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NAS WHITING FIELD
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BASELINE RISK ASSESSMENT WORK PLAN OPERABLE UNITS 3 (OU3), 4 (OU4), 5 (OU5), AND 6 (OU6) NAS WHITING FIELD FL

5/1/1996

ABB ENVIRONMENTAL

BASELINE RISK ASSESSMENT WORKPLAN
OPERABLE UNITS 3, 4, 5, AND 6

NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA

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

MAY 1996

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

ID 00217

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OPERABLE UNITS 3, 4, 5, AND 6

NAVAL AIR STATION WHITING FIELD
MILTON, FLORIDA

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

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May 1996

CERTIFICATION OF TECHNICAL DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., 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: May 9, 1996

NAME AND TITLE OF CERTIFYING OFFICIAL: Terry Hansen, P.G.
Task Order Manager

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Project Technical Lead

(DFAR 252.227-7036)

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 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, 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, and
- remedial design and remedial action.

The Southern Division, Naval Facilities Engineering Command manages and the U.S. Environmental Protection Agency and the Florida Department of Environmental

Protection (FDEP; formerly Florida Department of Environmental Regulation [FDER]) oversee the Navy's 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 Mr. Jeff Adams, 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 as part of the Department of Defense Installation Restoration (IR) program. The IR program was designed to identify and abate or control contamination migration resulting from past operations at naval facilities. As part of the RI/FS, a baseline risk assessment is required to assess the human health and ecological risks at the facility.

Originally to facilitate the RI/FS investigation and any remediation actions undertaken at the facility, operable units (OUs) were defined at NAS Whiting Field. The OUs that were to be addressed in the Baseline Risk Assessment Workplan are identified below.

OU 3,	Northwest Disposal and Crash Crew Training Area
OU 4,	Southwest Disposal Area
OU 5,	Southeast Disposal Area
OU 6,	Sludge Drying Beds

Since the writing of the draft of the Baseline Risk Assessment Workplan, Operable Units 3, 4, 5, and 6, Naval Air Station Whiting Field, there has been a redirection in approach to site investigation and remedial activities. The NAS Whiting Field partnering group consisting of the U.S. Environmental Protection Agency, State of Florida, and Navy, reevaluated site priorities based on perceived site risks and available funds. The draft workplan grouped investigative and remedial activities by OU instead of by site. The reevaluation of activities by site will substantially alter the flow of work.

It has been agreed by the partnering groups that this document will only specify investigative and remedial activities by OU. Site-specific workplan addenda may be prepared as needed to clarify investigative or remedial activities, such as, changes in sampling numbers and locations.

The purpose of the workplan is to provide information on the methods to be used for assessing human health and ecological risks associated with OUs 3, 4, 5, and 6. The workplan identifies the methodology that will be used in the selection of contaminants of potential concern, exposure assessment, toxicity assessment, and risk characterization in the baseline risk assessments for each OU.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
AFFF	aqueous (nontoxic) film-forming foam
AQUIRE	USEPA Aquatic Information Retrieval database
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registration
AVGAS	aviation gasoline
AWQC	Federal Ambient Water Quality Criteria
BERA	baseline ecological risk assessment
BRAs	baseline risk assessments
BW	body weight
C	chemical concentration, media specific
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor, media specific
CLP	Contract Laboratory program
CPC	contaminant of potential concern
CR	contact rate, media specific
CSF	cancer slope factors (USEPA)
DDT	4,4'-dichlorodiphenyltrichloroethane
DOD	Department of Defense
ECPC	ecological contaminants of potential concern
ED	exposure duration, population specific
EF	exposure frequency, population specific
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
ERA	ecological risk assessment
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FGS	Florida Geological Survey
FNAI	Florida Natural Areas Inventory
HEAST	Health Effects Assessment Summary Tables (USEPA)
HHCPC	human health chemicals of potential concern
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IAS	initial assessment study
IR	installation restoration

GLOSSARY (Continued)

IRIS	Integrated Risk Information System
LC	lethal concentration
LOEC	lowest observed effect concentration
MCL	maximum contaminant level
μg	microgram
$\mu g/\ell$	micrograms per liter
mg	milligram
mg/cm^2	milligrams per centimeter squared
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
NACIP	Naval Assessment and Control of Installation and Pollutants
NAS	Naval Air Station
NAVFAC-ENGCOM	Naval Facilities Engineering Command
NEESA	Naval Energy and Environmental Support Activity
NOEC	no observed effect concentration
NWFWMD	Northwest Florida Water Management District
OFW	Outstanding Florida Water
OU	operable unit
PARCC	precision, accuracy, representativeness, comparability and completeness
PA	preliminary assessment
PCBs	polychlorinated biphenyls
QA/QC	Quality Assurance/Quality Control
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RGOs	remedial goal options
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
RTVs	reference toxicity values
SARA	Superfund Amendments and Reauthorization Act
SI	site inspection
SOUTHNAVFAC-ENGCOM	Southern Division, Naval Facilities Engineering Command
SQL	sample quantitation limit
SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
TPH	total petroleum hydrocarbon

GLOSSARY (Continued)

TRAWING FIVE	Training Air Wing Five
UCL	upper confidence level
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), and as directed in Executive Order 12580 of January 1987, the Department of Defense (DOD) is conducting an installation restoration (IR) program for evaluating and remediating problems related to releases and disposal of toxic and hazardous materials at DOD facilities. The Navy Assessment and Control of Installation Pollutants (NACIP) program was developed by the Navy and has been modified to implement the IR program for all Navy and Marine Corps facilities.

The NACIP program was originally conducted in three phases: (1) Phase I, Initial Assessment Study (IAS); (2) Phase II, Confirmation Study (including a verification step and a characterization step); and (3) Phase III, Planning and Implementation of Remedial Measures. The three-phase Remedial Investigation (RI) program was modified in 1987-88 to be consistent with CERCLA and SARA. The updated nomenclature for the remedial investigation and feasibility study (RI/FS) process is as follows:

- preliminary assessment and site inspection,
- remedial investigation,
- feasibility study, and
- planning and implementation of remedial design.

In addition to these programs, military facilities are subject to regulations promulgated by the 1976 Resource Conservation and Recovery Act (RCRA) and the 1984 Hazardous and Solid Waste Amendments. Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) has the responsibility for administration of the Navy IR program in the southeastern United States.

This workplan provides information on the methods to be used for assessing human health and ecological risks associated with Operable Units (OUs) 3, 4, 5, and 6 at Naval Air Station (NAS) Whiting Field, Milton, Florida. The workplan identifies the methodology that will be used in the selection of contaminants of potential concern (CPCs), exposure assessment, toxicity assessment, and risk characterization in the baseline risk assessments (BRAs) for each OU. Since the writing of the draft of the BRA Workplan, Operable Units 3,4,5, and 6 Naval Air Station Whiting Field, there has been a redirection in approach to site investigation and remedial activities. The NAS Whiting Field partnering group consisting of the U.S. Environmental Protection Agency (USEPA), State of Florida, and Navy, reevaluated site priorities based on perceived site risks and available funds. The draft workplan grouped investigative and remedial activities by OU instead of by site. The reevaluation of activities by site will substantially alter the flow of work.

It has been agreed by the partnering groups that this document will only specify investigative and remedial activities by OU. Site-specific workplan addenda may be prepared as needed to clarify investigative or remedial activities, such as, changes in sampling numbers and locations.

This Risk Assessment Workplan is organized into the following chapters:

- Background and Physical Setting (Chapter 2.0),
- OUs 3, 4, 5, and 6 Site Descriptions (Chapter 3.0),
- Public Health BRA Methodology (Chapter 4.0), and
- Ecological BRA Methodology (Chapter 5.0).

2.0 BACKGROUND AND PHYSICAL SETTING

This chapter briefly summarizes the available data with regard to the physical setting at NAS Whiting Field.

2.1 LOCATION. NAS Whiting Field is located in Florida's northwest coastal area approximately 7 miles north of Milton and 20 miles northeast of Pensacola (Figure 2-1). NAS Whiting Field currently consists of two air fields, North Field and South Field, separated by an industrial area and covers approximately 2,560 acres in Santa Rosa County. Figure 2-2 presents the installation layout and the location of the RI sites.

