	806	NR	700	70	NA	NA	NA	100	8,000	NA
Pesticides and PCBs (µg/kg)											
Dieldrin	4.9 to 210	74	NR	NR	30	NA	NA	NA	70	4	NA
Inorganic Analytes (mg/kg)											
Arsenic	0.93 to 3.8	2.7	NR	NR	0.4	NA	NA	NA	0.8	29	3.2

[1] Values are from Florida Department of Environmental Protection Chapter 62-777, Florida Administrative Code, Soil Cleanup Target Levels (FDEP, 1999).

Notes: µg/kg = micrograms per kilogram.
NA = not applicable.
NR = not reported because the calculated remedial goal option exceeds the exposure point concentration.
mg/kg = milligrams per kilogram.

Table 6-10
Summary of Remedial Goal Options for Groundwater

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Range of Detected Concentrations	Exposure Point Concentration	Total Excess Lifetime Cancer Risk (Based on risk to resident [adult and child])			Total Hazard Index (Based on risk to child resident)			Florida Groundwater Cleanup Target Level[1]	Federal MCL[2]	Background Screening Concentration
			10^{-4}	10^{-5}	10^{-6}	3	1	0.1			
Volatile Organic Compounds (μg/ℓ)											
Benzene	2	6	NR	NR	2.3	NA	NA	NA	1	5	NA
Vinyl chloride	2	2	NR	0.4	0.04	NA	NA	NA	1	2	NA
Inorganic Analytes (μg/ℓ)											
Arsenic	0.6 to 3.3	1.1	NR	0.5	0.05	NA	NA	NA	50	50	ND
Iron	271 to 8,810	8,810	NR	NR	0.3	NA	NA	NA	300	300	964

[1] Florida Department of Environmental Protection Groundwater Cleanup Target Levels, Chapter 62-777, Florida Administrative Code (FDEP, 1999).
[2] Federal MCLs are taken from USEPA Drinking Water Regulations and Health Advisories from October 1996.

Notes: MCL = maximum contaminant level.
μg/ℓ = micrograms per liter.
NR = not reported because the calculated RGO exceeds the EPC.
NA = not applicable.
ND = not detected in any background sample.

- The total ELCR at Site 11 associated with ingestion of soil by a hypothetical future resident (7×10^{-5}) exceeds Florida's target risk level of concern (1×10^{-6}) due to benzo(a)pyrene and arsenic. The total ELCR at Site 11 associated with ingestion of groundwater by hypothetical future resident (9×10^{-5}) exceeds Florida's target risk level of concern due to vinyl chloride and arsenic.

- The background levels of arsenic at Site 11 exceed Florida residential soil cleanup target levels and may result in an unacceptable carcinogenic risk. It is likely that naturally occurring arsenic contributes to the exceedance of the FDEP target risk level.

- The surface soil, subsurface soil, and groundwater noncancer risks are at or below USEPA and FDEP target levels for all potential current and hypothetical future receptors.

CHAPTER 7.0

7.0 ECOLOGICAL RISK ASSESSMENT

The ERA evaluates actual and potential adverse effects to ecological receptors associated with exposure to chemicals from Site 11, the Southeast Open Disposal Area (B) (Landfill), at NAS Whiting Field. The ERA for Site 11 follows the methodologies described in the NAS Whiting Field GIR (ABB-ES, 1998), and current guidance materials for ERAs at Superfund sites including the following:

- *Risk Assessment Guidance for Superfund Volume 2: Environmental Evaluation Manual* (USEPA, 1989c)
- *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference* (USEPA, 1989d)
- *Framework for Ecological Risk Assessment* (USEPA, 1992b)
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997d)
- *Supplemental Guidance to RAGS: Region 4 Bulletins on Ecological Risk Assessment* (USEPA, 1995a)
- *Proposed Guidelines for Ecological Risk Assessment* (USEPA, 1996c)

Risk assessment guidance included in the USEPA "Eco Update" bulletins (1991c, 1992c, and 1992d) and recent publications (e.g., Maughan, 1993; Suter, 1993) were also consulted.

This ERA was conducted to determine if ecological receptors are potentially exposed to contaminants from Site 11 at concentrations that could cause adverse ecological effects. The Site 11 ERA consists of eight sections.

- Site Characterization (Section 7.1) describes current ecological conditions at the site.
- Problem Formulation (Section 7.2) establishes the goals and focus of the assessment and identifies major factors to be considered.
- Hazard Assessment and Selection of Ecological Chemicals of Potential Concern (ECPCs) (Section 7.3) reviews the analytical data and identifies chemicals present at the site that may pose ecological risks.
- Exposure Assessment (Section 7.4) identifies complete exposure pathways and quantifies the magnitude and frequency of exposure.
- Ecological Effects Assessment (Section 7.5) identifies potential adverse effects to ecological receptors associated with the chemicals of concern identified in Section 7.3.
- Risk Characterization (Section 7.6) integrates exposure and concentration-toxicity response information to derive a likely estimate of adverse effects.

- Uncertainties (Section 7.7) identifies assumptions of the ERA process that may influence the risk assessment conclusions.

- Summary of Ecological Risk (Section 7.8).

7.1 SITE CHARACTERIZATION. NAS Whiting Field Site 11 is approximately 3 acres in size and is located along the eastern facility property boundary near the South Air Field (see Figure 1-2). The site is an old borrow pit that was used as an open disposal area from 1943 until approximately 1970. During its active period, Site 11 received a wide variety of wastes, including general refuse, construction debris, tree clippings, furniture, waste solvents, paint, transformer oils, hydraulic fluid, and various other oils. When disposal activities were discontinued in 1970, a final covering of soil from NAS Whiting Field was placed over the site and pine trees were planted (Geraghty & Miller, 1986).

As shown in the Site 11 vegetative cover map (Figure 7-1), planted pine trees border the northern, western, and southern perimeter of the site. The eastern boundary of Site 11 is characterized as an old field, while the center of the site is dominated by shrubs.

Saplings and shrubs commonly found in the planted pine area of Site 11 include various oaks (*Quercus* sp.), long-leaf pine (*Pinus palustris*), slash pine (*Pinus elliotii*), yaupon holly (*Ilex vomitoria*), blueberry (*Vaccinium* sp.), gallberry (*Ilex coriacea*), Chinese privet (*Ligustrum sinense*), cherry (*Prunus* sp.), red maple (*Acer rubrum*), hickory (*Carya* sp.), red cedar (*Juniperus virginiana*), winged sumac (*Rhus copallina*), groundsel tree (*Baccharis halimifolia*), and willow (*Salix* sp.). Species commonly found in the herbaceous strata of the planted pine habitat include several members of the aster, madder, and pea families; morning glories; grapes; yucca; Japanese honeysuckle, and several grasses. A complete list of the vegetative species occurring at Site 11 is provided in Appendix G of the GIR (ABB-ES, 1998).

NAS Whiting Field maintains a program for planting and harvesting of pine trees, primarily long-leaf and slash pines. The planted pine area of Site 11 is subject to controlled burns and timber harvesting activities. As part of the ecosystem management plan, planted pine forests undergo periodic burning, usually once every four years, and selective thinning of long-leaf and slash pines every eight to ten years. These forestry management activities provide a variety of habitats and food sources. The planted pine area of Site 11 is reaching a mature status with a well-developed canopy and an open understory typical of uplands pine forests of the southeastern United States.

Southeastern pine forests provide habitats for a diverse array of birds, including insectivorous gleaners of pine needles and bark, flycatchers, seed-eaters, and nocturnal and diurnal aerial predators (Wolfe et. al., 1988). The pine flatwoods at Site 11 are likely to host such an assemblage of species. Birds of prey, such as owls and hawks, may also nest in these wooded areas.

It is likely that the terrestrial invertebrate biomass at Site 11 serves as a forage base for a variety of wildlife species, including adult amphibians, reptiles, small birds, and small mammals. Small reptiles, mammals, and birds may use the open portions of Site 11 for foraging, while returning to the forested

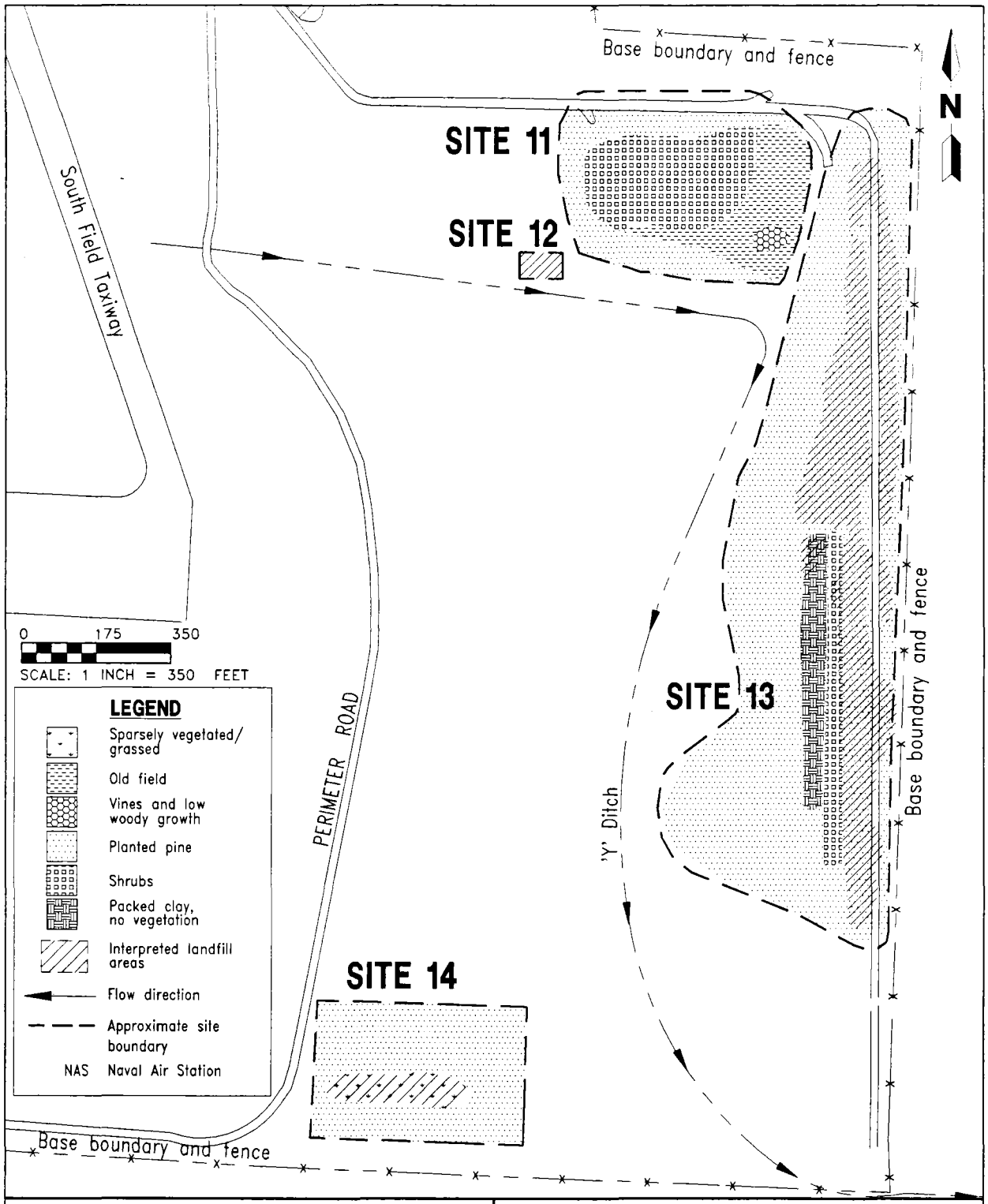


FIGURE 7-1
VEGETATIVE COVER MAP

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REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

pine area for protection. Predatory birds and mammals inhabiting the pine flatwood areas may also be attracted to the site.

Mammals and birds that may occur in the planted pine area of Site 11 include the Eastern cottontail rabbit (*Sylvilagus floridanus*), the hispid cotton rat (*Sigmodon hispidus*), cotton mouse (*Peromyscus gossypinus*), short-tailed shrew (*Blarina brevicauda*), American robin (*Turdus migratorius*), and Eastern meadowlark (*Sturnella magna*). Predatory mammals and birds such as the red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), great horned owl (*Bubo virginianus*), and the red-tailed hawk (*Buteo jamaicensis*) may also forage in the area of Site 11.

The "Y" drainage ditch is located approximately 80 feet south of site; however, off-site migration of site-related surface soil constituents to the ditch is unlikely because the topography of Site 11 gently slopes toward the east-northeast. During the 1986 verification study, a low point was observed in the northeastern corner where surface drainage ponds (Geraghty & Miller, 1986). Although ponding was not observed during the 1995 site characterization survey, it is expected that any runoff from the site would migrate in a northeasterly direction toward Big Coldwater Creek, which is located approximately 1.7 miles from Site 11.

Although no aquatic habitat is present at Site 11, groundwater from Site 11 may discharge to Big Coldwater Creek. Groundwater discharge to surface water is not evaluated as part of the ERA for Site 11 because Big Coldwater Creek receives groundwater discharge and stormwater runoff from multiple sources of potential contamination at NAS Whiting Field. In addition, Big Coldwater Creek is located more than 9,000 feet from Site 11 and concentrations of contaminants in Site 11 groundwater are low enough that they are not a concern for current and future discharges to surface water.

7.2 PROBLEM FORMULATION. The problem formulation is the initial step of the ERA process. Problem formulation is composed of identification of receptors, identification of exposure pathways for those receptors, and selection of assessment and measurement endpoints based on information gathered from the site characterization.

7.2.1 Identification of Receptors Ecological receptors that may potentially utilize the available planted pine and overgrown field habitat at Site 11 include terrestrial wildlife (i.e., mammals, birds, reptiles, and adult amphibians), terrestrial plants, and soil invertebrates. Terrestrial flora and fauna potentially using NAS Whiting Field are identified in the GIR (ABB-ES, 1998). Aquatic receptors are not evaluated in the ERA because no aquatic habitats exist at Site 11.

Certain species that potentially reside at NAS Whiting Field are protected by Federal and/or State laws. A list of State and federally protected species is provided in the GIR (ABB-ES, 1998). Observations made during an ecological survey of NAS Whiting field indicate that no State or federally listed rare, threatened, or endangered species or species of concern are known or likely to inhabit Site 11 (Nature Conservancy, 1997).

7.2.2 Identification of Exposure Pathways Exposure pathways are identified for three groups of receptors (terrestrial wildlife, terrestrial plants, and soil invertebrates). A complete exposure pathway includes a source of contamination, an exposure route, and a receptor. A conceptual model of the exposure pathways from source to ecological receptors is depicted in the contaminant pathway model on Figure 7-2.

All potential routes of exposure are considered in the ERA and are presented in the contaminant pathway model. The model differentiates between those exposure routes that are quantitatively evaluated and those that are qualitatively discussed. This limitation is necessary to focus the risk evaluation on those pathways for which contaminant exposures are the highest and most likely to occur. Those pathways that cannot be quantitatively evaluated, due to a lack of toxicological information, are qualitatively discussed and addressed as uncertainties. The general approach used to identify exposure pathways for the three groups of receptors is explained below.

Terrestrial Wildlife. Terrestrial wildlife may be exposed to contaminants in surface soil, surface water, and food items that are contaminated as a result of ingestion, dermal adsorption, and inhalation of fugitive dust and volatile emissions. Because no surface water is present at Site 11, only exposures to surface soil and potentially contaminated food are evaluated in the Site 11 ERA.