NAS Whiting Field, home of Training Air Wing Five (TRAWING FIVE), was constructed in the early 1940s. It was commissioned as the Naval Auxiliary Air Station Whiting Field in July 1943 and has served as a naval aviation training facility since that time. The field's mission has been to train student naval aviators in basic instruments; formation and tactic phases of fixed-wing, propeller-driven aircraft; and basic and advanced helicopter operation.

2.1.1 Topography NAS Whiting Field is located within the boundaries of the Northwest Florida Water Management District (NWFWMD), which encompasses the entire Florida panhandle. The topography of northwest Florida is the result of 25 million years of stream erosion, deposition, and wave action during periods when the shoreline exceeded its present level. NAS Whiting Field is located on a local upland area with elevations ranging approximately 35 to 200 feet above sea level.

2.1.2 Surface Hydrology NAS Whiting Field is located on a plateau that is bounded on the west and southwest by Clear Creek and to the northeast and east by Big Coldwater Creek (Figure 2-1). Clear Creek and Big Coldwater Creek are tributaries of the Blackwater River, which discharges to the estuarine waters of the East Bay of the Escambia Bay coastal system. Clear Creek has been designated as a Class III waterway by the Florida Department of Environmental Protection (FDEP); Class III waters are suitable for the propagation of fish and aquatic life and for body-contact recreation. Clear Creek has a drainage area of 24 square miles and an estimated annual discharge rate of 40 to 66 cubic feet per second (ABB Environmental Services, Inc. [ABB-ES], 1992a). Big Coldwater Creek has also been classified as a Class III stream, although the section of Big Coldwater Creek located within the Blackwater River State Forest (to the northeast of the installation) has been classified as an Outstanding Florida Water (OFW). FDEP has also ranked the Blackwater River as an OFW; no significant degradation of OFWs is permitted by FDEP. The drainage area for Big Coldwater Creek is 237 square miles with an average annual discharge rate of 500 to 600 cubic feet per second (ABB-ES, 1992a).

Because of the flat, open nature of the airfield and industrial facilities at NAS Whiting Field, an extensive storm drainage system exists. Flat-bottomed concrete swales carry stormwater runoff from the runway, support, and industrial areas of the installation to discharge points located in the floodplains of Clear Creek and Big Coldwater Creek. In addition, treated sewage effluent from the NAS Whiting Field Sanitary Waste Water Treatment Plant discharges to Clear Creek and its associated floodplain (ABB-ES, 1992b). With the exception of the Clear Creek