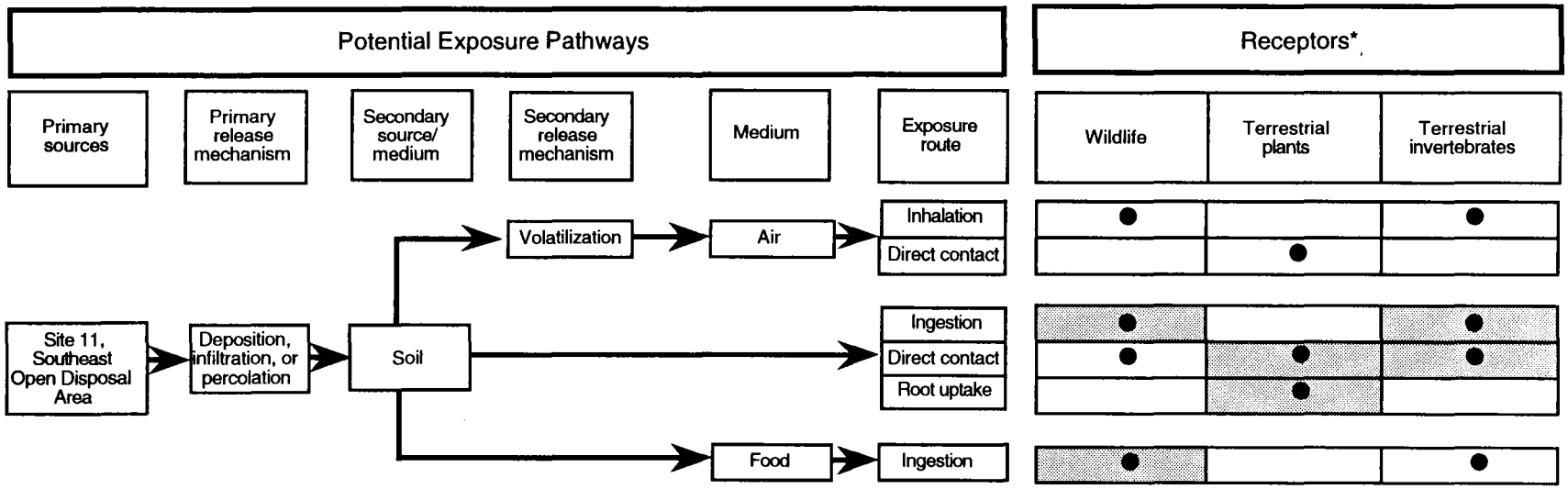
Dermal adsorption is considered to be a negligible exposure pathway because the presence of fur, feathers, or a chitinous exoskeleton is likely to prevent contamination from coming in direct contact with the skin (personal communication with Ted Simon, USEPA Region 4, September 1997). In addition, soil trapped in the fur or feathers is likely to be ingested during grooming or preening activities, which are evaluated as part of the indirect ingestion exposure pathway.

Exposure via inhalation of fugitive dust is also not likely to be a significant exposure pathway because the vegetation at Site 11 would limit the release of fugitive dust. Only one volatile constituent, acetone, was detected in the surface soil at Site 11. Exposures associated with VOCs are not evaluated in the ERA because of the low frequency and detection of VOCs in the surface soil. In addition, no evidence of burrowing animals and/or burrows was noted during the site characterization.

Potential contaminant exposures for reptiles and adult amphibians exist at NAS Whiting Field; however, ingestion toxicity data and bioaccumulation factors (BAF) are generally not available for these receptors. Therefore, potential risks associated with ingestion of affected media and food to these reptiles and amphibians will be qualitatively addressed in the Uncertainties Section of the ERA.

Terrestrial Plants and Invertebrates. Terrestrial plants and soil invertebrates may be exposed to contamination in surface soil by direct contact with and root uptake (plants) or ingestion (invertebrates) of soil. The ingestion exposure routes include the ingestion of soil and food items containing chemicals accumulated from Site 11 surface soil. Because the depth to groundwater is between 44 and 90 feet bls, far below the root zone of Site 11 plants, it is not expected that terrestrial plants are exposed to contamination in groundwater.

7.2.3 Identification of Endpoints The assessment and measurement endpoints selected for the Site 11 ERA are listed in Table 7-1. Assessment endpoints



NOTES:
NAS = Naval Air Station
ERA = ecological risk assessment

* Shading indicates the exposure pathways that are quantitatively evaluated for receptors in the Site 11 ERA. Nonshaded pathways are not evaluated because they are not considered significant pathways.

FIGURE 7-2
SITE 11, CONTAMINANT PATHWAY MODEL FOR ECOLOGICAL RECEPTORS

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

2534-09 FIG 7-2 (site 11) FINAL 010798MAW

Table 7-1
Endpoints Selected for
Ecological Risk Assessment

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Assessment Endpoint [a]	Receptor	Measurement Endpoint	Decision Point
Survival and growth of plant communities used as forage material.	Terrestrial plants	Germination of lettuce seeds exposed to surface soil samples in laboratory toxicity tests.	Significant differences ($P \leq 0.05$) in germination of lettuce seeds exposed to surface soil from Site 11 as compared to laboratory control and reference soil.
Survival and growth of terrestrial invertebrate communities used as forage material.	Terrestrial invertebrates	Survival and growth of earthworms exposed to surface soil samples in toxicity tests.	Significant differences ($P \leq 0.05$) in survival and/or growth of earthworms exposed to surface soil from Site 11 as compared to earthworms exposed to laboratory control and reference soil.
Survival and maintenance of wildlife populations.	Wildlife species	Oral chemical doses (mg/kg BW/day) based on measured adverse effects on growth, reproduction, or survival (i.e., NOAEL, LOAEL, and LD_{50} studies) of mammalian and avian laboratory test populations.	Comparison of potential dietary exposures in mammalian and avian wildlife with literature-derived RTVs. HQs >1 indicate potential risk.

[a] The assessment endpoints are discussed in further detail in Subsection 7.2.3.

Notes: P = probability.
≤ = less than or equal to.
mg/kg = milligrams per kilogram.
BW/day = body weight per day.
NOAEL = no observed adverse effect level.
LOAEL = lowest observed adverse effect level.
LD_{50} = lethal dose to 50 percent of a test population.
RTV = reference toxicity value.
HQ = hazard quotient.
> = greater than.

represent the ecological component to be protected, whereas the measurement endpoints approximate or provide a measure of the achievement of the assessment endpoint. The assessment endpoint selected for the Site 11 ERA is the survival and maintenance of receptor populations and communities at Site 11. The measurement endpoints used to gauge the likelihood of population- and community-level effects for terrestrial wildlife are chemical-specific toxicological benchmark values derived from the literature that are based on laboratory-measured survival, growth, and reproductive effects. For terrestrial plants and soil invertebrates at Site 11, the assessment endpoint is measured by the survival and growth of the earthworm (*Eisenia foetida*) in toxicity testing and response of the lettuce seed (*Lactuca sativa*) in germination tests with Site 11 surface soil samples. Table 7-1 presents the assessment endpoint, endpoint species, measurement endpoint, and decision point (i.e., the level at which additional evaluation may be warranted).

Four hypotheses were developed to gauge potential risks associated with exposure to Site 11 surface soil. These hypotheses are designed for multiple species and trophic levels and represent both individual and community dynamics. Hypotheses for the Site 11 ERA listed below.

1. Are ECPCs present in the surface soil at concentrations sufficiently high to reduce plant or soil invertebrate biomass or plant cover availability such that small mammal and bird populations could be affected?

2. Are ECPCs present in the surface soil at concentrations sufficiently high to reduce the survivability and growth of terrestrial plants and soil invertebrates?

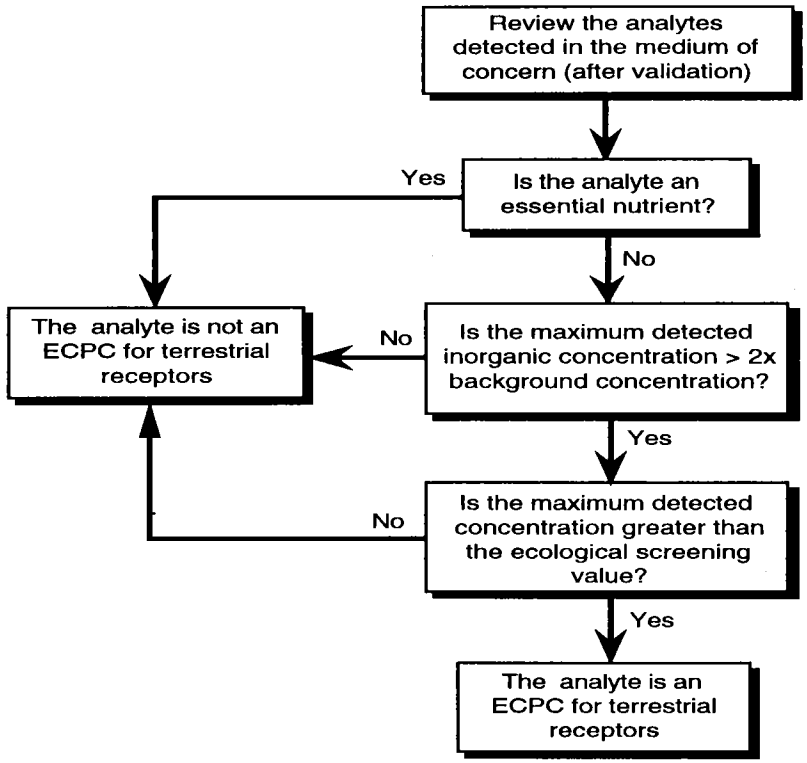
3. Are ECPC concentrations in plants and invertebrates sufficiently high as to adversely affect foraging small mammal or bird populations following consumption of contaminated prey?

4. Are bioaccumulating chemicals sufficiently high to reduce survivability, growth, or reproduction in top predators (i.e., foxes and owls)?

7.3 HAZARD ASSESSMENT AND SELECTION OF ECPCs. The hazard assessment includes a review of analytical data and selection of ECPCs. ECPCs represent analytes detected in environmental media (i.e., surface soil) that are considered in the ERA and could present a potential risk for ecological receptors. The process for selecting ECPCs is depicted on Figure 7-3. Additional details regarding the ECPC selection process are provided in Subsection 2.4.2 of the GIR (ABB-ES, 1998). Analytical data for Site 11 were evaluated for use in risk assessment pursuant to national guidance, *Guidance for Data Useability in Risk Assessment (Parts A and B)* (USEPA, 1992e).

Following the data validation step, calcium, iron, magnesium, potassium, and sodium are excluded as ECPCs because they are considered to be essential nutrients and not toxic. The rationale for eliminating essential nutrients as ECPCs is provided in the GIR (ABB-ES, 1998).

Inorganic chemicals representative of background conditions are not selected as ECPCs. In accordance with USEPA Region IV guidance (USEPA, 1991b), an inorganic



NOTES:
NAS = Naval Air Station
ECPC = ecological chemical of potential concern
> = greater than
x = times
Terrestrial receptors include terrestrial wildlife, plants, and invertebrates

FIGURE 7-3
ECOLOGICAL CHEMICAL OF POTENTIAL CONCERN SELECTION PROCESS

REMEDIAL INVESTIGATION REPORT
SITE 11, SOUTHEAST OPEN DISPOSAL AREA

NAS WHITING FIELD
MILTON, FLORIDA

2534-09 FIG 7-3 (site 11) FINAL 021798MAW

analyte is not selected as an ECPC if the maximum detected concentration is less than 2 times the average detected inorganic concentration in background samples. The maximum detected concentrations are compared against representative site-specific background soil screening concentrations to eliminate chemicals that are unlikely to be site related.

A site-specific background investigation was conducted at NAS Whiting Field, and the findings are presented in Section 3.3.1.1 of the GIR (ABB-ES, 1998). The site-specific background study used to establish background screening values for Site 11 consists of nine surface soil samples (BKG-SL-02, BKG-SL-06, BKG-SL-07, BKG-SL-08, BKS00101, BKS00201, BKS00301, BKS00401, and BKS00501) and one duplicate sample (BKS00201D) collected from Troup loamy sand and Dothan fine sandy loam soil types, which are similar to the soil types at Site 11.

Analytes that are not essential nutrients and exceed the background screening concentration are also screened against ecological screening values for surface soil. The surface soil ecological screening values are the Dutch Soil Criteria "A", which refer to background concentrations in surface soil issued by the U.S. Fish and Wildlife Service (Beyer, 1990). If the maximum detected concentration of an analyte exceeds the ecological screening value, the analyte is retained as an ECPC for terrestrial wildlife, which also includes terrestrial plants and soil invertebrates.

During the August 1992 Phase IIA investigation, five surface soil samples (11-SL-01 through 11-SL-05) and one duplicate (11-SL-01A) were collected at Site 11 (Figure 3-2). These samples were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, and TAL inorganic analytes. In January 1996, 13 additional surface soil samples were collected from Site 11 as part of the Phase IIB investigation. Five of the thirteen sampling locations were determined using the random and unbiased systematic sampling method described in Section 3.3. These five samples (11S00101 through 11S00501) were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, TAL inorganic analytes and TPH. The remaining eight samples (11S00601 through 11S01301) were collected within a 10-foot-radius surrounding the Phase IIA sample 11-SL-2, where an elevated lead concentration of 2,230 mg/kg was detected. These eight samples were analyzed for lead only for source delineation.

Table 7-2 presents a summary of the analytical data and the following information: frequency of detection, range of detection limits, range of detected concentrations, average of detected concentrations, background screening concentrations, ecological screening values, and selected ECPCs. ECPCs selected for the surface soil samples collected at Site 11 include one VOC (acetone), 14 semivolatiles (2-methylnaphthalene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)-fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, and bis(2-ethylhexyl)phthalate), five pesticides (4,4'-DDD, 4,4'-DDT, dieldrin, alpha-chlordane, and gamma-chlordane), three inorganic analytes (lead, silver, and zinc), and TPH.

7.4 EXPOSURE ASSESSMENT. The purpose of the ecological exposure assessment is to estimate or measure the amount of an ECPC to which an ecological receptor may be exposed. The following sections briefly describe how contaminant exposures are estimated or measured for wildlife, terrestrial plants, and invertebrates at Site 11. The contaminant pathway model (Figure 7-2) provides a summary of the

Table 7-2
Selection of Ecological Chemicals of Potential Concern for Surface Soil Associated with Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
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Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentration[2]	Average of Detected Concentrations[3]	Background Screening Concentration[4]	Ecological Screening Value[5]	Chemical of Ecological Concern[6]	95th % UCL[7]	Average of All Samples[8]	Exposure Point Concentration	
										RME[9]	CT[10]
Volatiles Organic Compounds (µg/kg)											
Acetone	1/10	11 to 13	53.25*	53.3	ND	NA	Yes	16.8	10.3	16.8	10.3
Semivolatile Organic Compounds (µg/kg)											
2-Methylnaphthalene	1/10	350 to 4,000	49	49	ND	NA	Yes	757	352	49	49
Acenaphthylene	1/10	350 to 4,000	110	110	ND	NA	Yes	614	358	110	110
Anthracene	1/10	350 to 4,000	280	280	ND	100	Yes	620	375	280	280
Benzo(a)anthracene	1/10	350 to 4,000	1,800	1,800	ND	NA	Yes	976	527	976	527
Benzo(a)pyrene	1/10	350 to 4,000	910	910	ND	100	Yes	806	438	806	438
Benzo(b)fluoranthene	1/10	350 to 4,000	710	710	ND	NA	Yes	777	418	710	418
Benzo(g,h,i)perylene	1/10	350 to 4,000	310	310	ND	NA	Yes	626	378	310	310
Benzo(k)fluoranthene	1/10	350 to 4,000	870	870	ND	NA	Yes	800	434	800	434
Chrysene	1/10	350 to 4,000	2,500	2,500	ND	NA	Yes	1,142	597	1,142	597
Fluoranthene	1/10	350 to 4,000	1,300	1,300	ND	100	Yes	873	477	873	477
Indeno(1,2,3-cd)-pyrene	1/10	350 to 4,000	230	230	ND	NA	Yes	608	370	230	230
Phenanthrene	1/10	350 to 4,000	2,100	2,100	ND	100	Yes	1,045	557	1,045	557
Pyrene	1/10	350 to 4,000	3,400	3,400	ND	100	Yes	1,375	687	1,375	687
bis(2-Ethylhexyl)-phthalate	5/10	350 to 4,000	52 to 540	175	80.3	NA	Yes	727	360	540	360

See notes at end of table.