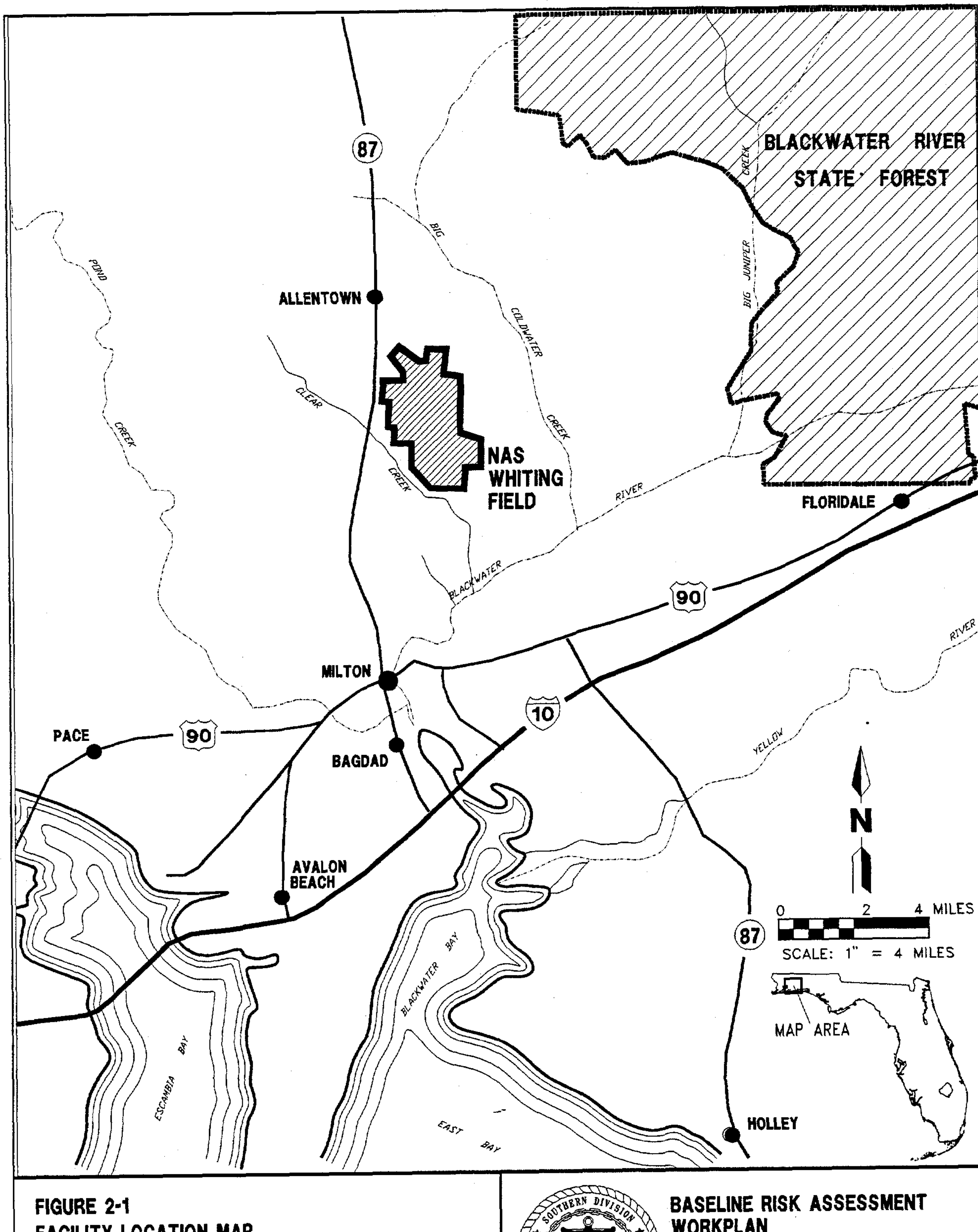

FIGURE 2-1
FACILITY LOCATION MAP

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BASELINE RISK ASSESSMENT WORKPLAN
OPERABLE UNITS 3,4,5, AND 6

NAS WHITING FIELD
MILTON, FLORIDA

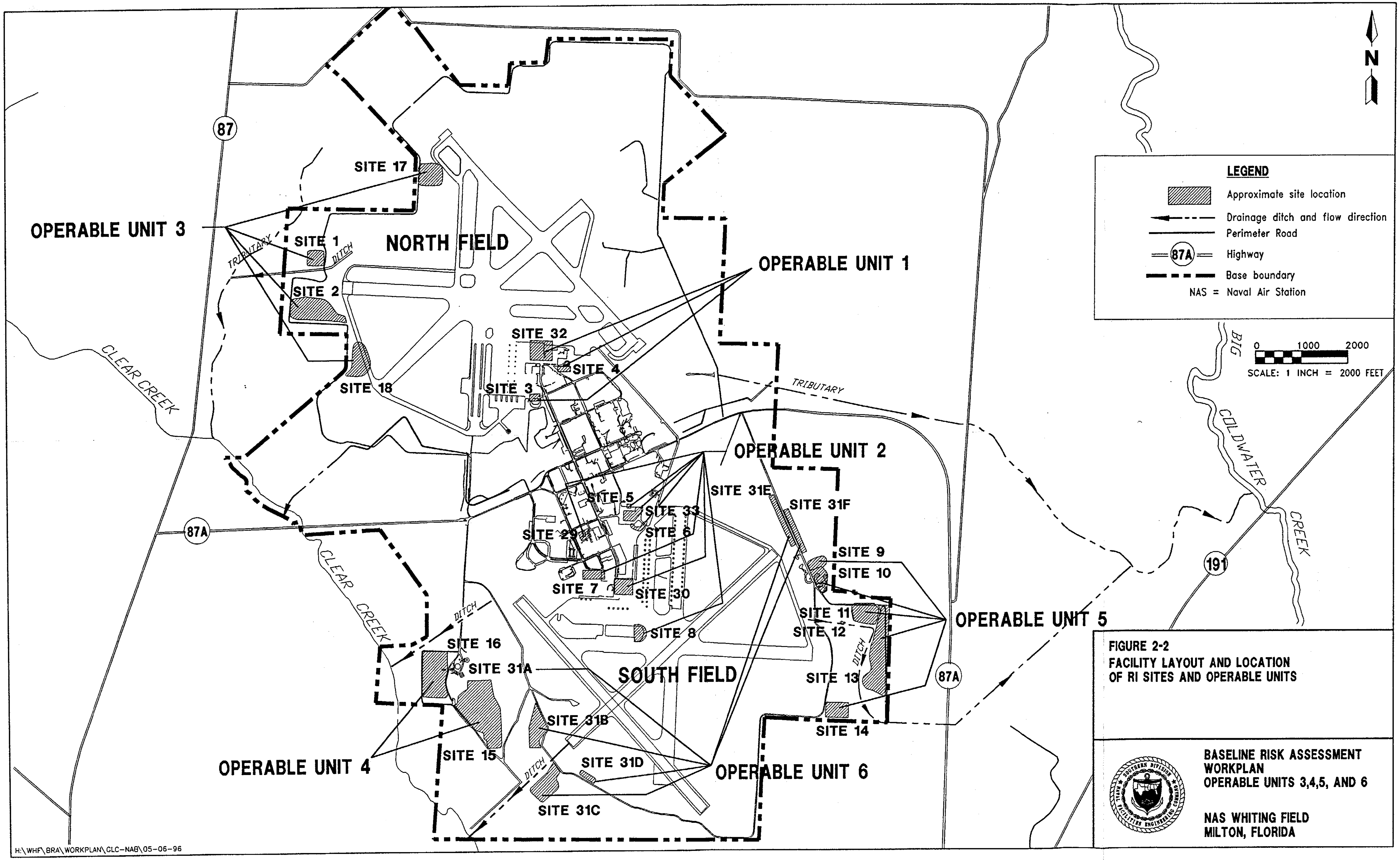

FIGURE 2-2
FACILITY LAYOUT AND LOCATION
OF RI SITES AND OPERABLE UNITS

BASELINE RISK ASSESSMENT
WORKPLAN
OPERABLE UNITS 3,4,5, AND 6

NAS WHITING FIELD
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floodplain, none of the identified disposal sites at NAS Whiting Field lie within the 100- or 500-year floodplain.

2.1.3 Regional Geology and Hydrogeology The majority of Santa Rosa County, including NAS Whiting Field, is located in the Western Highland subdivision of the Coastal Plain Physiographic Province, which is a major physiographic division of the United States that extends eastward from Texas to as far north as New York (Marsh, 1966). The Coastal Plain is primarily underlain by beds of sand, silt, clay, and limestone that gently dip toward the coast. Most of these sediments were deposited during periods of prehistoric sea level fluctuations. The Western Highland subdivision consists of a well-drained southward sloping plateau that has been eroded by numerous streams. Three marine shorelines can be recognized from existing topographic profiles across Escambia and Santa Rosa counties.

Groundwater in northwest Florida occurs within three major zones. These zones are referred to as aquifer systems and include: the surficial aquifer system (referred to as the sand-and-gravel aquifer in the western panhandle), the intermediate aquifer system, and the Floridan aquifer system (NWFWMD, 1982; Scott, 1992).

The Sand-and-Gravel Aquifer. The sand-and-gravel aquifer is the major water-bearing unit in Santa Rosa County and the only aquifer that has been studied to date in the IR program. The aquifer consists of a complex sequence of sand, gravel, silt, and clay believed to be between 200 and 350 feet thick in the vicinity of the installation (Musgrove, 1965). Water in the saturated zones of the sand-and-gravel aquifer is usually unconfined; therefore, the saturated zone is free to rise and decline with seasonal variation of precipitation (recharge) and discharge to stream valleys. The presence of interbedded clay layers often creates localized artesian conditions where the less permeable clay confines water within the aquifer below the clay layer. The confining unit restricts the vertical movement of water into or out of the aquifer zone. The water level or potentiometric surface of a confined aquifer is above the confining unit, and, if the potentiometric surface is higher than the land surface, the aquifer will flow as a spring or a well. In some areas, the aquifer may be subdivided into upper and lower zones, which are separated by layers of clay or clayey sand. These semiconfining layers typically allow the upper part of the aquifer to serve as the primary source of water to the more productive lower zone of the aquifer. Groundwater can also potentially move laterally along the semiconfining layers until it discharges into the local stream or other surface water features (NWFWMD, 1991; Scott, 1992).

Virtually all of the groundwater used in Santa Rosa County is drawn from the sand-and-gravel aquifer. The aquifer is recharged primarily by rainfall. The western Florida panhandle receives between 55 to 67 inches of rainfall per year (NWFWMD, 1988). Approximately 60 percent of the total volume of rainfall is returned to the water cycle by evapotranspiration before entering the aquifer systems. Rainfall is generally highest in the summer months and lowest in fall and winter. Water level readings generally correspond to the amount of rainfall received prior to the water level survey.

The groundwater flow direction of the sand-and-gravel aquifer at NAS Whiting Field appears to be to the south-southwest (toward Clear Creek) in the western half of the installation and to the southeast in the eastern half (ABB-ES, 1995).

The water quality of the sand-and-gravel aquifer is satisfactory for most uses because the concentrations of naturally occurring dissolved minerals are low due to the insolubility of the predominantly quartz sand through which the water migrates. However, as rainwater dissolves carbon dioxide in the atmosphere, carbonic acid is created that lowers the pH of the groundwater. The pH may fall as low as 5.0 in some areas, which may cause leaching of iron from sediments and result in high concentrations of iron in the groundwater (Florida Geological Survey [FGS], 1992).

The Intermediate Aquifer System. The intermediate aquifer system in Escambia and Santa Rosa counties is not significant due to a lack of aquifer material. The intermediate aquifer system generally equates to the Pensacola clay, and primarily functions as a confining layer between the sand-and-gravel and upper Floridan aquifer (Scott, 1992). In the vicinity of the installation, the upper Pensacola clay is absent, rendering the lower members (if present) indistinguishable from the sediment of the sand-and-gravel aquifer (Musgrove and others, 1965).

The Floridan Aquifer System. The Floridan aquifer system is present throughout the extent of the NWFWMD. The system is over 1,000 feet thick in the vicinity of the installation. In Santa Rosa and Escambia counties, the system consists of an upper and lower aquifer separated by a confining layer (the Bucatuna clay of the Byram Formation). The carbonate sequence containing the upper and lower Floridan aquifer system dips below the level of the Gulf of Mexico in the area and becomes saline. Additionally, the carbonate rock is highly soluble in the acidic groundwater, causing the water to be highly mineralized. Consequently, the aquifer is not commonly used as a source of water in the western part of the Florida panhandle (Scott, 1992).

2.1.4 Ecology To date, minimal characterization of the ecological setting of NAS Whiting Field has taken place in the IR program. The following paragraphs generally describe the terrestrial and aquatic habitats that comprise the natural areas of NAS Whiting Field. As part of the RI, a qualitative ecological survey will identify and verify major vegetative cover types and dominant taxa at the facility. The methodology for the qualitative ecological survey is described in Subsection 5.3.1 of this workplan.

2.1.4.1 **Terrestrial Cover Types** Much of the terrestrial habitat at NAS Whiting Field is a mesic upland pine-dominated community. This cover type is characterized by widely spaced longleaf pine (*Pinus palustris*) and includes slash pine (*Pinus elliotii*), water oak (*Quercus nigra*), laurel-leaved oak (*Q. laurifolia*), black cherry (*Prunus serotina*), largeleaf magnolia (*Magnolia grandiflora*), and various holly species (*Ilex* spp.). Greenbriar (*Smilax bona-nox*), blueberry (*Vaccinium arbutifolium*), poison ivy (*Toxicodendron radicans*), and bracken fern (*Pteridium aquilinum*) are also present.

Typical animals found in an upland pine forest include eastern fence lizard (*Sceloporus undulatus*), eastern diamondback rattlesnake (*Crotalus adamanteus*), bobwhite (*Colinus virginianus*), red-bellied woodpecker (*Melanerpes carolinus*), eastern fox squirrel (*Sciurus niger*), hispid cotton rat (*Sigmodon hispidus*), cotton mouse (*Peromyscus gossypinus*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), and white-tailed deer (*Odocoileus virginianus*) (Florida Natural Areas Inventory [FNAI], 1990).