Table 7-2 (Continued)
Selection of Ecological Chemicals of Potential Concern for Surface Soil Associated with Site 11

Remedial Investigation Report
Site 11, Southeast Open Disposal Area (B) (Landfill)
Naval Air Station Whiting Field
Milton, Florida

Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentration[2]	Average of Detected Concentrations[3]	Background Screening Concentration[4]	Ecological Screening Value[5]	Chemical of Ecological Concern[6]	95th % UCL[7]	Average of All Samples[8]	Exposure Point Concentration	
										RME[9]	CT[10]
Pesticides and PCBs (μg/kg)											
4,4'-DDD	1/10	3.6 to 980	140	140	ND	100	Yes	123	55.9	123	55.9
4,4'-DDE	7/10	3.7 to 980	2.1 to 88	26.5	ND	100	No[11]				
4,4'-DDT	8/10	3.7 to 980	2.3 to 530	81.8	ND	100	Yes	168	66.5	168	66.5
Aldrin	1/10	1.9 to 490	0.96 to 0.96	0.96	ND	100	No[11]				
Dieldrin	8/10	3.7 to 980	4.9 to 210	42.9	ND	100	Yes	74	35.4	74	35.4
Heptachlor	1/10	1.9 to 490	4.8	4.8	ND	100	No[11]				
Heptachlor epoxide	1/10	1.9 to 490	8.8	8.8	ND	100	No[11]				
alpha-Chlordane	4/10	1.9 to 4,900	39 to 310	140	ND	100	Yes	130	69.9	130	69.9
gamma-Chlordane	4/10	1.9 to 4,900	29 to 260	111	ND	100	Yes	108	58.1	108	58.1
Inorganic Analytes (mg/kg)											
Aluminum	10/10	40	2,110 to 10,800	7,486	15,314	NA	No[12]				
Antimony	1/10	2.6 to 12	3.5	3.5	8	NA	No[12]				
Arsenic	10/10	2	0.93 to 3.8	2.1	3.0	20	No[11]				
Barium	10/10	40	4.6 to 96	19.2	23.8	200	No[11]				
Beryllium	7/10	0.05 to 1	0.05 to 0.14	0.09	0.36	NA	No[12]				
Cadmium	2/10	0.58 to 1	0.24 to 0.28	0.26	0.58	1	No[12]				
Calcium	10/10	1,000	184.5* to 1,790	445	402	NA	No[13]				
Chromium	10/10	2	2.7 to 19.6	7.9	10.8	100	No[11]				
Cobalt	6/10	0.33 to 10	0.35 to 3.4	1.5	3	20	No[11]				

See notes at end of table.

Table 7-2 (Continued)
Selection of Ecological Chemicals of Potential Concern for Surface Soil Associated with Site 11

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Analyte	Frequency of Detection[1]	Range of Reporting Limit	Range of Detected Concentration[2]	Average of Detected Concen-trations[3]	Background Screening Concen-tration[4]	Ecological Screening Value[5]	Chemical of Ecological Concern[6]	95th % UCL[7]	Average of All Samples[8]	Exposure Point Concentration	
										RME[9]	CT[10]
Inorganic Analytes (mg/kg)											
Copper	8/10	5	3.7 to 19.4	7.2	9.4	50	No[11]				
Cyanide	5/10	0.23 to 0.5	0.09 to 0.19	0.12	0.26	NA	No[12]				
Iron	10/10	20	1,500 to 11,700	5,250	8,588	NA	No[13]				
Lead	18/18	0.6 to 1	5.2 to 2,230	146	11.4	50	Yes	166	146	166	146
Magnesium	10/10	1,000	54.2 to 1,260	214	258	NA	No[13]				
Manganese	10/10	3	31.4 to 280*	126	404	NA	No[12]				
Mercury	6/10	0.1	0.04 to 0.08	0.05	0.12	0.5	No[11,12]				
Nickel	4/10	2.3 to 8	1.6 to 10	3.9	7.2	50	No[11]				
Potassium	8/10	128 to 1,000	62.1 to 166	111	177	NA	No[12,13]				
Selenium	1/10	0.44 to 1	0.16 to 0.16	0.16	0.44	NA	No[12]				
Silver	5/10	2	0.55 to 1.9	1	0.7	NA	Yes	1.3	1	1.3	1
Sodium	10/10	1,000	160 to 307	188	388	NA	No[12,13]				
Vanadium	10/10	10	4.4 to 20.3	12.9	21.2	NA	No[12]				
Zinc	10/10	4	5.7 to 260	40.5	15.4	200	Yes	124	40.5	124	40.5
Other (mg/kg)											
Total petroleum hydrocarbons	5/5	1.8 to 1.9	7 to 53.1	17.9	ND	NA	Yes	NC	17.9	53.1	17.9

See notes at end of table.

Table 7-2 (Continued)
Selection of Ecological Chemicals of Potential Concern for Surface Soil Associated with Site 11

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[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] The value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect value, one-half of the detection limit is used as a surrogate for the nondetect value.
[3] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The background screening value is twice the average of detected concentrations for inorganic analytes in background samples. Background screening values for organic analyte values are one times the average of detected concentrations. Organic values are included for comparison purposes only (i.e., not used to select ecological contaminant of potential concerns).
[5] The ecological screening values are the Dutch Soil Criteria as reported in the U.S. Fish and Wildlife Service Biological Report 1990(2), "Evaluating Soil Contamination," (Beyer, 1990).
[6] These chemicals are retained for further evaluation in the ecological risk assessment.
[7] The 95th percent upper confidence limit (UCL) is calculated on the log-transformed average of all samples using the formula provided in the USEPA *Supplemental Guidance to RAGS: Calculating the Concentration Term*. The 95 percent UCL is not calculated when there are less than 10 total samples. (USEPA,1992f)
[8] The average of all samples assigns a value of one-half of the detection limit as a surrogate concentration for nondetect values.
[9] The reasonable maximum exposure point concentration (EPC) is equal to the lesser of the maximum detected concentration or the 95th percent UCL.
[10] The central tendency (CT) EPC is equal to the lesser of the average of all samples or the maximum exposure point concentration.
[11] The maximum detected concentration is less than the ecological screening value.
[12] The maximum detected concentration is less than the background screening concentration.
[13] The analyte is an essential nutrient and not considered toxic.

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: Samples 11-SL-01, 11-SL-02, 11-SL-03, 11-SL-04, 11-SL-05, 11S00101, 11S00201, 11S00301, 11S00401, and 11S00501 were analyzed for VOCs, SVOCs, pesticides and PCBs, and inorganics. Samples 11S00601, 11S00701, 11S00801, 11S00901, 11S01010, 11S01101, 11S01201, and 11S01301 were analyzed for lead only. Samples 11S00101, 11S00201, 11S00301, 11S00401, and 11S00501 were analyzed for TPH only.
Duplicate samples: 11-SL-01A and 11S00601D.
Background samples: BKG-SL-02, BKG-SL-06, and BKG-SL-07.
Background duplicate samples: BKSS00201D.

* = average of sample and duplicate.
μg/kg = micrograms per kilogram.
NA = not available.
DDT = dichlorodiphenyltrichloroethane.
DDE = dichlorodiphenyldichloroethene.
% = percent.
SVOC = semivolatile organic compound.
NC = not calculated
ND = not detected in any background sample.
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
mg/kg = milligrams per kilogram.
RME = reasonable maximum exposure.
VOC = volatile organic compounds.
TPH = total petroleum hydrocarbon.

potential exposure pathways that exist at Site 11 for each group of receptors. Additional details regarding the exposure assessment is provided in the GIR (ABB-ES, 1998).

7.4.1 Calculation of EPCs The EPC is a representative concentration used for evaluating risks throughout this ERA. RME and Central Tendency (CT) concentrations are derived for each ECPC. If the sample size is greater than or equal to ten, the RME value is equal to the lesser of the maximum detected concentration and the 95th percent upper confidence limit (UCL) calculated on the log-transformed arithmetic mean (USEPA, 1992f). One-half of the detection limit is used to calculate the 95th percent UCL. If the sample size is less than or equal to nine, the RME concentration is equal to the maximum detected concentration. If potential risks are predicted based on the RME scenario, then the CT exposure scenario is also evaluated. The CT exposure concentration is represented by the arithmetic mean of all samples. One-half of the detection limit is also used as a surrogate value for sample results that are below the detection limit.

With the exception of TPH, 10 or more surface soil samples were collected for all constituents at Site 11. For all constituents except TPH, the lesser of the maximum detected concentration and the 95th percent UCL is used as the RME concentration (USEPA, 1992f). Because TPH was analyzed in only five samples, the RME concentration for TPH is equal to the maximum detected concentration. Table 7-2 presents the RME and CT EPCs for the selected ECPCs.

7.4.2 Terrestrial Wildlife Exposure routes for wildlife receptors include direct and indirect ingestion of soil and ingestion of food containing site-related chemicals. The actual amount of an ECPC taken in by wildlife species (i.e., ingestion dose in milligrams per kilogram per day depends on a number of factors. A potential dietary exposure (PDE) model is used to estimate exposure to representative wildlife species. The PDE (or body dose) is calculated for each ECPC in surface soil using the equations presented in Table 7-3 and the methodologies described in the GIR (ABB-ES, 1998). The PPE is calculated based on the estimated concentrations of the ECPCs in food items that the species would consume; the amount of surface soil that it would ingest; the relative amount of different food items in its diet, body weight, and the food ingestion rate.

Wildlife species from different trophic guilds that may be present at the site were selected for the PDE model. The model uses species-specific feeding and habitat characteristics to estimate chemical exposures to wildlife species relative to their position in the food chain. Terrestrial receptors were chosen to represent the trophic levels typically found in the southeastern pine flatwoods and disturbed upland communities present at Site 11. The representative wildlife species considered in the ERA are summarized in Table 7-4 and discussed below.

- **Cotton mouse** (*Peromyscus gossypinus*). The cotton mouse represents a small mammalian herbivore that could potentially be exposed to contamination in soil and in plant tissue (accumulated from the soil). The cotton mouse home range is estimated at 0.147 acre and could reside entirely on the site. The cotton mouse represents the small mammal herbivore community at Site 11.

Table 7-3
Estimation of Potential Chemical Exposures for Representative Wildlife Species

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Estimation of Chemical Exposures Related to Surface Soil

Scope: Estimates the amount (dose) of a chemical ingested and accumulated by a species via incidental ingestion of surface soil and food items containing site-related chemicals.

Soil Chemical Concentration: The maximum detected concentration of the ecological chemicals of potential concern when the sample size is ≤ 9, and the lesser of the maximum detected concentration or the 95th percent upper confidence limit when the sample size is ≥ 10.

Soil Exposure Concentration:

$$\text{Soil Exposure (mg/kg)} = \left(\text{\% of Diet as Soil} \times \text{Soil Concentration (mg/kg)} \right)$$

Primary Prey Item Concentration (TN_1)

$$\text{Primary Prey Item Concentration (mg/kg)} = \left(BAF_{\text{inv or plant}} \times \text{Soil Concentration (mg/kg)} \right)$$

Secondary Prey Item Concentration (TN_2):

$$\text{Secondary Prey Item Concentration (mg/kg)} = \left(BAF_{\text{mam or bird}} \times \text{Tissue Concentration of Primary Prey Items}^{*} \text{ (mg/kg)} \right)$$

where BAF = bioaccumulation factor or mg/kg fresh weight tissue over mg/kg dry weight soil for invertebrates and plants, and mg/kg fresh weight tissue over mg/kg fresh weight food for small mammals and small birds.

* For a discussion of the weighted chemical concentration in prey items, see explanation of the PDE term below, and the General Information Report (ABB-ES, 1998)

Total Exposure Related to Surface Soil:

$$\text{PDE (mg/kgBW-day)} = \frac{[P_1 \times T_1 + \ldots + P_N \times T_N + \text{soil exposure}] \times IR_{Diet} \times SFF \times ED}{BW}$$

where
- PDE = potential dietary exposure (mg/kgBW-day),
- P_N = percent of diet composed of food item N,
- T_N = tissue concentration in either the primary or secondary prey item N_1 and N_2, respectively (mg/kg),
- IR_{Diet} = food ingestion rate of receptor (kg of food or dietary item per day),
- BW = body weight (kg) of receptor,
- SFF = site foraging frequency (site area [acres] divided by home range [acres]), assumed to be equal to 1 for lethal exposure scenario, and
- ED = exposure duration (fraction of year species is expected to occur on site)

Notes:
- ≤ = less than or equal to.
- ≥ = greater than or equal to.
- mg/kg = milligrams per kilogram.
- % = percent.
- BAF = bioaccumulation factors.
- inv = invertebrate species
- mam = mammal species.
- mg/kg BW-day = milligrams per kilogram of body weight per day.
- kg = kilograms.

Table 7-4
Ecological Receptors Evaluated
For Surface Soil

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Receptor Evaluated		Method of Evaluation
Common Name	Scientific Name	
Terrestrial Plants	Lettuce seed (*Lactuca sativa*)	Toxicity testing of surface soil
Terrestrial Invertebrate	Earthworms (*Eisenia foetida*)	Toxicity testing of surface soil
Cotton mouse	*Peromyscus gossypinus*	Food-web model
Short-tailed shrew	*Blarina brevicauda*	Food-web model
Eastern meadowlark	*Sturnella magna*	Food-web model
Red fox	*Vulpes vulpes*	Food-web model
Great horned owl	*Bubo virginianus*	Food-web model

- **Short-tailed shrew** (*Blarina brevicauda*). The short-tailed shrew finds suitable habitat in forests, fields, marshes, and brush. It primarily feeds on earthworms, snails, centipedes, insects, small vertebrates, and slugs (DeGraaf and Rudis, 1986). Insectivorous species may receive relatively high chemical doses of bioaccumulating compounds as a result of their voracious appetites. The shrew has an estimated home range of 0.96 acres and represents small omnivorous mammals that may be found in the old field portion of Site 11.

- **Eastern meadowlark** (*Sturnella magna*). The eastern meadowlark is most commonly found in open pastures, prairies, farms, and meadows and has a home range of approximately 5 acres. The meadowlark feeds primarily on invertebrates, although its diet is supplemented with plants. The meadowlark represents insectivorous avian receptors found in open areas of Site 11 (DeGraaf and Rudis, 1986).

- **Red Fox** (*Vulpes vulpes*). This omnivorous mammal prefers open woodlands and grassy fields and is most active at night and twilight. It is an opportunistic forager, feeding on small mammals, birds, amphibians, reptiles, invertebrates, berries, and other fruits (Burt and Grossenheider, 1976). The red fox has an estimated home range of approximately 250 acres and represents the large predatory mammal guild at Site 11.

- **Great Horned Owl** (*Bubo virginianus*). The great horned owl is primarily a nocturnal hunter of small mammals. Its habitat includes deep woods and heavily wooded swamps often near open country where it may hunt for primary prey items consisting of small mammals and birds (DeGraaf and Rudis, 1986). The great horned owl home range is approximately 15 acres. The owl represents the predatory avian carnivores of both the open and forested areas of Site 11.

Parameters for quantitatively evaluating exposures to wildlife include body weight, food ingestion rate, home range, and relative consumption of food items. Exposure assumptions for each of the representative wildlife species for Site 11 are provided in Table 7-5 and Table F-4 of Appendix F. In addition to these parameters, the species foraging habits and bioaccumulation in food items are also considered.The Site Foraging Frequency (SFF) considers the frequency a receptor feeds within the site area by estimating the acreage of the site relative to the receptor's home range, and by considering the fraction of the year the receptor would be exposed to site-related chemicals (i.e., the exposure duration). By definition the SFF cannot exceed 1. The area of Site 11 (approximately 3 acres) is larger than the home range for the cotton mouse and short-tailed shrew and smaller than the home range for the Eastern meadowlark, red fox, and great horned owl. Because all representative wildlife species are expected to actively forage at the site year round, it is assumed that the exposure durations for these organisms are 1.

Wildlife species may be exposed to ECPCs in surface soil via incidental ingestion of soil or by ingesting prey items that have bioaccumulated these ECPCs. To estimate this exposure, a PDE is estimated for all representative wildlife species for each ECPC according to the equations in Table 7-3.

Prey items for wildlife species in the food-web exposure models include invertebrates and plants as well as small mammals and birds. BAFs are used in the wildlife exposure model to estimate the transfer of chemicals between soil and plants or soil invertebrates and between these organisms and primary consumer species. To estimate the PDE, tissue concentrations of ECPCs in prey items are estimated using BAFs for surface soil. BAFs for most receptors are extrapolated from literature values or estimated using regression equations from scientific literature. Based on the evidence provided in several reference materials (Suter, 1993; Maughan, 1993), an assumption is made that VOCs do not bioaccumulate in prey tissue. The general approach used to select BAFs for Site 11 is summarized in Table 7-6.

BAFs for invertebrate and plant food items are defined as the ratio of the ECPC concentration in plant or invertebrate tissue (mg chemical/kg tissue wet-weight) to the ECPC concentration in surface soil (mg chemical/kg dry-weight soil). BAFs reported in the scientific literature for avian and mammalian receptors are the reported ratios of ECPC concentrations in the tissues of these receptors (mg chemical/kg tissue wet-weight) to the concentrations of ECPCs in their food items (mg chemical/kg tissue wet-weight). BAFs for each of the ECPCs evaluated at Site 11 are included in Table F-1 of Appendix F.

For each representative wildlife species, the estimated percentage of soil in the overall diet is multiplied by the concentration of each ECPC in the soil and the food ingestion rate (kilograms per day [kg/d]) to determine the soil exposure concentration.

7.4.3 Terrestrial Plants and Invertebrates Terrestrial plants and invertebrates may be exposed to ECPCs via direct contact with and root uptake (plants) or ingestion (invertebrates) of ECPCs measured in Site 11 surface soil. For the purposes of the Site 11 ERA, exposures to terrestrial plants and invertebrates are assumed to occur within the top one-foot-interval of surface soil. Exposure of terrestrial plants to groundwater is not evaluated because the depth to the water table is approximately 44 to 90 feet bls (see hydrogeological discussion in Chapter 5.0 of this report).

Table 7-5
Exposure Parameters for Representative Wildlife Species

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Representative Wildlife Species	Body Weight (kg)	Reported Diet	Assumed Diet for Terrestrial Exposure Assessment (% of diet)	Food Ingestion Rate (kg/day)	Home Range (acres)
Cotton mouse [a] (*Peromyscus gossypinus*)	0.021 [b]	Seeds and some insects. [c]	88% Plants 10% Invertebrates 2% Soil [d]	0.0029 [e]	0.147 [f]
Short-tailed shrew (*Blarina brevicauda*)	0.017 [g]	Earthworms, slugs, snails, fungi, insects, and vegetation. [c]	78% Invertebrates 12% Plants 10% Soil [c]	0.0024 [e]	0.96 ± 0.09 [c]
Eastern meadowlark (*Sturnella magna*)	0.087 [h]	Insects, seeds, and invertebrates (beetles, grubs, bugs, grasshoppers, crickets, ants, and spiders) [h]	75% Invertebrates 20% Plants 5% Soil [h]	0.0119 [j]	5 [h]
Red fox (*Vulpes vulpes*)	4.69 [c]	Small mammals, birds, and invertebrates, as well as berries and other fruits. [c]	57% Small mammals 20% Invertebrates 10% Small birds 10% Plants 3% Soil [c]	0.24 [e]	250 [c]
Great horned owl (*Bubo virginianus*)	1.5 [i]	Mostly rabbits, mice, rats, squirrels, birds, bats, snakes, frogs, crayfish, and grasshoppers [i]	80% Small mammals 19% Small birds 1% Soil [c]	0.078 [j]	15 [k]

References:

[a] Values for the deer mouse were used for the cotton mouse (U.S. Environmental Protection Agency [USEPA], 1993b).
[b] Average of adult male and female deer mice in North America (USEPA, 1993b).
[c] Based on average exposure parameters cited in *Wildlife Exposure Factors Handbook* (USEPA, 1993b).
[d] Average of the deer mouse value is used for cotton mouse based on similarities in diet. Other values were based on diet composition (USEPA 1993b).
[e] Calculated using the mammal equation based on body weight (Wt) in kg. Food ingestion (kg/day) = $0.0687 \times Wt^{0.822}$ (kg) (USEPA, 1993b).
[f] Average for male and female deer mice, Virginia/mixed deciduous forest (USEPA, 1993b).
[g] Mean of means reported for male and female shrews in summer and fall (USEPA, 1993b).
[h] Terres (1980).
[i] DeGraaf & Rudis (1986).
[j] Calculated using the bird equation based on body weight (Wt) in kg. Food ingestion (kg/day) = $0.0582 \times Wt^{0.651}$ (kg) (USEPA, 1993b).
[k] Great horned owl home range taken from low end of range in southeast Madison County, N.Y. (Hager, 1957).

Notes: kg = kilograms.
% = percent.
kg/day = kilograms per day.
± = plus or minus.

Table 7-6
Estimation of Bioaccumulation Factors

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Receptor Group	Nature of Approach	General Approach
Terrestrial Plants		
Unit: mg/kg wet tissue per mg/kg dry soil	Literature Values	When available, literature values were used to estimate plant BAFs.
	Extrapolation and Empirical Data	When literature values were not available, plant BAFs for inorganic compounds were obtained from Baes et al. (1984).[1]
	Assumption	Although evidence suggests that plants may transport organic analytes with log K_{ow}s < 5 (i.e., volatile organic compounds [VOCs]) from the roots into leafy portions (Briggs et al., 1982; Briggs et al., 1983), bioaccumulation data for VOCs are generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it is assumed that transfer of VOCs from plant tissue to animal tissue does not occur.
Terrestrial Invertebrates		
Unit : mg/kg wet tissue per mg/kg dry soil	Literature Values	When no specific values were available, literature values were used to estimate BAFs for invertebrates.
	Assumption	Bioaccumulation data for VOCs is generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it is assumed that soil invertebrates do not bioaccumulate VOCs.
Small Mammals		
Unit : mg/kg wet tissue per mg/kg wet food	Literature Values	When available, literature values were used to estimate BAFs for small mammals.
	Extrapolation and Empirical Data	When literature values were not available, BAFs for small mammals for inorganics were derived from ingestion-to-beef biotransfer factors (BTFs) presented in Baes et al. (1984)[2].
	Assumption	Bioaccumulation data for VOCs are generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it is assumed that small mammals do not bioaccumulate VOCs.
Small Birds		
Unit: mg/kg wet tissue per mg/kg wet food	Literature Values	When available, literature values were used to estimate BAFs for small birds.
	No Information	BAFs were not obtained for SVOCs or for inorganic compounds as there is little bioaccumulation data available for birds. It is assumed that small birds do not accumulate VOCs.

[1] BAFs derived from Baes et al. (1984). Values are based on analysis of literature references, correlations with other chemical and physical parameters, or comparisons of observed and predicted elemental concentrations in vegetative and reproductive plant material and soil. Data are based on dry weight and were converted to a fresh weight basis assuming that plants are 80 percent water. This is generally consistent with the water content of berries (82 to 87 percent water) and leafy vegetables (87 to 95 percent water), presented in Suter (1993). Grains contain a much lower percentage of water (approximately 10 percent); therefore, this assumption likely underestimates exposure to graminivores.
[2] BTFs were converted to a BAF (mg/kg tissue divided by mg/kg food) by multiplying by a food ingestion rate of 12 kg (dry weight) per day (average intake for lactating and nonlactating cattle reported in Travis and Arms, 1988).

Notes: mg/kg = milligrams per kilogram.
BAFs = bioaccumulation factors.
kg = kilogram.
Log K_{ow} = Logarithmic expression of the octanol-water partition coefficient.
< = less than.
BTF = biotransfer factor.

7.5 ECOLOGICAL EFFECTS ASSESSMENT. The ecological effects assessment discusses what measurement endpoints were used to evaluate potential adverse impacts to the assessment endpoints (i.e., the survival and maintenance of receptor populations). The methods used for identifying and characterizing ecological effects for ECPCs in surface soil are described in the following subsections and in greater detail in Subsection 2.4.4 of the GIR (ABB-ES, 1998).

Wildlife receptors, terrestrial plants, and terrestrial invertebrates are potentially exposed to ECPCs in surface soil at Site 11. The measures of adverse ecological effects for these receptors are discussed separately.

7.5.1 Terrestrial Wildlife As identified in the problem formulation, the assessment endpoint selected for terrestrial wildlife is the survival and maintenance of wildlife populations and communities within the habitats present at Site 11. Because no long-term wildlife population data are available at NAS Whiting Field, a direct measurement of this assessment endpoint is not possible. The literature-derived results of laboratory toxicity studies that relate the dose of a chemical in an oral exposure with an adverse response to growth, reproduction, or survival of a test population (avian or mammalian species) are used as a measure of the assessment endpoint. Wildlife ingestion toxicity data are presented in Appendix F, Table F-2.

Reference toxicity values (RTVs) are derived for each ECPC and representative wildlife species according to the data hierarchy presented in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Interim Final (USEPA, 1997d). The RTV represents the lowest exposure level (e.g., concentration in the diet) shown to produce adverse effects (e.g., reduced growth, impaired reproduction, increased mortality). For each ECPC, two RTVs representing lethal and sublethal effects are selected for each representative wildlife species. Lethal effects are those that result in mortality while sublethal effects are those that impair or prevent reproduction or growth. The RTVs are assumed to be a measure of the assessment endpoints for the protection of the survival, growth, and reproduction of terrestrial wildlife populations. Lethal RTVs are developed using the data hierarchy below and discussed in items 1, 2, and 3, while sublethal RTVs are derived using the methodology discussed in items 1 and 2.

1) For contaminants with well-documented adverse effects, the highest exposure level that is a no observed adverse effect level (NOAEL) is selected as the RTV.

2) If NOAEL values are not available, one-tenth of the lowest observed adverse effect level (LOAEL) is selected as the RTV.

3) If NOAEL or LOAEL values are not available, the lowest reported oral LD_{50} (oral dose [in mg/kg body weight-day] lethal to 50 percent of a test population) is used to derive the lethal RTV. The lethal RTV is one-fifth of the lowest reported LD_{50} value for the species most closely related to the representative wildlife receptor. One-fifth of an oral LD_{50} value is considered to be protective against lethal effects for 99.9 percent of individuals in a test population (USEPA, 1986b). An assumption is made that the value represented by one-fifth of an oral LD_{50} would be protective of 99.9 percent of the individuals within the

terrestrial wildlife populations and represents a level of acceptable risk.

A summary of lethal and sublethal RTVs selected from the ingestion toxicity data is provided in Table F-3 of Appendix F.

If neither lethal nor sublethal toxicity information is available for a taxonomic group, no RTVs are identified and risks associated with the respective ECPC are not quantitatively evaluated. However, the absence of specific data for a taxonomic group does not imply that there is no toxicological effect associated with contaminant exposure by these receptors; therefore, potential risks to these taxonomic groups are qualitatively discussed in the Uncertainties Section (Section 7.7).

7.5.2 Terrestrial Plants and Invertebrates The assessment endpoints selected for terrestrial plants and soil invertebrates are survivability and growth of terrestrial plant and soil invertebrate communities as well as reduction in the biomass of terrestrial plants and abundance of soil invertebrates used as forage material. The toxicity of surface soil at Site 11 was measured using two soil laboratory toxicity tests including a 30-day survival and growth test with earthworms (*Eisenia foetida*) and a 120-hour lettuce seed (*Lactuca sativa*) germination test.

Surface soil samples (samples 11N00201, 11N00301, 11N00401, and 10N00501) for toxicity testing were collected from four locations at Site 11 and two reference soil samples (sample BKN00301 and its duplicate sample BKN00301D and sample BKN00101) from uncontaminated sites at NAS Whiting Field . The Site 11 and reference soil samples were collected concurrently with surface soil samples (11S00201, 11S00301, 11S00401, 11S00501, BKNS00301, and BKNS00101) for chemical analyses and represent split samples. Therefore, the results of the chemical analyses can be used to establish contaminant exposure concentrations and provide the means to interpret responses in the bioassays. If adverse effects were observed in either of the bioassays, simple linear regressions were completed to determine if a correlation(s) exists between the concentration of an analyte and the adverse response measured in the bioassay.

The results of the earthworm and lettuce seed toxicity testing of surface soil samples from Site 11 are presented in Table 7-7. Additional information on the toxicity testing of Site 11 surface soil with *E. foetida* and *L. sativa* is included in Appendix F of the GIR (ABB-ES, 1998).

Because the earthworm survival and lettuce seed germination data in the reference sample, BKN00101, were significantly different ($P \leq 0.05$) than the reference location, BKN00301, and data from sample BKN00301 were not significantly different from the laboratory control, toxicity data from BKN00101 were not included in the statistical comparison of site-related data and control/reference data. Site-related toxicity data were evaluated by a statistical comparison of mean survival, growth (as wet weight), or germination with the reference sample (BKN00301 and BKN00301D) and the laboratory control.

With the exception of one soil sample (11N00201), the soil samples collected at Site 11 were not toxic to earthworms. Earthworms exposed to soil collected at 11N00201 for 30 days experienced 77 percent mortality. There were no significant differences ($P \leq 0.05$) in the growth of earthworms between the reference and

laboratory control samples and the Site 11 samples after 30 days of exposure. There were also no significant differences ($P \leq 0.05$) in germination of lettuce seeds between the reference and laboratory control samples and the Site 11 samples following 120 hours of exposure.

Table 7-7
Results of Site 11 Surface Soil Toxicity Testing

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Sample Location	Earthworm (*Eisenia foetida*)		Lettuce Seed (*Lactuca sativa*)
	Survival After 14 days (30 days) (%)	Weight Change (%)[1]	Germination After 120 Hours (%)
11N00201	100 (23)*	11.8	94
11N00301	100 (100)	4.6	91
11N00401	100 (100)	5.2	91
11N00501	100 (100)	7.2	86
Laboratory Control	100 (81)	13	91
BKN00301 (Reference)	100 (100)	10.9	97
BKN00301D (Reference)	100 (100)	5.0	90
BKN00101 (Reference)	100 (63)*	29.1	43*

[1] Growth of *E. foetida* is expressed as mean individual wet weight.

Notes: * = significantly different from the laboratory control and reference BKN00301.
% = percent.

7.6 RISK CHARACTERIZATION. This section presents the risk characterization for ecological receptors exposed to affected surface soil at Site 11. Potential risks associated with exposures to ECPCs in surface soil at Site 11 are discussed separately for wildlife, terrestrial plants, and soil invertebrates. Risks to wildlife are characterized by comparing the PDE concentrations (based on RME and CT exposure concentrations) for each surface soil ECPC with its respective RTV (estimated threshold dose for toxicity). Risks for terrestrial plants and soil invertebrates are evaluated by comparing toxicity benchmarks to RME and CT exposure concentrations.

7.6.1 Terrestrial Wildlife Risks for the representative wildlife species associated with ingestion and bioaccumulation of ECPCs in surface soil and prey items are quantitatively evaluated using HQs. HQs are calculated for each ECPC by dividing the PDE concentration by the selected lethal and sublethal RTV. HIs are determined for each receptor by summing the HQs for all ECPCs. When the estimated PDE is less than the RTV (i.e., the HQ < 1), it is assumed that chemical exposures are not associated with adverse effects to receptors and no risks to wildlife populations exist. For instance, if the PDE calculated using the RME concentration is less than the lethal RTV, then it is assumed that adverse effects to the survival of wildlife populations are unlikely to occur. Similarly, if the reasonable maximum PDE is less than the sublethal RTV, then it is assumed that adverse effects to wildlife populations related to growth and reproduction are unlikely to occur. When an HI is greater than or equal to 1,

a discussion of the ecological significance of the HQs comprising the HI is completed and risks from exposure to CT concentrations of ECPCs are evaluated.

This hazard ranking scheme evaluates potential ecological effects to individual organisms and does not evaluate potential populationwide effects. Contaminants may cause population reductions by affecting birth and mortality rates, immigration, and emigration (USEPA, 1989c). In many circumstances, lethal or sublethal effects may occur to individual organisms with little population- or community-level impacts; however, as the number of individual organisms experiencing toxic effects increases, the probability that population effects will occur also increases. The number of affected individuals in a population presumably increases with increasing HQ or HI values; therefore, the likelihood of population-level effects occurring is generally expected to increase with higher HQ or HI values.

The lethal and sublethal HQs and HIs are calculated for each ECPC and each representative wildlife species. Tables F-5 through F-9 of Appendix F present the HQ and HI calculations. A summary of risks to representative wildlife receptors is provided in Table 7-8.

Table 7-8
Summary of HIs for Terrestrial Wildlife[1]

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Site 11, Southeast Open Disposal Area (B) (Landfill)
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Ecological Receptors	Lethal Effects from Exposure to Reasonable Maximum EPCs	Sublethal Effects from Exposure to Reasonable Maximum EPCs	Sublethal Effects from Exposure to Central Tendency EPCs
Cotton mouse	0.071	1.5	0.55
Short-tailed shrew	0.15	4.5	2.2
Eastern meadowlark	0.07	3.5	1.8
Red fox	0.66	6.3	2.7
Great horned owl	0.43	20	9.5

[1] The information is a summary of the HIs presented in Tables E-4 through E-9 of Appendix E.

Notes: EPC = exposure point concentration.
HI = hazard index.

Summary HIs for representative wildlife species exposed to RME concentrations of ECPCs for lethal effects were less than 1; therefore, lethal risks are not predicted for these receptors (i.e., bioaccumulating chemicals are not sufficiently high to reduce survivability in small mammals and birds and in top predators).