Where the forest has been cleared for facility operations, the dominant cover type is grasslands. Open grasslands dominate the uplands in the vicinity of the north and south airfields.

2.1.4.2 **Aquatic and Wetlands Cover Types** NAS Whiting Field is bounded by low-lying receiving waters: Clear Creek located to the west and southwest, and Big Coldwater Creek located to the northeast and east. These two streams are tributaries of the Blackwater River, which discharges to the estuarine waters of the East Bay of the Escambia Bay coastal system. Runoff from individual sites discharges into the Clear Creek floodplain and to drainage ditches that flow into Clear Creek. Although the Clear Creek floodplain will be evaluated in a separate investigation, surface water bodies associated with the individual waste sites will be characterized during ecological field investigations.

2.1.4.3 **Wetland** Wetland exists at NAS Whiting Field in the Clear Creek floodplain located along the southwestern boundary of the facility. Floodplain wetland typically is not permanently inundated, but is subjected to frequent flooding. Two types of floodplain wetland communities were identified during a 1993 ecological field program at Clear Creek (ABB-ES, 1994): floodplain forest and floodplain swamp.

The floodplain forest cover type occurs on slightly drier soils within the floodplain. At NAS Whiting Field, the floodplain forest is dominated by buttressed woody vegetation, including tupelo (*Nyssa sylvatica*), red maple (*Acer rubra*), white cedar (*Chamaecyparis thyoides*), and sweet bay magnolia (*Magnolia virginiana*). Swamp titi (*Cyrilla racemiflora*) comprises a dense shrub layer, and several holly species (*Ilex* spp.), Virginia willow (*Itea virginica*), poison ivy (*Toxicodendron radicans*), royal fern (*Osmunda cinnamomea*), and chain fern (*Woodwardia areolata*) all occur regularly throughout the floodplain forest along Clear Creek.

The floodplain swamp cover type occurs on wetter, flooded soils in low spots, channels, and depressions within the Clear Creek floodplain. The floodplain swamp is associated with and grades into floodplain forest (ABB-ES, 1994). The floodplain swamp at NAS Whiting Field is dominated by buttressed woody vegetation, including tupelo and red maple. Swamp titi is the dominant member of the shrub community. Goldenclub (*Orontium aquaticum*), beggar ticks (*Bidens mitis*), marsh St. John's wort (*Triadenum virginicum*), an orchid (*Platanthera repens*), three-way sedge (*Dulichium arundinaceum*), and pipewort (*Eriocaulaon decangulare*) all occur in the substory of the NAS Whiting Field floodplain swamp.

Floodplain forests and swamps offer habitat to a variety of animals. Typical temporary and permanent residents include marbled salamander (*Ambystoma opacum*), gray treefrog (*Hyla chrysoscelis*), alligator (*Alligator mississippiensis*), black swamp snake (*Seminatrix pygaea*), yellow-crowned night-heron (*Nyctanassa violacea*), red-shouldered hawk (*Buteo lineatus*), woodcock (*Scolopax minor*), Carolina wren (*Thyrothorus ludovicianus*), red-eyed vireo (*Vireo olivaceus*), opossum (*Didelphis virginiana*), rice rat (*Oryzomys palustris*), and raccoon (*Procyon lotor*) (Florida Natural Areas Inventory, 1990).

2.2.4.4 **Rare, Endangered, and Threatened Species** Two State-listed plant species have been observed in the Clear Creek floodplain: the white-topped pitcher plant (*Sarracenia leucophylla*) and the water sundew (*Drosera intermedia*) (ABB-ES, 1994). These two species, as well as Florida anise-tree (*Illicum floridanum*), were also identified during a survey of rare, threatened, and endangered plants at NAS Whiting Field and nearby outlying landing fields (Environmental Protection Systems, 1991).

During the RI, trustee agencies including, but not limited to, the U.S. Fish and Wildlife Service, the Florida Department of Natural Resources, and the Florida Natural Areas Inventory will be contacted for information regarding State- or Federal-listed endangered or threatened species. Field investigations will also assist in identifying habitats likely to support any rare, endangered, and threatened species at the facility.

3.0 SITE HISTORY OF OPERABLE UNITS

NAS Whiting Field was constructed in the early 1940s and has served as a naval aviation training facility since 1943. The installation has generated a variety of wastes related to pilot training, operation and maintenance of aircraft with ground support equipment, and the station's facility maintenance activities. Prior to the establishment of programs to manage hazardous wastes and recycle waste oils, the majority of oil and hazardous materials used at NAS Whiting Field were reportedly disposed of onsite. Wastes dumped into onsite disposal areas included waste paints, paint thinners, solvents, waste oils, waste gasoline, hydraulic fluids, aviation gasoline (AVGAS), tank bottom sludges, polychlorinated biphenyls (PCBs), transformer fluids, and paint stripping wastewater (ABB-ES, 1992a). NAS Whiting Field disposal areas typically consisted of natural or man-made depressions located within the confines of the installation. In addition to the onsite disposal of materials into disposal areas, equipment failure and accidental releases of oil and hazardous materials have also occurred at NAS Whiting Field.

An IAS under the U.S. Navy's IR program identified 16 hazardous materials disposal or spill sites at NAS Whiting Field (Envirodyne Engineers, Inc., 1985). Subsequent studies resulted in the identification of an additional seven sites (ABB-ES, 1992b). The locations of the 23 sites at NAS Whiting Field are shown on Figure 2-2. The RI sites at NAS Whiting Field have been defined into OUs to facilitate site investigation and remedial activities. The OUs addressed in this workplan are detailed below.

3.1 OU 3, NORTHWEST PERIMETER ROAD SITES. OU 3 consists of four sites in an area west of the North Field. The sites include two disposal areas (Sites 1 and 2) and two former crash crew training areas (Sites 17 and 18) (Figure 2-2).

Site 1 - Northwest Disposal Area. The approximately 1-acre site is located west of Perimeter Road and north of a drainage ditch. The site is northwest of the North Field flightlines.

The site consists of a topographic depression, approximately 10 feet below Perimeter Road, with a cover of pine trees. Surface water drainage is toward the drainage ditch. The drainage ditch flows in a westerly direction and discharges into Clear Creek, approximately 1,300 feet west of the site (Figure 2-2).

This site was formerly used as a secondary refuse disposal area from 1943 until 1965. Access to the site was uncontrolled. Waste reportedly disposed of at the site included materials used in the operation and maintenance of aircraft (waste paint, paint thinners, paint stripping wastewater, solvents, spent oils, and hydraulic fluids). The total quantity of liquid wastes disposed of at this site was estimated at 80,000 gallons (Envirodyne Engineers, 1985).

Site 2 - Northwest Open Disposal Area. Site 2 is located on the western flanks of the North Field flightlines, directly between Sites 1 and 18 (Figure 2-2).

The site, a depression about 20 feet below the surrounding land elevation, was originally a borrow pit. It covers an area of approximately 12 acres. The site is presently vegetated by woody shrubs, small trees, and weeds. Because of the basin-like structure of the site, there is no surface water overland flow from the site. Instead, any surface flow reaching the site either infiltrates into the subsurface and/or evaporates into the atmosphere. A surface drainage ditch, which flows in a westerly direction toward Clear Creek, is located just north of Site 2.

From 1976 to 1984, the site was used as an open disposal area primarily for construction and demolition debris. Wastes reportedly disposed of include asphalt, wood, tires, furniture, and similar bulky materials not suitable for landfill disposal.

Site 17 - Crash Crew Training Area. Site 17 is located on the northwestern side of the North Field flightlines, approximately 1,750 feet north of a drainage ditch and east of Perimeter Road (Figure 2-2).

The site consists of seven shallow pits of varying sizes, described as burn pits. These pits together occupy an area of approximately 1.0 acre, but the total area of Site 17 is approximately 3.0 acres. The burn pits are located on a gently sloping, grassy apron to the southwest of an aircraft taxiway. When active, some burn areas were occupied by open metal tanks, abandoned aircraft fuselage, and mounds of soil mixed with burnt debris. In August 1994, the open metal tanks and aircraft fuselage were removed, and the soil mounds were dispersed across the site area. Runoff at this site flows from northeast to the southwest.