Based on exposure to RME concentrations of ECPCs in the surface soil, sublethal risks are predicted for all representative wildlife species. The sublethal HIs for the short-tailed shrew (RME HI = 4.5 and CT HI = 2.2), Eastern meadowlark (RME HI = 3.5 and CT HI = 1.8), red fox (RME HI = 6.3 and CT HI = 2.7), and great horned owl (RME HI = 20 and CT HI = 9.5) are all above 1 based on RME and CT

exposure concentrations. The primary contributor to the sublethal HIs for the short-tailed shrew and the meadowlark is 4,4'-DDD.

Dieldrin and lead are primary contributors to sublethal risks for the red fox, while 4,4'-DDD, 4,4'-DDT and alpha- and gamma-chlordane are the primary risk drivers for the great horned owl.

Based on the results of the 1992 Phase IIA and 1996 Phase IIB surface soil investigations at Site 11, it appears that elevated concentrations of 4,4'-DDD, 4,4'-DDT, dieldrin, and lead in the surface soil may be localized at sampling location 11-SL-02. 4,4'-DDD was detected only at location 11-SL-02 and maximum concentrations of 4,4'-DDT, dieldrin, and lead were also detected at location 11-SL-02 as compared to the other sampling locations.

In order to evaluate whether or not potential risks to wildlife receptors exist outside the immediate area of sampling location 11-SL-02, the RME exposure concentrations for 4,4'-DDD, 4,4'-DDT, dieldrin, and lead were recalculated by excluding the concentrations of these analytes detected at 11-SL-02. The RME concentration for lead is equal to the 95th percent UCL because lead was analyzed in 17 additional samples, and the UCL is less than the maximum detected concentration. The RME concentration for 4,4'-DDD is not calculated because this pesticide was only detected at location 11-SL-02. The RME concentrations for 4,4'-DDT and dieldrin are equal to their maximum detected concentrations because these analytes were analyzed in only nine additional samples. The recalculated RME concentrations for the aforementioned analytes are as follows: 4,4'-DDD (not detected), 4,4'-DDT (0.045 mg/kg), dieldrin (0.044 mg/kg), and lead (37 mg/kg). The recalculated RME concentrations, excluding the data from location 11-SL-02, were then used to derive HIs via the food-web model. The sublethal HQs and HIs calculated using the revised RME exposure concentrations for each of the representative wildlife species are presented in Tables F-10 and F-11 of Appendix F.

Sublethal risks to small mammal and bird populations are not predicted based on the revised RMEs for 4,4'-DDD, 4,4'-DDT, dieldrin, and lead. Although sublethal HI for the Eastern meadowlark was 1.0, all HQ values for individual constituents were less than 1. Although adverse effects to individual small bids are possible at HI values of one, the likelihood of population-level effects are considered negligible. Sublethal HIs for the red fox (HI = 3.9) and the great horned owl (HI = 4.5) still exceed 1. The primary risk contributor for the fox is dieldrin; for the owl, the primary risk contributors are 4,4'-DDT, alpha-chlordane, and gamma-chlordane.

The results of the food-web modeling suggest that lethal risks to terrestrial wildlife at Site 11 are not expected. Sublethal risks to small mammals and birds and top predators associated with ingestion of pesticides (including 4,4'-DDD, 4,4'-DDT, dieldrin, alpha-chlordane, and gamma-chlordane) and lead in surface soil and related food items may occur. However, it appears that elevated concentrations of 4,4'-DDD and lead are localized in the immediate area surrounding sampling location 11-SL-02. Because sublethal risks to small mammals and birds appear to be localized to one discrete location or "hot-spot," it is unlikely that the reproduction or growth of these wildlife populations would be impacted outside the immediate area of 11-SL-02. However, sublethal impacts to growth and reproduction of top predator populations are possible over the entire area of Site 11.

7.6.2 Terrestrial Plants After 120 hours of exposure to Site 11 surface soil, lettuce seed germination was not inhibited. As shown in Table 7-7, lettuce seed germination ranged from 86 to 94 percent in soil collected from Site 11 as compared to 91 percent in the laboratory control and 94 percent in the reference sample, BKN00301, and its duplicate BKN00301D. The results of the toxicity testing show that surface soil samples collected at Site 11 are not expected to impact the survival and growth of terrestrial plants. Consequently, reduction of plant biomass and/or plant cover at Site 11 and subsequent impacts to small mammal and bird populations are not expected to occur.

7.6.3 Terrestrial Invertebrates With the exception of one sample (11S00201), the soil samples collected at Site 11 were not toxic to *E. foetida*. Following 30 days of exposure, survival and growth of earthworms in samples 11S00301, 11S00401, and 11S00501 were not significantly different ($P \leq 0.05$) from the laboratory control or reference sample. Worms exposed to soil from station 11S00201 experienced 77 percent mortality. Based on the results of the toxicity testing, it is assumed that with the exception of soil at location 11S00201, the contamination present in surface soil at Site 11 does not present an unacceptable risk for terrestrial soil invertebrates.

Of the soil samples collected during the 1996 Phase IIB investigation (11S00101 through 11S00501), sample location 11S00201 is characterized by concentrations of TPH and 4,4'-DDT greater than any other surface soil sampling location. TPH was detected at 53.1 mg/kg and 4,4'-DDT was detected at 0.027 mg/kg at this location. Appendix F presents a series of simple linear regression analyses that evaluate statistical relationships between biological effects observed in the surface soil bioassays and concentrations of selected analytes in Site 11 surface soil. Selected analytes include TPH, bis(2-ethylhexyl)phthalate, 4,4'-DDT, dieldrin, lead, and zinc. These analyses suggest that concentrations of TPH and 4,4'-DDT are both positively correlated with earthworm mortality with the square of the product moment correlation coefficient through data points in known "y"s and known "x"s) (R^2) values of 0.99 (TPH) and 0.95 (4,4'-DDT). As concentrations of either TPH or 4,4'-DDT increase (at location 11S00201), earthworm survival rates decrease.

7.7 UNCERTAINTY ANALYSIS. The objective of the uncertainty analysis is to discuss the assumptions of the ERA process that may influence the risk assessment results and conclusions. Table 2.5 of the GIR presents several general uncertainties inherent in the risk assessment process (ABB-ES, 1998).

Specific uncertainties associated with exposure to surface soil at Site 11 include the following:

- Although selected as an ECPC for surface soil, TPH was not evaluated in the ERA for terrestrial wildlife (i.e., mammals and birds) because toxicological benchmarks were not available. TPH was detected in five samples collected during the Phase IIB investigation at concentrations ranging from 7 to 53.1 mg/kg. It is believed that detected concentrations of TPH are likely the result of past disposal activities at Site 11. Based on the detected concentrations of volatile and semivolatile constituents, and the finding of no risk associated with these constituents, it is unlikely that detected concentrations of TPH in the surface soil of Site 11 pose a risk to terrestrial wildlife receptors.

- Risks to avian species may have been underestimated because bioaccumulation and toxicity data for this taxonomic group are generally lacking in the literature. As a result, potential risks associated with several ECPCs were not evaluated for avian species. If the toxicological and contaminant transport data obtained from studies conducted on mammals were used to estimate risks to avian species, then risk estimates for birds would be higher. However, there is also uncertainty in assuming that the metabolic functions of mammals and birds are similar enough to use intertaxonomic surrogates.

- Risks to adult amphibian and reptile species were not estimated because bioaccumulation and toxicity data for this taxonomic group are generally lacking in the literature. As a result, potential risks associated with ECPCs are uncertain for these species. Intertaxonomic surrogates were not used to calculate dietary risks to reptiles because of the uncertainty associated with extrapolation of data from endothermic to essentially ectothermic species.

- An assumption has been made that organisms evaluated in the toxicity tests are representative of species at the site. Depending on the sensitivities of terrestrial plants and invertebrates occurring at Site 11, risks may be over or underestimated.

- Inclusion of the lead confirmatory samples in the EPC calculation may result in overestimation of risk.

7.8 SUMMARY OF ECOLOGICAL ASSESSMENT FOR SITE 11. Potential risks for ecological receptors including terrestrial wildlife, terrestrial plants, and soil invertebrates were evaluated for ECPCs in surface soil at Site 11.

Risks associated with exposures to ECPCs in Site 11 surface soil were evaluated for terrestrial wildlife based on a model that estimates the amount of contaminant exposure obtained via the diet and incidental ingestion of surface soil. Comparison of estimated doses for wildlife species with reference toxicity doses representing thresholds for lethal and sublethal effects is the basis of wildlife risk evaluation. Based on the results of the food-web model, lethal risks to terrestrial wildlife at Site 11 are not predicted. Sublethal risks to terrestrial wildlife associated with ingestion of pesticides and lead in surface soil and food items were identified; however, elevated concentrations of 4,4'-DDD and lead are localized in the immediate area surrounding sampling location 11-SL-02. Sublethal risks to small mammal and bird populations appear to be localized to location 11-SL-02 while impacts to top predator populations are predicted over the entire area of Site 11.

Risks to terrestrial plants and soil invertebrates at Site 11 were evaluated based on the results of laboratory toxicity testing of surface soil samples from Site 11 with earthworms (*Eisenia foetida*) and lettuce seeds (*Lactuca sativa*). With the exception of soil from sampling location 11S00201, soil collected from Site 11 was not toxic to the test species and risks associated with exposure to ECPCs in surface soil were not identified for soil invertebrates, terrestrial plants, or foraging mammal and bird populations. At location 11S00201, significant earthworm mortality (77 percent) was observed. It is likely that elevated TPH and 4,4'-DDT concentrations (53.1 and 0.27 mg/kg, respectively) may

be at least partially responsible for the observed mortality in the laboratory toxicity tests.

In summary, the results of the ERA suggest that the growth and reproduction of small mammal and bird populations may be impacted in the area near sampling location 11-SL-02, while sublethal impacts to top predator populations are likely over the entire area of Site 11. Reductions in the biomass of terrestrial plants used as forage material at Site 11 are not expected. However, the survival of terrestrial invertebrates and consequent abundance for foraging mammals and birds may impacted at sampling location 11S00201.

CHAPTER 8.0

8.0 CONTAMINANT FATE AND TRANSPORT

This chapter discusses the fate and transport of human health and ecological CPCs detected in soil and groundwater samples at Site 11. Fate, in the context of this chapter, refers to the ultimate disposition of a given CPC following its release into the environment. Transport refers to the mechanism(s) by which a given chemical released into the environment will arrive at its fate. Explanation of the fate and transport of chemicals in the environment can be very complicated or very simple, depending on the physical, chemical, and biological characteristics of the compound or metal considered and the environment into which that compound is released.

Several organic compounds and inorganics were detected in soil and groundwater sampled at Site 11. Because of the number of potential chemicals detected and the myriad fate and transport scenarios possible for those chemicals in the media, this discussion will focus only on those chemicals that may pose adverse risk to human or ecological receptors, as identified by the HHRA (Chapter 6.0) and the ERA (Chapter 7.0) in this report.

The following discussion of contaminant fate and transport is divided into two sections. Section 8.1 discusses potential migration routes of a chemical(s) in the media evaluated and does not focus specifically on media found to be of concern at Site 11. The site-specific persistence, fate, and transport of those compounds and elements found to pose a potential risk to human health or the environment are discussed in Section 8.2.

8.1 POTENTIAL ROUTES OF MIGRATION. Several routes of migration are possible for a contaminant in the various media: air, soil, surface water, groundwater, and biota. These routes are summarized below.

Air. Gases and particulate material can be transported in the atmosphere. Organic compounds, metals, and metal complexes that exist as gases at surface temperature and pressure may disperse or diffuse into the air and particulates may become entrained in air and thereby migrate. The extent to which gaseous constituents and particulate material remain airborne is a function of the level of excitation of the air (wind and temperature) and fate processes acting on the constituent and, for particulates, their density. Particulate material as discussed herein consists of organic compounds and inorganic material that would otherwise not be present in a gaseous medium under atmospheric conditions.

Soil. The primary agents of migration acting on soil include wind, rainwater, running water, biological activity, and human activity. Wind commonly transports soil in the form of particulate material. Rainwater may cause soil to migrate either by washing soil particles downward into the subsurface or by carrying soil particles overland to surface water bodies or other areas of deposition. The amount and type of vegetative cover and surface disturbance affects the degree to which wind and water cause soil to migrate.

Surface Water. The mechanisms for migration of constituents in surface water are dissolution and suspension. Several organic compounds and metals are soluble in water and can be transported in the aqueous phase. Other organic compounds and elements are not soluble in water, but may be transported by surface water via

suspension. The amount of suspended particulate material in surface water is largely a function of the water's energy; as that energy decreases, suspended material will settle and become part of the soil or sediment. Colloidal material may remain in suspension (by electrochemical forces) in water of very low energy (e.g., standing water).

Sediment. Saltation, traction, suspension, biological action, and human action are the primary mechanisms of migration for sediment. Physical, chemical, and biological processes affecting a constituent will determine where and how migration from sediment will occur.

Groundwater. Groundwater is a liquid medium capable of transporting constituents as colloidal forms, as complexes, as pure phase liquids, or as dissolved-phase liquids. Organic compounds and elements generally reach groundwater either by being placed directly into the water table (e.g., disposal pits) or by being leached from soil or solid waste to the water table by physical or chemical processes. Groundwater may discharge to the land surface, surface water bodies, other aquifers, or pumping wells. The migration of constituents from groundwater upon discharge depends on the chemical and/or physical processes acting upon that individual constituent in the medium to which it is discharged.

Biota. Biota may be considered a medium for migration of certain organic compounds and inorganics. Several compounds and elements are known to accumulate in the tissues of organisms at various levels in the food chain. As these organisms are consumed by other organisms, compounds and elements are accumulated in their tissue and passed on to organisms higher in the food chain. In this manner, contaminants may be transported by biota. Additionally, some organisms disturb bed sediments in streams and rivers. This disturbance can cause organic compounds and elements to be transported downstream as suspended material in surface water.

8.2 CONTAMINANT PERSISTENCE AND FATE. The discussion of contaminant persistence and fate in the environment is divided into three subsections. Subsection 8.2.1 discusses the processes that control the persistence and fate of organic compounds and inorganics in the environment. Subsection 8.2.2 discusses the primary persistence and fate characteristics of the constituents detected at Site 11. Subsection 8.2.3 discusses contaminant transport for Site 11.

8.2.1 Processes The persistence and fate of chemical constituents in the environment depends on various chemical, physical, and biological processes. The predominant processes affecting the environmental persistence and fate of chemical constituents include solubility, photolysis, volatilization, hydrolysis, oxidation, chemical speciation, complexion, precipitation or coprecipitation, cationic exchange, sorption, biodegradation or biotransformation, and bioaccumulation. These processes are briefly summarized below.

Solubility. The solubility of chemical constituents in water is important in assessing their mobility in the environment. This is particularly important for the transport and ultimate fate of chemicals from soil and sediment to water (i.e., groundwater and/or surface water). Generally for organic compounds, aqueous solubility is a function of molecular size, molecular polarity, temperature, and the presence of other dissolved organic cosolvents. For metals and other inorganic parameters, solubility is generally controlled by chemical

speciation, pH, redox potential (Eh), oxygen content, and the presence of dissolved and/or colloidal organic compounds (e.g., humic and fulvic acids) or other inorganic ion species (e.g., hydroxides and sulfates) (USEPA, 1979). Increased solubility is usually directly related to increased environmental mobility with groundwater and/or surface water being the principal transport medium. Therefore, solubility is a significant factor affecting the fate of a compound or element in the water environment.

Photolysis. Many chemical constituents, particularly organic compounds, are susceptible to photolytic degradation either directly or indirectly. Direct photolysis involves a splitting of the chemical compound by light, whereas indirect photolysis occurs when another compound is transformed by light into a reactive species (i.e., usually a hydroxyl radical) that reacts with and modifies the original compound. In general, photolysis primarily occurs within the atmosphere, although it may also occur to a limited extent in surface water and/or soil under certain environmental conditions (USEPA, 1979).

Volatilization. Volatilization of organic chemicals from soil or water to the atmosphere is an important pathway for chemicals with high vapor pressures. For organic compounds, volatilization is a function of partial pressure gradients, temperature, and molecular size and is more likely to occur for compounds with low molecular weights. In addition, certain metals such as mercury, arsenic, and lead are capable of undergoing biologically mediated transformation (i.e., alkylation) that form volatile end products. Volatilization is important for the transport of certain chemical constituents from surface soil (i.e., vadose zone), sediment, and surface water and is evaluated using Henry's law and other associated chemical-specific rate constants.