From 1951 to 1991, crash crew training was performed at the site. A typical training session involved pouring approximately 100 gallons of fuel (JP-4, JP-5, or AVGAS mixed with waste oil) into a burn pit, igniting the fuel, and then extinguishing it with an aqueous (nontoxic) film-forming foam (AFFF). As an estimate of the volume of material used for crash crew training, 6,285 gallons of contaminated fuel and 3,148 gallons of AFFF were used in 1984 for both Sites 17 and 18 (Geraghty & Miller, 1986). Overland flow from the burn pits is evidenced by oil stains on the surface soil of the drainage swales leading from the burn pits.

Site 18 - Crash Crew Training Area. Site 18 is located on the southwestern flank of the North Field flightlines and east of Perimeter Road (Figure 2-2).

The site consists of five shallow pits of varying sizes, described as burn pits. These pits occupy an area of approximately 1.0 acre, but the total area of Site 18 is approximately 5.5 acres. The burn pits are located on a moderately sloping, grassy apron between an abandoned aircraft taxiway and Perimeter Road. When active, some pits were occupied by open metal tanks. Four, rusted metal drums, which were partially buried in the soil, were removed in 1993. In August 1994, two abandoned and charred aircraft fuselages were removed from the site, and a mound of soil mixed with burnt debris was dispersed over the site. Surface water runoff at this site flows from northeast to the southwest.

The crash crew training operations for Site 18 including materials used were identical to those for Site 17.

3.2 OU 4, SOUTHWEST PERIMETER ROAD SITES. Two sites in an area southwest of the South Field comprise OU 4. The sites include one landfill (Site 15) and one disposal area (Site 16) (Figure 2-2).

Site 15 - Southwest Landfill. Site 15 is located southwest of the South Field, approximately 200 feet southeast of the NAS Whiting Field Wastewater Treatment Plant and 1,200 feet east of Clear Creek.

The site was a trench-and-fill landfill covering an area of 15 acres. The land surface at the site is covered by pine trees and generally slopes from east to west at an average grade of 5 percent. Smaller tracts within the site are bare of vegetation, resulting in severe surface erosion in these areas. Berms were constructed perpendicular to the slope to reduce the severity of surface erosion in the area.

This site was the primary refuse disposal area for NAS Whiting Field from 1965 to 1979. Wastes associated with aircraft operation and maintenance were also disposed of at Site 15 (paint, paint thinners, paint stripping wastewater, solvents, spent oils, and hydraulic fluids). Bagged asbestos was reportedly disposed of at the site, as well as dielectric fluid potentially containing PCBs. An estimated 3,000 to 4,000 tons of wastes per year were reportedly buried at the site (Envirodyne Engineers, 1985). The waste materials were covered with soil on a daily basis.

Site 16 - Open Disposal and Burning Area. Site 16 is located west of South Field, approximately 450 feet east of Clear Creek and 350 feet west of the NAS Whiting Field Wastewater Treatment Plant (Figure 2-2).

The site consisted of two large pits covering an area of approximately 10 acres. The land surface at the site is presently covered by tall pine trees and generally slopes from northeast to southwest at an average grade of 5 percent. Smaller tracts within the site are bare of vegetation, with erosion prevalent on the steeper, bare slopes.

From 1943 to 1965, Site 16 was used as the primary waste disposal area for NAS Whiting Field. Spent diesel fuel was used to burn most of the wastes to reduce volume. Reportedly, the burning was not a controlled process. The waste consisted of general refuse plus waste generated from aircraft operation and maintenance, including paints, paint-stripping wastewater, solvents, waste oil, and hydraulic fluid. PCB-contaminated transformer oil may also have been disposed of at the site. An estimated volume of 3,000 to 4,000 tons of waste were reportedly disposed of at the site annually.

3.3 OU 5, SOUTHEAST PERIMETER ROAD SITES. Six sites in an area directly east of the South Field flightlines comprise OU 5. The sites include two landfills (Sites 13 and 14) and four disposal areas (Sites 9, 10, 11, and 12) (Figure 2-2).

Site 9 - Waste Fuel Disposal Area. Site 9 is located approximately 300 feet east of the South Field taxiway and 450 feet southeast of the northeast-southwest trending runway of South Field (Figure 2-2).

The site consists of a clay borrow pit where waste fuel was disposed of in the 1950s and 1960s. The disposal area was later covered with soil. The exact location of the site has not been conclusively determined. Record searches and interviews with NAS Whiting Field personnel located the pit but not the fuel disposal location (ABB-ES, 1993). Current investigations have focused on a large borrow pit located in the area currently considered to be the general site location. This pit is approximately 10 feet below the elevation of Perimeter Road. Surface runoff from the surrounding terrain drains into the borrow pit.

Tank trucks reportedly transported approximately 300 to 400 gallons of waste fuel to the site per trip. The waste fuels reportedly included AVGAS containing tetraethyl lead. (ABB-ES, 1993).

Site 10 - Southeast Open Disposal Area A. Site 10 is adjacent to and south of the assumed location of Site 9 (Figure 2-2).

The site is approximately 4 acres in area and is presently covered with woody shrubs and small trees. Most of the surface runoff at the site flows into a small depression adjacent to Site 9. Runoff from the site and the depression is east toward Big Coldwater Creek, approximately 1.9 miles away.

Site 10 was used as an open disposal area from 1965 to 1973. The site was used mostly for inert types of wastes such as construction debris (concrete, lumber, asphalt, etc.), trees, metal cans, and similar materials not suitable for landfill disposal. Transformer oil containing PCBs may also have been disposed of at this site. Empty cans of pesticides and herbicides were also reportedly disposed of at this site. Because access to the site was uncontrolled, other wastes of unknown origin may have been disposed of at the site (Envirodyne Engineers, 1985).

Site 11 - Southeast Open Disposal Area B. Site 11 is located near the eastern property fenceline and north of an open drainage ditch (Figure 2-2).

The 40-acre site slopes gently toward the northeast, and surface water runoff from the site ultimately flows into Big Coldwater Creek, located approximately 1.7 miles to the east. The area is covered by a mix of pine trees and brush, except along the access road. Surface erosion at the site is generally along the access road.

The site was used as an open disposal area with uncontrolled access from 1943 to 1970. The site was reportedly used to dispose of a variety of wastes, including general refuse, construction debris (concrete, asphalt, lumber, etc.), tree clippings, and furniture. Transformer oil containing PCBs as well as wastes associated with the operation and maintenance of aircraft (paint, paint thinner, solvents, waste oils, and hydraulic fluid) may also have been disposed of at the site. A final soil covering was placed over the site in the early part of the 1970s, and pine trees were also reportedly planted at the same time (Envirodyne Engineers, 1985).

Site 12 - Tetraethyl Lead Disposal Area. Site 12 is located approximately 50 feet west of Site 11 and 5 feet north of a drainage ditch (Figure 2-2).

The site is a fenced area that is approximately 0.06 acre in size. There are six soil or dirt mounds within the fenced area. These mounds vary in height from 2.2 to 3.8 feet above the ground surface. The area is covered in dense shrubbery with a few scattered trees. The ground surface slopes gently south, toward the ditch. This unlined ditch receives surface runoff from the site that flows into the Big Coldwater Creek, approximately 1.7 miles east of the site.

Tank bottom sludge from the cleaning of the North and South Aqua Fuel System storage tanks and fuel filters, contaminated with tetraethyl lead, were reportedly disposed of at Site 12 on May 1, 1968. An estimated 200 to 400 gallons of sludge per mound were reportedly disposed of at this site (Geraghty & Miller, 1986).

Site 13 - Sanitary Landfill. Site 13 is located east and southeast of Site 11, oriented parallel to the eastern property fenceline in the area. A drainage ditch is located west and south of the site (Figure 2-2).

The landfill consisted of an elongate trench aligned parallel to the eastern property fenceline, covering approximately 5.5 acres. The surface of the landfill is poorly vegetated, with a sparse scattering of trees on the eastern side. The western side is relatively bare of vegetation. The land surface slopes downward from the northeast to the southwest, and erosion gullies are evident at the site. Ponding of surface water runoff is present on the southern end of the site.

Site 13 was the last operating landfill for NAS Whiting Field and was in use from 1979 to 1988. During the first year of operation the landfill may have received waste solvents and residue from paint stripping. Since 1980, the landfill has received only general refuse and nonhazardous waste. Construction and demolition debris were excluded. Asbestos wrapped in plastic was also disposed of at the landfill.

Site 14 - Short-Term Sanitary Landfill. Site 14 is located approximately 1,000 feet southeast of the east-west runway on the South Field and southwest of Site 13 (Figure 2-2).

Site 14 is approximately 1 acre in size and consists of an elongate trench oriented in an east-west direction. Much of the central part of the site is covered with small trees and shrubs. The site perimeter is covered with pine trees. The site generally slopes from west to east. Surface water runoff flows in an easterly direction toward the drainage ditch.

This site was operated as a landfill (during a 6- to 9-month period) from 1978 to 1979. The site was abandoned after this short time due to the excessive clay content in the soil, which caused ponding at the site (Geraghty & Miller, 1986). As a result, trucks delivering wastes were continually getting stuck at the site. The majority of the wastes disposed of at this site may have been general refuse and nonhazardous wastes. However, waste solvents and residue from paint-stripping operations could also have been disposed of at this site.

3.4 OU 6, PERIMETER ROAD SLUDGE DRYING BEDS. OU 6 consists of a single site designation that includes multiple disposal areas along the South Field Perimeter Road (Figure 2-2).

Site 31 - Sludge Drying Beds and Disposal Area. Site 31 includes the sludge drying beds located near the Wastewater Treatment Plant (Site 31A), three sludge disposal areas at the southwest perimeter of the northeast-to-southwest-trending South Field Taxiway (Sites 31B, 31C, and 31D), and two sludge disposal areas at the northeast perimeter of the northeast-to-southwest-trending South Field Taxiway (Sites 31E and 31F) (Figure 2-2).

Site 31A is a sludge drying bed unit, 92 feet long by 80 feet wide. The unit consists of four sludge drying beds surrounded by containment walls 2.5 to 3.0 feet deep. The area of the site is approximately 0.2 acre in size. The surface of each sludge drying bed is covered with a coarse-grained sand and fine-grained gravel mixture.

Site 31A received wet sludge from the wastewater treatment plant that could have contained hazardous substances such as methylene chloride and heavy metals. The dried sludge was periodically trucked off and disposed of at Sites 31B, 31C, and 31D. Site 31A was inactivated in 1990.

Site 31B, Site 31C, and Site 31D are located in an area of surface water retention berms on the southwestern slopes of the South Field. The purpose of the berms is to reduce soil erosion from surface water runoff. Disposal in these areas consisted of both liquid and sludge materials.

Sites 31E and 31F are locations where liquid sludge was formerly sprayed on the grassy surface on the east and west sides of the perimeter road. The extent of the disposal areas is not known with certainty, but an estimate of the area covered for both sites is approximately 6.9 acres.

4.0 HUMAN HEALTH RISK ASSESSMENT (HHRA)

The HHRA characterizes the risks (current and future) associated with potential human exposures to site-related contaminants from hazardous waste sites. An HHRA will be completed for all sites within OUs 3, 4, 5, and 6. The process consists of six basic components: (1) data evaluation and summarization, (2) selection of CPCs, (3) exposure assessment, (4) toxicity assessment, (5) risk characterization, and (6) uncertainty analysis. A brief description of each component is presented in the following subsections.

The HHRA will be conducted according to CERCLA methodology. The following Federal and USEPA Region IV guidelines are used to direct and support the HHRA:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A* (USEPA, 1989a);
- *Supplemental Region IV Risk Assessment Guidance* (USEPA, 1991a);
- *New Interim Region IV Risk Assessment Guidance* (USEPA, 1992a);
- *Exposure Factors Handbook* (USEPA, 1989b);
- *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors* (USEPA, 1991b); and
- *Guidance for Data Useability in Risk Assessment* (Part A) (USEPA, 1992c).

The HHRA also considers FDEP standards and guidance (FDEP, 1994a; 1994b; 1995).

Preliminary screening evaluations conducted at NAS Whiting Field will indicate the nature and extent of chemical contamination at the sites. These findings will be used to determine whether a full baseline risk assessment is needed, or whether a modified version of the process described below is more appropriate.

4.1 DATA EVALUATION AND SUMMARIZATION. The data used in risk assessment result from analyses conducted under the Contract Laboratory program with documented Quality Assurance/Quality Control (QA/QC) procedures. Before analytical results are released by the laboratory, both the sample and QC data are carefully reviewed to verify sample identity, instrument calibration, detection limits, dilution factors, numerical computations, accuracy of transcriptions, and chemical interpretations. The QC data are reduced and spike recoveries are included in control charts, and the resulting data are reviewed to ascertain whether they are within the laboratory-defined limits for accuracy and precision. Any nonconforming data are discussed in the data package cover letter and case narrative.

The data are reviewed and validated using the Naval Energy and Environmental Support Activity (NEESA, 1988) guidance document 20.2-047B, *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program*. The data review and validation process is independent of the laboratory's checks.

4.1.1 Evaluation of Quantitation Limits Sample quantitation limits (SQLs) are compared to corresponding standards and criteria. For soil, SQLs will be compared to the USEPA risk-based concentrations and State of Florida cleanup goals. The groundwater SQLs will be compared to Federal and State maximum contaminant levels (MCLs) and Florida guidance concentrations. SQLs in excess of those screening values represent an area of uncertainty in the analytical results. The effect of this uncertainty will be noted in the risk assessment.

4.1.2 Evaluation of Qualified and Coded Data The laboratories and data validators may attach qualifiers and codes to the analytical data. The qualifiers may pertain to QA/QC variances in identification or quantitation of an analyte. When data have both laboratory and validation qualifiers, the validation qualifiers supersede the laboratory qualifiers. All positive detections (unqualified or qualified with a "J") are considered detected concentrations for the risk assessment. All nondetects (qualified with a "U" or "UJ") are retained in the risk assessment as samples without positive detections. If an analyte has all nondetect results for all samples in a given medium, it is not considered in the risk assessment for that medium. All sample results with an "R" validation qualifier are not considered in the risk assessment because these values have been rejected and are unusable.

Once the data are reviewed and validated, the analytical precision, accuracy, representativeness, comparability, and completeness (PARCC) of the data are evaluated to determine data usability.

4.1.3 Precision Precision is a measure of the agreement of a set of replicate results obtained from duplicate laboratory analyses of samples collected from the same location. Precision is calculated from laboratory analytical data and cannot be measured directly.

4.1.4 Accuracy Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is used to identify the bias in a given measurement system (i.e., laboratory conditions, sample matrix, and sampling conditions).

4.1.5 Representativeness Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic laboratory QC sample result (i.e., rinsate blanks, field blanks, trip blanks, and laboratory method blanks). Positive detections of target analytes in the QC blank samples identify contaminants that possibly are introduced to the associated environmental sample during sample collection, transport, or laboratory analysis.

4.1.6 Comparability Comparability is a qualitative measure designed to express the confidence with which one data set may be compared with another. Factors affecting comparability include sample collections and handling techniques, sample matrix types, and analytical method. Comparability is limited by other PARCC parameters because only when precision and accuracy are known can data sets be compared with confidence.

Comparability of the NAS Whiting Field background data is assured by using standard operating procedures for sample collection, using standard chemical analytical methods, and reporting the analytical results in standard units.

4.1.7 Completeness Completeness is defined as the percentage of measurements that are judged to be valid compared to the total number of measurements made. Valid usable values are data that are not qualified as rejected (R qualifier) by the data validation process. Completeness is evaluated to determine if an acceptable level of data was obtained so that a scientific site assessment can be completed with valid usable data. Completeness equals the total number of analytes in each sample (equipment rinsate, field and trip blanks, and duplicate samples) minus the total number of rejected analytes divided by the total number of analytes.

4.1.8 Evaluate Tentatively Identified Compounds Tentatively identified compounds or tentatively identified compounds (both identity and concentration are uncertain) will be reviewed. If the number of tentatively identified compounds is small relative to the number of detected target compound list (TCL) analytes, and if there is no historical information to suggest the tentatively identified compounds should be present, the tentatively identified compounds will not be quantitatively evaluated. If the number of tentatively identified compounds is large relative to the TCL chemicals, the tentatively identified compounds will be included in the quantitative evaluation, and the uncertainty in the identity and concentrations of these analytes will be fully discussed in the uncertainty analysis.