Hydrolysis. Hydrolysis involves the decomposition of a chemical compound by its reaction with water. The rate of reaction may be promoted by acid (hydronium ion, $[H_3O^+]$) and/or base (hydroxyl ion, $[OH^-]$) compounds. In general, most organic compounds are resistant to hydrolytic reactions unless they contain a functional group (or groups) capable of reacting with water. Metallic compounds, however, generally dissociate readily in water depending upon the aqueous environmental conditions (e.g., pH and ionic strength). For metals, hydrolytic dissociation is an indirect process that affects the primary fate and transport mechanism of aqueous solubility.

Oxidation. The direct oxidation of organic compounds in natural environmental matrices may occur but this is generally a slow, insignificant transformation mechanism of minimal importance (USEPA, 1979). However, some inorganic compounds may be rapidly oxidized under naturally occurring environmental conditions when the surrounding environment changes from anaerobic to aerobic conditions.

Chemical Speciation. Chemical speciation is important primarily for metals that may exist in multiple forms in the environment, particularly within aqueous matrices. In general, the aqueous speciation of metals depends primarily upon the relative stabilities of individual valence states (which are element specific), oxygen content, pH and Eh condition, and the presence of available complexating agents and/or other cations and anions (USEPA, 1979). Because various metallic species exhibit differential aqueous solubilities and differential mobilities within soils and/or sediments (USEPA, 1979), the particular speciation of an individual metal will greatly affect its environmental mobility.

Complexation. For metals, complexation with various ligands is an important process because these complexes may be highly soluble in water. Complexation may, therefore, greatly enhance mobility within environmental matrices, particularly in groundwater and surface water, depending upon the aqueous solubility of the resulting complex. Complexation depends upon numerous factors such as pH, Eh, type and concentration of complexing ligands, and other ions present (USEPA, 1979).

Most metals are capable of forming numerous organic and/or inorganic complexes in the natural environment (USEPA, 1979). Metals may form organo-metallic complexes, especially with naturally occurring organic acids (i.e., humic and fulvic acids). In some cases, these metallic species may exhibit varying affinities for different organic ligands (i.e., mercury and arsenic for amino acids and their derivatives) (USEPA, 1979). Metals may also form metallo-inorganic complexes with inorganic ligands such as carbonate, halogens (usually chlorine), hydroxyl, and sulfate (USEPA, 1979). However, organo-metallic complex formation is usually favored over metallo-inorganic complexes.

Precipitation and Coprecipitation. Both chemical precipitation and co-precipitation are important removal mechanisms, particularly for metals and metallo-cyanides in the environment. Precipitation and/or coprecipitation reactions depend on numerous aqueous environmental conditions such as pH, Eh, organic ligands present, oxygen content, and cationic and anionic species present (USEPA, 1979). Depending on the specific conditions, the removal of aqueous metallic species and metallo-cyanides from groundwater and/or surface water can greatly affect a metal's environmental mobility and, hence, its ultimate fate and transport.

Cation Exchange. Cation exchange is important primarily for metals and other ions that may substitute with other cations of similar charge and size within the lattice structure of clay minerals in soil and/or sediment (USEPA, 1979). This process, therefore, can significantly affect the mobility of an aqueous metal cation by removing it from solution under certain environmental conditions.

Sorption. The sorption of chemical constituents by inorganic particulate matter (i.e., soil or sediment) and organic compounds is an important process that affects mobility in the environment. This process is particularly important for the fate and transport of chemicals from soil or sediment to water (i.e., groundwater and surface water). In general, most metals exhibit a potential for adsorption to inorganic particulate matter and organic compounds (USEPA, 1979). Organic compounds also exhibit sorptive capability, but show greater variability in their ability to sorb to particulate or organic matter. The tendency for organic compounds to sorb to soils or sediment is reflected in their organic carbon partitioning coefficients (K_{oc}). K_{oc} is a measure of relative adsorption potential. The normal range of K_{oc} values is from 1 to 10^7 with higher values indicating greater sorption potential. Actual adsorption is chemical specific and is largely dependent on the organic content of the soil. The fraction of organic carbon, f_{oc}, in soil times the K_{oc} is defined as the distribution coefficient, K_d. The K_d is a ratio of the concentration adsorbed to the concentration partitioned to water.

Regardless of chemical class, sorption is a reversible process whereby desorption can be favored over sorption under certain environmental conditions (e.g., low pH for metals). For organic compounds in general, as the molecular weight

increases and the aqueous solubility decreases (i.e., low polarity and high hydrophobicity), the sorptive binding affinity increases (i.e., K_{oc} increases). The tendency for chemical constituents to adsorb to inorganic particulate and/or organic compounds is a particularly important process because sorption to soils and/or sediments can effectively reduce a chemical constituent's mobility.

Biodegradation or Biotransformation. Biodegradation is a result of the enzyme-catalyzed transformation of chemicals. Organisms require energy, carbon, and essential nutrients from the environment for their growth and maintenance. In the process, chemicals from the environment will be transformed by enzymes into a form that can be used by the organism. The biodegradation rate is the rate by which contaminants will be degraded. The rate is a function of microbial biomass and a chemical's concentration under given environmental conditions. When a pollutant is introduced into the environment, there is often a lag time before biodegradation begins while the organism generates an enzyme capable of digesting the chemical. Co-metabolism occurs when a pollutant can be biotransformed only in the presence of another compound that serves as a carbon and energy source (USEPA, 1979).

Bioaccumulation. Bioconcentration and bioaccumulation data are important when evaluating the impact of chemicals in the aquatic environment. The process is characterized by hydrophobic chemicals that can be partitioned into fat and lipid tissues and inorganic chemicals that can be partitioned into bone marrow. The bioconcentration factor is a measure of the concentration of a chemical in tissue (on a dry-weight basis) divided by the concentration in water, and is a commonly used parameter to quantify bioconcentration (USEPA, 1979). The process is significant because bioaccumulation magnifies up through the food chain.

8.2.2 Persistence and Fate of Site 11 CPCs This section discusses the persistence and fate characteristics for CPCs detected at Site 11. To focus the discussion of persistence and fate characteristics, only those constituents that were (1) identified by the human health or ERAs (presented in Chapters 6.0 and 7.0, respectively) as CPCs and (2) those constituents that were present above relevant standards will be addressed. These constituents are summarized below by medium for Site 11.

Human Health Assessment Constituents

- Surface soil: Six PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo-(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene), one pesticide compound (dieldrin) and three inorganic analytes (arsenic iron, and lead).

- Groundwater: Three VOCs (1,2-dichloroethene, benzene, vinyl chloride), one SVOC (bis(2-ethylhexyl)phthalate), and five inorganic analytes (aluminum, arsenic, iron, manganese, and thallium).

Ecological Assessment Constituents

- Surface soil: One VOC (acetone); fourteen SVOCs (bis(2-ethylhexyl-phthalate, 2-methylnaphthalene, acenaphthylene, anthracene, benzo(a)-anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene), five pesticides (4,4'-DDD, 4,4'-DDT,

dieldrin, alpha-chlordane, and gamma-chlordane), three inorganic analytes (lead, silver, and zinc), and TPH.

The fate and persistence characteristics of these constituents are summarized below by analytical fraction.

VOCs

Acetone. Acetone (C_3H_6O) is both a naturally occurring and manmade compound. It has been identified as a naturally occurring volatile metabolite of both plants and insects; forest fires have also been identified as a natural source of the compound. Acetone is commonly used as a solvent and is a by-product of several manufacturing processes (Howard, 1990).

The majority of acetone released to the environment is by emissions to the atmosphere; in the atmosphere it will break down by photolysis or be removed by rain. If released to the soil it will both volatilize and leach into the ground. In soil and groundwater, acetone will readily biodegrade and is not likely to significantly adsorb to either soil or sediment (Howard, 1990).

Acetone is a commonly recognized field- or laboratory-derived contaminant according to the USEPA CLP Functional Guidelines for Organic Data Review (USEPA, 1994a). As such, the detected concentrations of acetone at Site 11 may not be related to past disposal activities at the site. Furthermore, given the fact that acetone readily volatilizes, it is unlikely that surface soil would retain detectable quantities of acetone for 25 years (waste disposal at Site 11 ended in approximately 1970).

1,2-DCE. 1,2-DCE ($C_2H_2CL_2$) exists as two isomers, *cis* and *trans*. The *trans* isomer is twice as toxic as the *cis* isomer. Both may enter the environment in emissions and wastewater and as a solvent and extractant in the production of perfumes, lacquers, and thermoplastics. In addition, 1,2-DCE is a breakdown product in the reductive dehalogenation of trichloroethene (TCE) and tetrachloroethene (PCE) (Howard, 1990).

When released to soil, 1,2-DCE will either evaporate or leach to the groundwater. Adsorption to soil and sediment particles is low and biodegradation in soil and groundwater is slow. The greatest removal mechanism of 1,2-DCE from soils and waters is through volatilization (Howard, 1990).

Benzene. Benzene (C_6H_6) may enter the environment as result of the production, storage, transport, venting, and combustion of gasoline, as well as, the production, transport and storage of benzene as a pure product. Benzene is also natural by-product of forest fires (Howard, 1990).

Benzene is highly volatile, and is highly mobile in soil. If released to the soil, benzene will evaporate or leach from the soil to the groundwater. Biodegradation of benzene is likely in shallow aerobic waters, though not under anaerobic conditions. Abiotic degradation is largely limited to benzene present in the atmosphere. Hydrolysis is an insignificant mechanism for the breakdown of benzene (Howard, 1990).

Vinyl chloride. The predominant use of vinyl chloride (C_2H_3CL) is in the plastics industry for the production of polyvinyl chloride (PVC). Vinyl chloride

is also a breakdown product resulting from the biodegradation of other chlorinated solvents such as TCE, PCE, and 1,2-DCE.

Vinyl chloride has a relatively high vapor pressure and should readily volatilize from dry soil. However, vinyl chloride is also readily soluble and may be leached through the soil by atmospheric waters and enter the groundwater water (ATSDR, 1991a). Vinyl chloride will biodegrade within groundwater but the rate is highly dependant upon microbial communities and general water chemistry (eg. aerobic versus anaerobic conditions).

SVOCs

Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate (also known as di(2-ethylhexyl)phthalate) ($C_{24}H_{38}O_4$) is principally used as a plasticizer in the production of PVC and vinyl chloride resins. PVC is used in many common household items such as toys, vinyl upholstery, shower curtains, adhesives, and as a component of paper and paperboard. Bis(2-ethylhexyl)phthalate has also been used as a solvent, an acaracide in orchards, and as an inert ingredient in pesticide products (ATSDR, 1993).

Bis(2-ethylhexyl)phthalate is a widely used chemical that enters the environment primarily through the disposal of industrial and municipal wastes in landfills. Bis(2-ethylhexyl)phthalate tends to adsorb strongly to soil and sediments and to bioconcentrate in aquatic organisms. Sorption, bioaccumulation, and biodegradation are likely to be competing processes, with the dominant fate being determined by local environmental conditions (ATSDR, 1993).

Bis(2-ethylhexyl)phthalate has a strong tendency to be adsorbed to atmospheric particulate matter, soils, and sediments. Bis(2-ethylhexyl)phthalate biodegradation in soil is slow since strong adsorption reduces the availability for degradation. Biodegradation is expected to occur under aerobic conditions. Bis(2-ethylhexyl)phthalate may slowly volatilize into air. In air, direct photolysis and photooxidation are not likely (ATSDR, 1993).

Bis(2-ethylhexyl)phthalate is relatively insoluble; however, it may leach to the groundwater in the presence of common organic solvents such as alcohols and ketones. Bis(2-ethylhexyl)phthalate in the water will undergo biodegradation under aerobic conditions. Chemical hydrolysis occurs too slowly to be important (ATSDR, 1993).

PAHs. A total of thirteen PAHs was identified as CPCs (2-methylnaphthalene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) at Site 11. PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. PAHs can either be manmade or occur naturally. A few of the PAHs are used in medicines and to make dyes, plastics, and pesticides, while others are contained in asphalt used in road construction. There are more than 100 different PAH compounds (ATSDR, 1993).

In air, PAHs are found sorbed to particulates and as gases. Particle-bound PAHs can be transported long distances and are removed from the atmosphere through precipitation and dry deposition. PAHs are transported in surface waters by volatilization and sorption to settling particles. The compounds are transformed

in surface waters by photooxidation, chemical oxidation, and microbial metabolism. Sorption of PAHs to soil and sediment increases with increasing organic content and is also directly dependant upon particle size. Microbial metabolism is the major process for degradation of PAHs in soil environments. PAHs have relatively low solubilities, but if transported through soils by either leaching or colloidal movement, PAHs can enter groundwater and be transported within an aquifer (ATSDR, 1993).

Pesticides

4,4'-DDT and 4,4'-DDD. 4,4'-DDT (DDT) and its primary metabolites, 4,4'-DDE (DDE) and 4,4'-DDD (DDD), are manmade chemicals and are not known to occur naturally in the environment. Most releases of the chemicals are related to their manufacture and use as insecticides in agriculture and vector control. Pesticidal use of DDT, except in public health emergency, was banned in the United States in 1972. Due to the extensive past use of DDT worldwide and the persistence of DDT and its metabolites, these materials are virtually ubiquitous and are continually being transformed and redistributed in the environment (ATSDR, 1992).

DDT, DDE, and DDD are only slightly soluble in water. Therefore they are not easily displaced from their site of application, nor do they tend to leach to groundwater. Appreciable amounts of the compounds may remain in the soil for extended periods of time and are only readily moved by physical erosion of soil particles (ATSDR, 1992).

Four mechanisms have been identified as accounting for the most losses of DDT residues from soils: volatilization, removal by harvest of organic matter, water runoff, and chemical transformation. Photooxidation of DDT is known to occur on soil surfaces; however, it is not known to hydrolyze. Biodegradation may occur under both aerobic and anaerobic conditions in the presence of certain soil microorganisms (ASTDR, 1992).

Dieldrin. The pesticides aldrin and dieldrin were used, from the 1950s until the early 1970s, as insecticides on crops such as corn and cotton. The USDA canceled all uses of aldrin and dieldrin in 1970. However, aldrin and dieldrin were approved for killing termites by the USEPA in 1972. Use of aldrin and dieldrin to control termites continued until 1987. Aldrin is readily converted to dieldrin which is ubiquitous in the environment (ASTDR, 1991b).

Dieldrin is persistent in the environment because it is more resistant to biotransformation and abiotic degradation than aldrin; as a result, dieldrin is found in low levels in all media, even at a distance from the site of concentration. Transport of dieldrin in soils is minimal because it tends to bind tightly to soil; however, it can volatilize from soil. Most dieldrin found in surface water is the result of runoff from contaminated soil. The resistance of dieldrin to soil leaching generally precludes its migration into groundwater (ASTDR, 1991b).

Chlordane. Chlordane is a manmade chemical that was registered for use as a pesticide in the United States from 1948 to 1988. It was used mainly to stop termites in houses and was used on corn and other crops. In soil, chlordane will adsorb to the organic matter and volatilize slowly over time. It will not leach significantly, in general staying in the surface soil and potentially remain for

up to 20 years. Volatilization from soil is a major loss mechanism for chlordane; the rate will depend on such parameters as the soil organic content, water content, temperature, and relative humidity (ASTDR, 1988a).

Inorganic Analytes

Aluminum. Aluminum is the third most common element in the environment, though it is not generally found in elevated concentrations in groundwater. Aluminum is known to complex readily, however, and high concentrations present in groundwater are generally due to silt-sized particles of aluminum-containing compounds often present as clays or aluminum hydroxides. Complexing and polymerization of the most common valence state of aluminum, Al^{+3}, represents the predominant transport mechanism for aluminum in the environment.

Arsenic. Arsenic has two stable forms in solution in groundwater, arsenate (As^{5+}) and arsenite (As^{3+}). In groundwater, with pH ranging from 3 to 7, the monovalent arsenate anion $H_2AsO_4^-$ is the dominant form. Upon entering surface water, via groundwater discharge, arsenic may partition to sediment from solution by hydrous iron oxide adsorption and/or coprecipitation (or a combination of both) with sulfides in the sediment. The Eh and pH conditions of the surface water and sediment govern the effectiveness of these mechanisms (adsorption and coprecipitation) as a sink for arsenic. These mechanisms appear to be the major inorganic factors controlling arsenic concentrations in surface water (Hem, 1992).