4.1.9 Data Used in the Risk Assessment The product of the data evaluation is a summary of usable data for each medium that is used in the HHRA. This summary includes the frequency of detection, the arithmetic mean (using only samples with detected contamination), the range of detected concentrations, the arithmetic mean of background concentrations, and the range of the quantitation limits. The summary information is used to select human health chemicals of potential concern (HHCPCs) as described in Section 4.2.

4.2 IDENTIFICATION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN.

HHCPCs are selected from all analytes detected at the site. The selection of HHCPCs from all detected analytes in each medium is based on the analyte concentrations, frequency of detection, comparison to background (inorganics only), and USEPA and Florida medium-specific screening criteria. HHCPCs include contaminants that are:

- positively identified in at least one sample and
- detected at levels significantly elevated above blank concentrations.

Chemicals that do not contribute significantly to human health risks are removed or "screened" from further consideration as HHCPCs, as recommended by USEPA (USEPA, 1991a). Analytes are excluded as HHCPCs if they meet any of the following criteria:

1. The maximum detected concentration is less than twice the arithmetic mean of the background concentration (inorganics only) (USEPA, 1991a).

2. The maximum reported soil or water concentration is less than either the USEPA Region III risk-based concentration (RBC) or State of Florida criteria and guidance values.

USEPA Region III RBCs corresponding to an excess lifetime cancer risk (ELCR) of $1x10^{-6}$ or hazard quotient (HQ) of 0.1 for each analyte detected are used in the screening process.

For surface soil, subsurface soil, and sediments, the residential soil RBCs are used. No RBC is available for lead in soil due to lack of dose-response values. Based on USEPA recommendation, a target level for cleanup at Superfund sites of 400 milligrams per kilogram (mg/kg) is used as the RBC for lead in soil (USEPA, 1994a).

For groundwater and surface water, tap water RBCs are used. No RBC is available for lead in groundwater; therefore, the treatment technology action level for drinking water of 15 micrograms per liter ($\mu g/\ell$) is used (USEPA, 1994b; FDEP 1994b).

State of Florida cleanup criteria based on the aggregate resident are used to screen surface soil (FDEP, 1994a). For subsurface soil, State of Florida cleanup criteria based on leachability are utilized in the process. The target HQ for noncarcinogenic substances is 1.0, while the target cancer risk is 1×10^{-6} in the soil cleanup criteria. For groundwater, Florida guidance concentrations are used for screening (FDEP, 1994a).

3. The average concentration of an essential nutrient (sodium, potassium, magnesium, iron, and calcium) in a medium is below a toxic screening level and consistent with or only slightly above the background concentration for that essential nutrient.

4. The frequency of detection (number of samples in which the analyte is detected divided by the number of samples analyzed for that analyte) is less than 5 percent (USEPA, 1989a) and professional judgement is used to ensure that the analyte is probably an anomaly.

tentatively identified compounds are screened based on suspected presence at the sites under consideration, contaminant concentration, migration potential via each of the identified exposure pathways, and the chemical's toxicity. The tentatively identified compounds of concern are evaluated qualitatively in the HHRA.

4.3 EXPOSURE ASSESSMENT. Exposure assessment estimates the types and magnitudes of potential human exposure to HHCPCs. This process involves three steps:

- characterization of the exposure setting,
- identification of exposure pathways and receptors, and
- quantification of exposures.

4.3.1 Characterization of Exposure Setting The physical characteristics of the site and the nature of the surrounding populations are evaluated to provide a basis for assessing potential exposures. The HHRA summarizes important site characteristics that may influence human contact with site contaminants including surface conditions, soil type, degree of vegetative cover, climate, geology, and conditions that affect the migration of contaminants, such as speed and direction of groundwater flow.

Evaluation of population characteristics includes the location of current populations relative to the site and the daily activities of these populations. The presence and location of potentially sensitive subpopulations, such as children or elderly, are also evaluated.

<u>4.3.2 Identification of Exposure Pathways and Receptors</u> This step involves the identification of all relevant exposure pathways through which specific populations may be exposed (current and future) to contaminants at the site. An exposure pathway consists of four necessary elements: a source or mechanism of chemical release, a transport or retention medium, a point of human contact, and a route of exposure at the point of contact (USEPA, 1989a).

The first step in defining potential exposure pathways is to identify all sources of contamination (i.e., surface water, groundwater, and surface soil). Once sources are identified, relevant fate and transport mechanisms are evaluated to predict current and potential future exposures. Population characteristics are then used to identify where people may contact contaminated media and the possible routes of exposure (i.e., inhalation, ingestion, or dermal absorption). The receptors to be evaluated are selected based on the current and realistic future use of the sites and surrounding areas. Four potentially exposed population scenarios are typically used in HHRAs: residents, both young child (age 1-6) and adult; trespassers, both older child (age 7-16) and adult; site maintenance worker; and full-time onsite worker.

Trespasser and site maintenance worker scenarios represent current land use for most OUs at NAS Whiting Field. The residential scenarios represent future land use because the land is not currently being used by a residential population but could potentially be used as such in the future. The excavation and full-time onsite worker scenarios are also considered for future land use. Table 4-1 identifies the typical exposure pathways for the two current land use population scenarios at OUs 3, 4, 5, and 6. Table 4-2 identifies the typical exposure pathways for the future land use population scenarios at OUs 3, 4, 5, and 6. The source of contamination or the initial receiving medium is usually the soil. Migration of contaminants from soil occurs through several different mechanisms such as leaching to groundwater, water or wind erosion to other media, and absorption by plants. Analytes may accumulate in plants and animals that are in contact with soil or whose food sources are in direct contact with soil. Mechanisms for migration into air include volatilization (primarily volatile organic compounds [VOCs]) and wind erosion of contaminated soil (all types of contaminants). Overland flow of water can result in migration of contaminants to surface water bodies and sediment. This process can also lead to relocation of the contaminants to other surface soil. Infiltration can result in migration into subsurface soil and into groundwater. Dissolved analytes (primarily soluble VOCs, semivolatile organic compounds [SVOCs], and inorganics) are very mobile and may be transported to wells or discharged to surface water.

<u>4.3.3 Quantification of Exposures</u> The next step is to calculate HHCPC intakes, via each exposure pathway, for each of the potentially exposed populations. Population-related variables are selected that describe the characteristics associated with individual receptors in that population. For example, intake is dependent upon contact rate, age, body weight, body surface area, exposure frequency, exposure duration, and averaging time. When possible, variables such as age, body weight, and body surface area are selected from the following USEPA guidance documents: standard default exposure factors (USEPA, 1991b), dermal

Table 4-1
Proposed Human Health Receptors to Be Evaluated for Current Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Current Land Use Receptors	Exposure Media and Exposure Routes	
OU 3 Site No. 1	Northwest Disposal Area	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 3 Site No. 2	Northwest Open Disposal Area	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 3 Site No. 17	Crash Crew Training Area (old)	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 3 Site No. 18	Crash Crew Training Area (new)	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 4 Site No. 15	Southwest Landfill	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 4 Site No. 16	Open Disposal and Burning Area	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 5 Site No. 9	Waste Fuel Disposal Area	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 5 Site No. 10	Southeast Open Disposal Area A	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None

See notes at end of table.

Table 4-1 (Continued)
Proposed Human Health Receptors to Be Evaluated for Current Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Current Land Use Receptors	Exposure Media and Exposure Routes	
OU 5 Site No. 11	Southeast Open Disposal Area B	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 5 Site No. 12	Tetraethyl Lead Disposal Area	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 5 Site No. 13	Sanitary Landfill	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 5 Site No. 14	Short-Term Sanitary Landfill	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 6 Site No. 31A	Sludge Drying Beds Unit	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 6 Site No. 31B/C/D	Sludge Disposal Area Southwest Perimeter of South Field Taxiway	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None
OU 6 Site No. 31E/F	Sludge Disposal Area Northeast of South Field Taxiway	Trespasser (older child and adult) Site Worker (groundskeeper)	Soil	Ingestion Dermal Inhalation
			Groundwater	None

[1] This preliminary list of human health receptors will be refined following the human health characterization phase of work.

Table 4-2
Proposed Human Health Receptors to Be Evaluated for Future Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Future Land Use Receptors	Exposure Media and Exposure Routes	
OU 3 Site No. 1	Northwest Disposal Area	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 3 Site No. 2	Northwest Open Disposal Area	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 3 Site No. 17	Crash Crew Training Area (old)	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 3 Site No. 18	Crash Crew Training Area (new)	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 4 Site No. 15	Southwest Landfill	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion

See notes at end of table.