Arsenic may be very mobile in the aquatic environment, cycling through the water column, sediment, biota, and air. Most arsenic released into the environment (on the earth's surface) eventually ends up either in sediments (in stream beds or lakes) or in the oceans. Eh and pH conditions largely govern the fate of arsenic (USEPA, 1979).

Iron. Iron is the second most abundant element in the environment. though dissolved concentrations present in groundwater are generally low. The chemical behavior of iron and its solubility depend upon the oxidation intensity and pH of the environmental system in which it is found. Iron exists in two valence states, Fe^{2+} and Fe^{3+}, with the Fe^{2+} or ferrous form the most common form of iron found in solution in the reducing conditions within the groundwater environment. Dissolved iron generally sorbs to sediment and may precipitate as iron hydroxide or may oxidize to form iron oxides and iron oxyhydroxides (USEPA, 1979). Iron also may complex with organic molecules, especially fluvic and humic acids. Aerated or flowing water with a pH in the range of 6.5 to 8.5 should contain little dissolved iron.

Lead. The accumulation of lead in most soils is primarily a function of the rate of deposition from the atmosphere. Most lead is retained strongly in soil, and very little is transported into surface water or groundwater. The fate of lead in soil is affected by the specific or exchange adsorption at mineral interfaces, the precipitation of sparingly soluble solid phases, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. These processes are dependant on such factors as soil pH, organic content of soil, the presence of inorganic colloids and iron oxides, ion-exchange characteristics, and the amount of lead in soil (ASTDR, 1988b).

The chemistry of lead in aqueous solutions is highly complex because this element can be found in a many forms. Lead has a tendency to form compounds of low solubility with major anions of natural water. In the natural environment, the divalent form (Pb^{2+}) is the stable ionic species of lead. Hydroxide, carbonate, sulfide, and, more rarely, sulfate may act as solubility controls in precipitating lead from water. The amount of lead that remains in the solution depends upon the pH of the water and the dissolved salt content (ASTDR, 1988b).

Manganese. Manganese is a naturally occurring element found in soil, lakes, streams, and food. Manganese does not occur in the environment as a pure metal, but is found combined with other chemicals like oxygen, sulfur, and chlorine. Elemental manganese and inorganic manganese compounds have negligible vapor pressures, but exist in air as suspended particulate matter derived from industrial emissions or the erosion of soils. Manganese is often transported in rivers as suspended sediment. The metal may exist in any of four oxidation states (2+, 3+, 4+, or 7+). Mn+2 is the most common form found in water with a pH between 4 and 7, but manganese may oxidize at a pH greater than 8. The transportation of manganese in water is controlled by the solubility of the specific chemical form present and the characteristics of available anions (ATSDR, 1990).

Silver. The major source of elevated silver levels in cultivated soils is from the application of sewage sludge and sludge effluents as agricultural amendments. Additional anthropogenic sources of silver in soil include atmospheric deposition and landfilling of household refuse or industrial wastes (ASTDR, 1989).

The mobility of silver in soils is affected by drainage (silver tends to be removed from well-drained soils), oxidation-reduction potential and pH conditions, and the presence of organic matter (which complexes with silver and reduces its mobility). Silver tends to form complexes with inorganic chemicals and humic substances in soils. Silver is toxic to soil microorganisms and inhibits bacterial biodegrative enzymes; therefore, biotransformation is not expected to be a significant process in the transformation and degradation of silver (ASTDR, 1989).

Thallium. Thallium is soluble over a wide range of oxidizing conditions but in reducing conditions, it precipitates to the metal form, and in the presence of sulfur, to an insoluble sulfide. Under high oxidizing conditions, thallium precipitates in the oxide or hydroxide form and settles into bed sediments.

The most common fate processes affecting thallium are adsorption and bioaccumulation. The ionic radius of thallium is similar to that of lead; thus, the fate of thallium in the environment is believed to be similar to that of lead (USEPA, 1979). Thallium may be strongly adsorbed by montmorillonite clay; thus, sediment is an active sink for thallium in the environment. The adsorption of thallium to clay particles is pH demandant. Adsorption is more effective under alkaline conditions rather than acidic conditions.

Thallium also may remain in solution in aerobic environments and is known to bioaccumulate.

Zinc. Zinc is a natural element found in soil. Zinc is also deposited in soils by atmospheric deposition. It is released to the atmosphere as dust and fumes from zinc production facilities, lead smelters, brass works, automobile

emissions, fuel combustion, incineration, and soil erosion. Zinc occurs in the environment in the +2 oxidation state. The relative mobility of zinc in soil is determined by the solubility of the compound, soil type, and pH and salinity of the soil (ASTDR, 1988c).

8.2.3 Transport of Contaminants This section discusses the transport of chemicals in various media at Site 11. All media, surface soil, subsurface soil, surface water, sediment, and groundwater will be discussed.

Surface Soil. Transport of the CPCs in soil is dependent on several factors, as discussed in Section 8.1. The primary agents of migration acting on soil include wind, water, and human activity. Soil can also act as a source medium from which the CPCs are transported to other media. Transport of the CPCs from soil via wind is not expected to be a major transport mechanism because of the vegetation present at Site 11. Vegetative cover is an effective means of limiting wind erosion of soil. Humans are effective at moving soil and can greatly affect the transport of soil-bound chemicals at hazardous waste sites. Under the current use of Site 11, human activity is not a major transport mechanism for the CPCs in soils. This condition may change based on the future use of Site 11.

Water can cause the transport of soil and, therefore, the CPCs in soil, via the mechanisms of physical transport of soil or the leaching of constituents from the soil to groundwater. Soil erosion, the physical transport of soil via surface water runoff, is currently not considered a major mechanism for the transport of the CPCs in soil at Site 11 because of (1) the low grade (slope) of the land surface at the site, (2) the vegetation at the site, and (3) the nature of the constituents remaining in the soil at the site.

The majority of the analytes detected in the soil at Site 11 are likely to remain attached to the soil because most metal analytes adsorb readily to or are natural constituents of clays and other minerals.

Surface Water. There are no permanent surface water bodies associated with Site 11. The "Y" drainage ditch is located approximately 80 feet south of site; however, off-site migration of site-related surface soil constituents to the ditch is unlikely because the topography of Site 11 gently slopes toward the east-northeast. During the 1986 verification study, a low point was observed in the northeastern corner where surface drainage ponds (Geraghty & Miller, 1986). Although ponding was not observed during the 1995 site characterization survey, it is expected that any runoff from the site would migrate in a northeasterly direction toward Big Coldwater Creek, which is located approximately 1.7 miles from Site 11.

Currently, transport of the CPCs at Site 11 via runoff is not considered an important transport mechanism because of (1) the low slope of the land surface at the site, (2) high infiltration capacity of soil at the site, (3) the heavy vegetation at Site 11, and (4) the tendency of the surface soil contaminants at the sites to remain attached to clays in the soil.

Sediment. The transport of sediment at Site 11 by the action of humans is not currently a significant transport mechanism. Little or no surficial erosion is likely due to vegetative cover and low topographic slope. Surficial drainage from the site is away from the "Y" ditch; therefore, the site is unlikely to impact the sediment within the ditch.

Groundwater. Both VOCs (vinyl chloride and 1,2-DCE) and inorganics were identified as CPC at Site 11. Given the low concentrations of the detected VOCs, it is likely that they are present as a dissolved phase. As such the transport and distribution of these compounds will be determined by groundwater flow and affected by dispersion, diffusion, retardation, and degradation. However, as discussed in Section 5.5, the observed concentrations of the inorganics in unfiltered groundwater at Site 11 were affected by turbidity in the groundwater samples at the time of collection. The groundwater samples collected in 1996 (during Phase IIB) are thought to be more representative of groundwater conditions at the site. It is probable that particulate material of larger than colloidal sizes does not easily move through the matrix of the aquifer. Colloid-sized material may be transported through the aquifer matrix at flow rates present in the surficial aquifer system at Site 11.

Hydrogeology at Site 11 is discussed in Section 5.6 of this report. The aquifer present at the site is the surficial (sand and gravel) aquifer. The CPCs identified for groundwater are associated with the surficial aquifer system. Recharge of the surficial aquifer at Site 11 occurs primarily by rainfall on the site and in the area north of the site. Groundwater flow direction in the surficial aquifer at Site 11 is primarily to the southeast. Big Coldwater Creek acts as a point of discharge approximately 9,000 feet east-southeast of the site.

Hydraulic data from the well clusters (WHF-11-4S/WHF-11-4D and WHF-13-1S/WHF-13-1I) completed at and downgradient of the site indicate that vertical gradient in this area is downward. The upper 100 to 150 feet of soils at Site 11 consist of sand and interlayered sand and clay. At least two significant (greater than 5 feet in thickness) clay layers have been encountered across the site. One or both clay layers may not be laterally continuous and may or may not represent a significant confining layer across the Southeast Disposal Area.

Horizontal hydraulic gradient estimates have been developed for the Site 11 area. The gradient was calculated for the period between September 1993 and November 1996 and averaged (Table 5-2). The average hydraulic gradient in the surficial aquifer is 0.0029 ft/ft in a southeasterly direction.

Hydraulic conductivity testing was successfully completed on monitoring wells WHF-11-3, WHF-13-2S, and WHF-14-2 across the Southeast Disposal Area. The average hydraulic conductivity value for the site is 0.0067 feet per minute or 9.65 ft/day (Table 5-4).

Horizontal groundwater seepage velocity calculations have been completed for the surficial aquifer system at Site 11 using available hydraulic information (Section 5.6). An average seepage velocity of 27 ft/yr was calculated using the seepage velocities for wells at sites across the Southeast Disposal Area. Disposal activities at Site 11 may have begun releasing contaminants to the aquifer approximately 50 years ago. Using the seepage velocity calculated above and a 50-year timeframe, the total distance of potential contaminant migration is estimated to be approximately 1,350 feet. It should be noted that slug tests provide an approximate estimate of hydraulic conductivity that can be more accurately measured using pumping tests. Slug test data may differ by up to a factor of 10 (Bouwer and Rice, 1989). Therefore, the value of 1,350 feet should be viewed as an estimate. In addition to potential variations in hydraulic conductivities along potential migration pathways, the physical processes of dispersion and diffusion, as wells as chemical degradation, dilution, and retardation, may greatly influence fate and transport contaminants released into the groundwater at Site 11.

CHAPTER 9.0

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS. The following is a summary based on the RI investigations at Site 11, Open Disposal Area (B), NAS Whiting Field.

- Interpretation of the geophysical survey suggested the presence of a single well-defined landfill boundary and three additional smaller anomalies likely caused by surface ferromagnetic metal lying on or near the ground surface.

- Methane and TVOCs were detected at 2 of the 46 soil gas locations investigated. At these locations, methane accounted for 58 percent and 100 percent of the total gas measurement. However, the occurrence of soil gas appears to be limited in areal extent and there is no evidence of off-site migration.

- Surface soil samples were reported to contain one VOC, fourteen semivolatile organic compounds (SVOCs), and nine pesticide compounds. However, only concentrations of two SVOCs (benzo(a)pyrene and benzo(a)-anthracene) and one pesticide compound (dieldrin) were detected at concentrations exceeding either the USEPA Region III RBCs or their Florida soil cleanup goals. The location of the benzo(a)pyrene and benzo(a)anthracene exceedances was excavated in June 1999 as part of a source removal action.

- Twenty-three inorganic analytes were detected in the surface soil. Aluminum, arsenic, iron, manganese, and lead were detected in one or more samples in excess of either or both the applicable USEPA Region III risk-based concentrations (RBCs) or the Florida soil cleanup goals for residential soil.

- Subsurface soil samples were reported to contain three VOCs, one SVOC, five pesticides, and two PCB compounds. However, none of the organic compounds were detected at concentrations exceeding the USEPA Region III RBCs or Florida soil cleanup goals.

- Nineteen inorganic analytes were detected in the subsurface soil samples. Concentrations of aluminum, beryllium, iron, and manganese in samples exceeded one or more of the USEPA Region III residential or industrial RBCs, or the Florida soil cleanup goals.

- All of the pH values except one reported for groundwater samples collected at Site 11 were outside the range of Florida Secondary Drinking Water Standards. However, all of the values except two were within the range observed in background samples collected at NAS Whiting Field.

- Four VOCs and two SVOCs were detected in groundwater samples from monitoring wells at Site 11. The detected concentrations of two of the VOCs (vinyl chloride and benzene) exceeded the Florida groundwater guidance concentrations for these compounds. No SVOCs, pesticides, or PCBs were detected in groundwater samples at concentrations exceeding the Florida groundwater guidance concentrations or Federal MCLs.

Seventeen inorganic analytes were detected in the Phase IIB groundwater samples. Three inorganic analytes (aluminum, iron, and manganese) were detected at levels that exceeded their respective Florida groundwater guidance concentrations and Federal MCLs.

- At Site 11, the groundwater flow direction is toward the southeast across the site and likely discharges to Big Coldwater Creek. Big Coldwater Creek is located approximately 9,000 feet downgradient of the site. The average horizontal hydraulic gradient for the site area is 0.0029 ft/ft. The geometric mean for the hydraulic conductivity data of monitoring wells in the site area was 8.38 ft/day, and the average seepage velocity value was 0.074 ft/day.

- The Human Health Risk Assessment for Site 11 identified six polynuclear aromatic hydrocarbons (benzo(a)anthracene, benzo(a)pyrene, benzo(b)-fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene), one pesticide compound (dieldrin), and three inorganic analytes (arsenic, iron, and lead) as the HHCPCs for surface soil at Site 11. No analytes were selected as HHCPCs for subsurface soil. In groundwater samples, three VOCs (1,2-dichloroethene, benzene, vinyl chloride), one SVOC (bis(2-ethylhexyl)phthalate), and five inorganic analytes (aluminum, arsenic, iron, manganese, and thallium) were identified as HHCPCs.

- The HHCPCs detected in surface soil, subsurface soil, and groundwater do not pose unacceptable carcinogenic risks to the evaluated receptors based on USEPA target risk range of 1×10^{-4} to 1×10^{-6}.

- The total ELCR at Site 11 associated with ingestion of soil by a hypothetical future resident (7×10^{-5}) exceeds Florida's target risk level of concern (1×10^{-6}) due to benzo(a)pyrene and arsenic. The total ELCR at Site 11 associated with ingestion of groundwater by hypothetical future resident (9×10^{-5} exceeds Florida's target level of concern due to vinyl chloride and arsenic.

- The surface soil, subsurface soil, and groundwater noncancer risks are at or below USEPA and FDEP target levels for all potential current and hypothetical future receptors.

- Risks associated with exposures to ECPCs in Site 11 surface soil were evaluated for terrestrial wildlife. Based on the results of the food-web model, lethal risks to terrestrial wildlife at Site 11 are not predicted.

- Sublethal risks to terrestrial wildlife associated with ingestion of pesticides and lead in surface soil and food items were identified; however, elevated concentrations of 4,4'-DDD and lead are localized in the immediate area surrounding sampling location 11-SL-02. Sublethal risks to small mammals and birds appear to be localized to location 11-SL-02 while impacts to top predator populations are predicted over the entire area of Site 11.

- The ERA concluded that growth and reproduction of small mammal and bird populations may be impacted in the area near sample location 11-SL-02,

while sublethal impacts to top predator populations are likely over the entire area of Site 11. In addition, the survival of terrestrial invertebrates and consequent abundance for foraging mammals and birds may be impacted from contaminants detected at surface soil location 11S00201 due to TPH and 4,4'-DDT.

9.2 RECOMMENDATIONS. Based upon the interpretation of findings from the remedial investigation activities, a FS is recommended for Site 11 to evaluate potential strategies for the reduction in human health and ecological risks associated with surface soil at the site. In addition, the presence of vinyl chloride in Site 11 groundwater samples at concentration exceeding Florida's target risk level indicates that additional sampling and remedial measures may be required. However, all groundwater contamination issues, including soil leaching, will be addressed as part of the current remedial investigation for the facilitywide groundwater study (Site 40).

CHAPTER 10.0

10.0 PROFESSIONAL REVIEW CERTIFICATION

The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures and protocols consistent with applied standards of practice. This report is based on the geologic investigation and associated information detailed in the text and appended to this report. If conditions are discovered or determined to exist that differ from those described, the undersigned geologist should be notified to evaluate the effects of any additional information on the assessment described in this report. The remedial investigation for Site 11, Southeast Open Disposal Area (B) (Landfill) was developed for NAS Whiting Field in Milton, Florida, and should not be construed to apply for any other purpose to any other site.

Eric A. Blomberg
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3-2-00
Date

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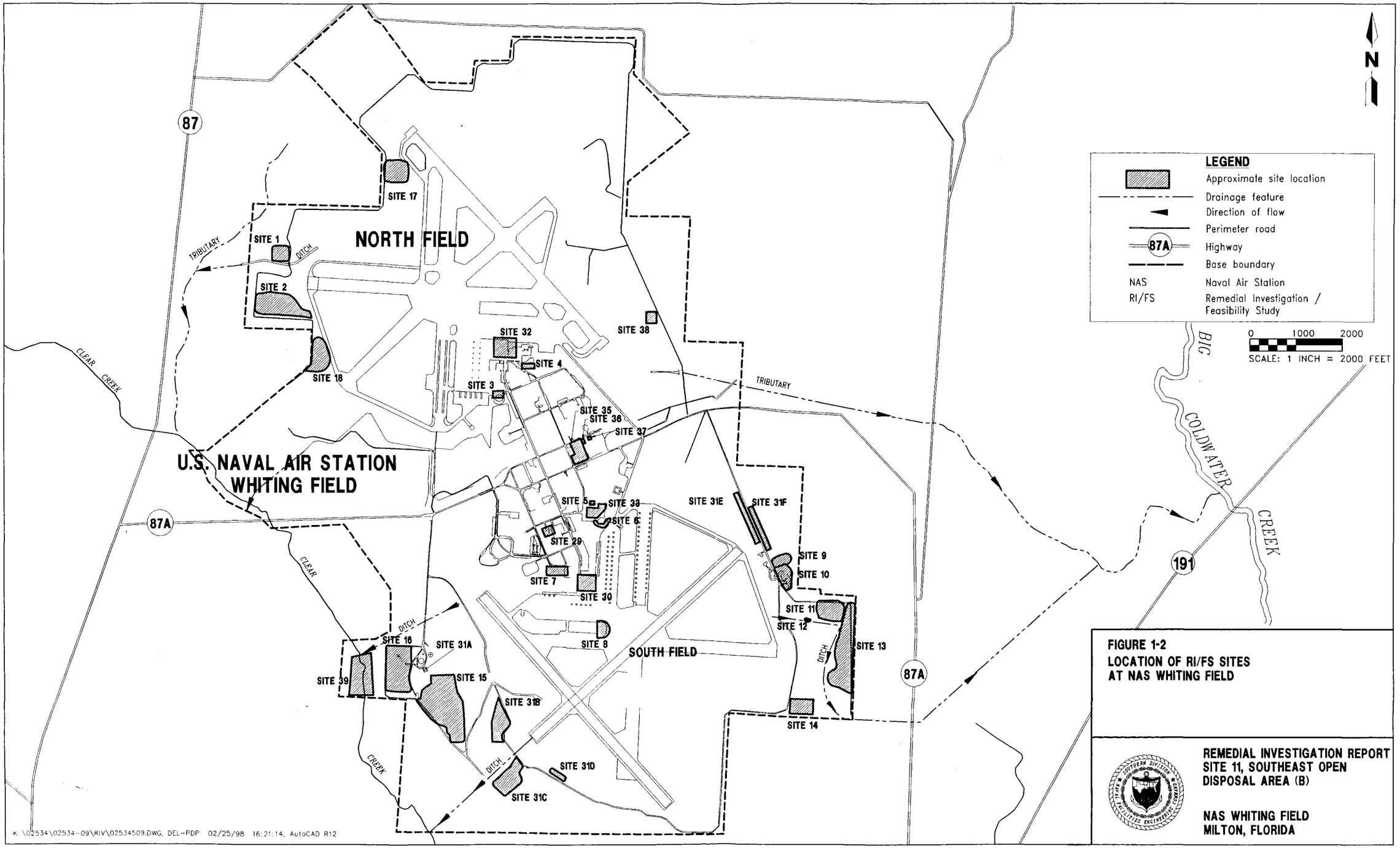

FIGURE 1-2
LOCATION OF RI/FS SITES AT NAS WHITING FIELD

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SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

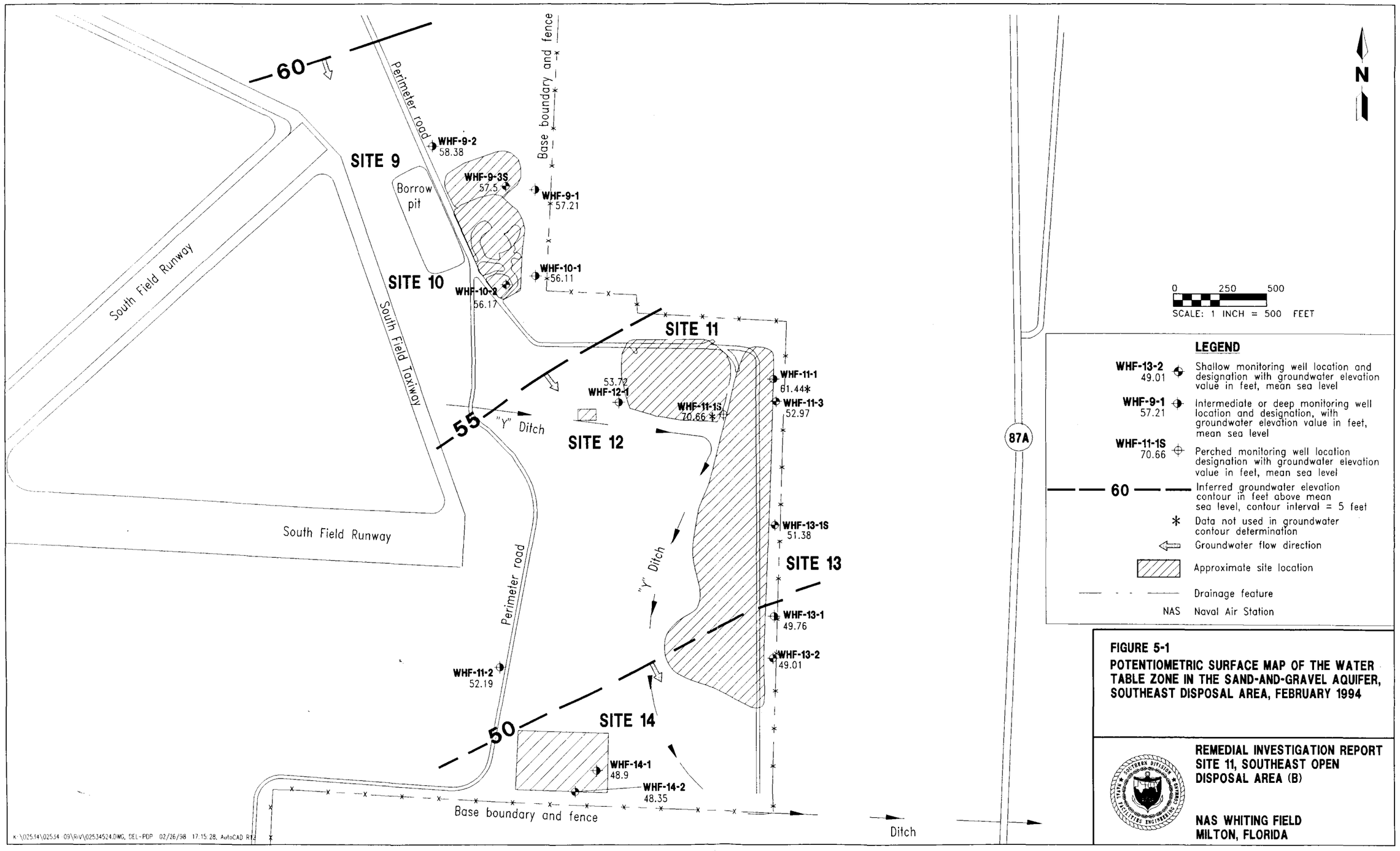

FIGURE 5-1
POTENTIOMETRIC SURFACE MAP OF THE WATER TABLE ZONE IN THE SAND-AND-GRAVEL AQUIFER, SOUTHEAST DISPOSAL AREA, FEBRUARY 1994

REMEDIAL INVESTIGATION REPORT
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MILTON, FLORIDA

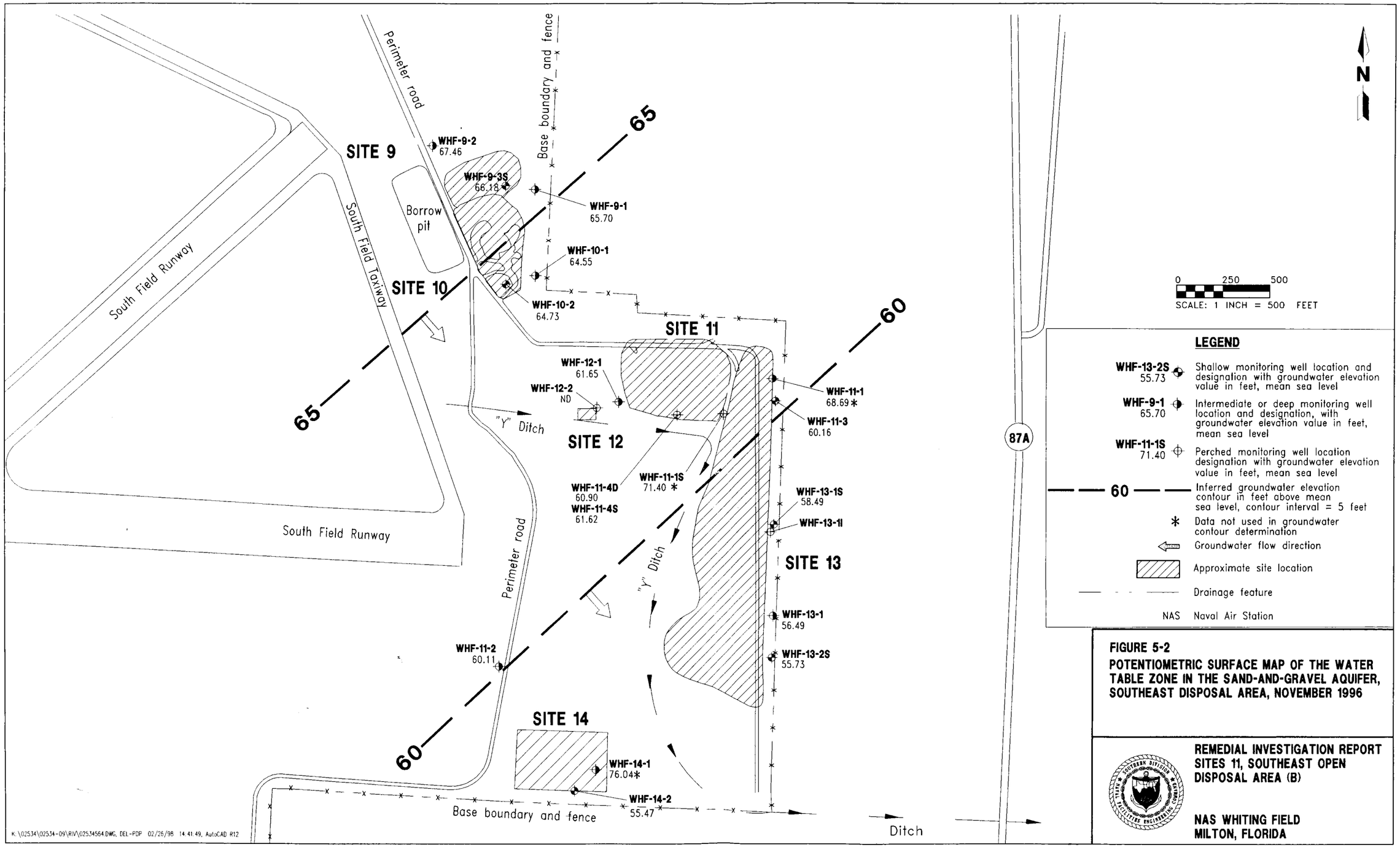

FIGURE 5-2
POTENTIOMETRIC SURFACE MAP OF THE WATER TABLE ZONE IN THE SAND-AND-GRAVEL AQUIFER, SOUTHEAST DISPOSAL AREA, NOVEMBER 1996

REMEDIAL INVESTIGATION REPORT SITES 11, SOUTHEAST OPEN DISPOSAL AREA (B)

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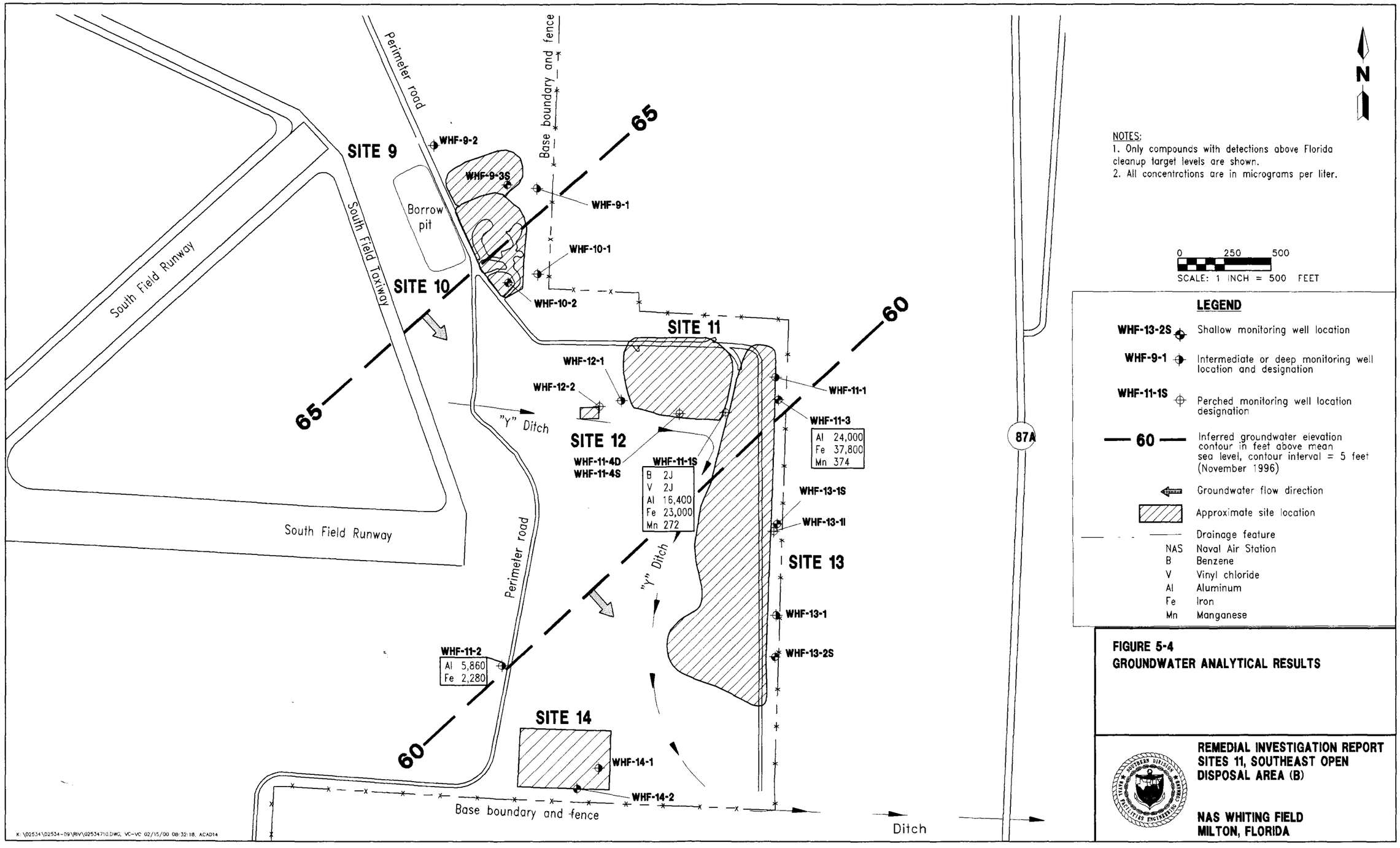

FIGURE 5-4
GROUNDWATER ANALYTICAL RESULTS

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SITES 11, SOUTHEAST OPEN DISPOSAL AREA (B)

NAS WHITING FIELD
MILTON, FLORIDA

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