Table 4-2 (Continued)
Proposed Human Health Receptors to Be Evaluated for Future Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Future Land Use Receptors	Exposure Media and Exposure Routes	
OU 4 Site No. 16	Open Disposal and Burning Area	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 5 Site No. 9	Waste Fuel Disposal Area	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 5 Site No. 10	Southeast Open Disposal Area A	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 5 Site No. 11	Southeast Open Disposal Area B	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion

See notes at end of table.

Table 4-2 (Continued)
Proposed Human Health Receptors to Be Evaluated for Future Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Future Land Use Receptors	Exposure Media and Exposure Routes	
OU 5 Site No. 12	Tetraethyl Lead Disposal Area	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 5 Site No. 13	Sanitary Landfill	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 5 Site No. 14	Short-Term Sanitary Landfill	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 6 Site No. 31A	Sludge Drying Beds Unit	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion
OU 6 Site No. 31B/C/D	Sludge disposal area Southwest Perimeter of South Field Taxiway	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion

See notes at end of table.

Table 4-2 (Continued)
Proposed Human Health Receptors to Be Evaluated for Future Land Use at Operable Units 3, 4, 5, and 6[1]

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Operable Unit (OU)	Name	Future Land Use Receptors	Exposure Media and Exposure Routes	
OU 6 Site No. 31E/F	Sludge disposal area Northeast of South Field Taxiway	Resident (adult and child) Trespasser (older child and adult) Occupational Worker Site Worker	Soil	Ingestion Dermal Inhalation
		Resident (adult)	Groundwater	Ingestion

[1] This preliminary list of human health receptors will be refined following the human health characterization phase of work.

exposure assessment principles and applications (USEPA, 1992b), and the exposure factors handbook (USEPA, 1989b).

The general equation for calculating chemical intake from the various media is:

$$Intake\ (mg/kg-day) = \frac{[C \times CR \times EF \times ED \times CF]}{[BW \times AT]}$$

where

C	=	chemical concentration, media specific;
CR	=	contact rate, media specific;
EF	=	exposure frequency, population specific;
ED	=	exposure duration, population specific;
CF	=	conversion factor, media specific;
BW	=	body weight of hypothetically exposed individual; and
AT	=	averaging time (for carcinogens, AT=70 years x 365 days per year; for noncarcinogens, AT=ED x EF).

The specific equations used to calculate intakes from the different exposure pathways and, where possible, the default values used in the risk calculation spreadsheets will be provided in an appendix to each OU HHRA. Examples of some equations and parameter values are provided in Appendix A.

Some exposure pathways require additional calculations before intake values can be calculated. The following are brief explanations of the additional calculations required for the inhalation of particulates, inhalation of vapors while showering, and dermal absorption.

Inhalation of Particulates from Soil At sites having the potential for wind erosion, a three-step modeling process is conducted. In the first step, respirable particle-phase emission rates are calculated. In the second, contaminant emission rates on a unit surface area basis are calculated. In the third phase, downwind ambient concentrations are estimated using air dispersion modeling. A complete discussion of the three-step process and the associated equations is presented in Appendix A.

Inhalation of Vapors while Showering For this exposure scenario, the contaminant concentrations in air are estimated based on release rates of volatiles from shower water. After reviewing the literature, the model selected to predict indoor (bathroom) concentrations is the Foster and Chrostowski (1987) model. The specific equations used to determine concentrations of contaminants in bathroom air are presented in Appendix A.

Dermal Absorption from Water The absorbed dose is calculated in accordance with the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report (USEPA, 1992b). The permeability constant approach is used to describe the dermal absorption to contaminants in water. For all inorganic chemicals, the model assumes a permeability constant equal to that of water, which is a steady-state condition for all analytes. For organic compounds, a nonsteady-state model is used to model the absorption that employs a dermal permeability constant estimated from the compound's octanol-water partition coefficient. A further description of the process used to determine absorption of contaminants from water is presented in Appendix A.

Dermal Absorption from Soil The absorbed dose from soil is calculated in accordance with the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report (USEPA, 1992b). Percutaneous absorption of chemicals in soil is chemical-dependent and matrix-dependent. According to USEPA Region IV guidance (USEPA, 1992a), absorption factors used in this risk assessment for organics and inorganics are 0.1 percent and 0.01 percent, respectively. A soil adherence factor of 1 milligram per square centimeter (mg/cm^2) per event is used in the dermal intake equations. The equations used to describe dermal absorption from soil are presented in Appendix A.

4.4 TOXICITY ASSESSMENT. The toxicity assessment evaluates the available evidence on the potential adverse effects associated with exposure to each analyte. With this information, a relationship between the extent of exposure and the likelihood or severity of adverse human health effects is developed. Two steps are typically associated with toxicity assessment: hazard identification and dose-response assessment.

Hazard identification describes adverse effects that have been associated with exposure to an agent and, more importantly, whether or not those effects will occur in humans. Characterizing the nature and strength of causation is also a part of the hazard identification step. The HHRA contains a toxicity profile for each HHCPC found at each OU. The toxicity profile describes the physical and toxicological properties of each contaminant.

A dose-response assessment is conducted to characterize and quantify the relationship between intake, or dose, of an HHCPC and the likelihood or severity of a toxic effect or response. There are two major types of toxic effects evaluated in this risk assessment: carcinogenic and noncarcinogenic.

Following USEPA guidance (USEPA, 1989a), these two endpoints are evaluated separately. For carcinogens, USEPA weight-of-evidence classifications and numerical toxicity factors have been developed and have undergone extensive peer review. Toxicity information used in the toxicity profile is primarily from Integrated Risk Information System (IRIS), Health Effects Assessment Summary Tables, Agency for Toxic Substances and Disease Registration (ATSDR) Toxicology Profiles, and the USEPA Environmental Criteria and Assessment Office.

A dose-response assessment will be completed to identify the relevant oral, dermal, and inhalation toxicity values for carcinogenic (cancer slope factors [CSFs]) and noncarcinogenic effects (reference doses [RfDs]) of the HHCPCs. As required by USEPA Region IV guidance (USEPA 1991a), risks associated with soil and water dermal contact will be evaluated using RfDs and CSFs that are specific to absorbed doses. It will, therefore, be necessary to adjust toxicity values (commonly oral toxicity values) based on administered dosage so that they can be used for evaluation of absorbed doses.

4.5 HUMAN HEALTH RISK CHARACTERIZATION. Risk characterization involves the integration of the exposure and toxicity assessment into quantitative expressions of potential human health risks associated with HHCPC exposure. Quantitative estimates of both carcinogenic and noncarcinogenic risks are made for each HHCPC and each complete exposure pathway identified in the exposure assessment. A clear distinction will be made between risks associated with current land use and those risks associated with potential future land and groundwater uses.

Exposure Point Concentration. Because contaminant concentration may vary over a site, an exposure point concentration (EPC) is used to express exposure as a reasonable maximum exposure (RME) for each exposure pathway.

An EPC is the lesser of the maximum detected or the 95th percent upper confidence limit (UCL) on the arithmetic mean. The following equation for calculating the UCL on the arithmetic mean for a lognormal distribution is used to calculate all UCLs:

$$UCL = (\overline{x} + 0.5s^2 + \frac{sH}{\sqrt{n-1}}$$

where:

UCL = upper conference limit
e = constant (base of the natural log, equal to 2.718)
xbar = mean of transformed data
s = standard deviation of the transformed data
H = H-statistic (from table published in Gilbert, 1987)
n = number of samples

In calculating the 95 percent UCLs, non-detects are assigned a value of one-half the associated reporting limits in the calculation of the arithmetic mean. In cases where there are fewer than 10 samples, the maximum detected concentration is identified as the EPC.

Carcinogenic Risks. Carcinogenic risks associated with exposure to individual chemicals will be estimated by multiplying the estimated chemical intake for each carcinogen (in units of milligrams per kilogram a day [mg/kg-day] by its USEPA CSF (in units of $(mg/kg\text{-}day)^{-1}$). The result is a chemical-specific excess lifetime cancer risk. This value represents the probability of developing cancer over the course of a 70-year lifetime as a result of exposure to a chemical. Within each exposure pathway, cancer risks associated with multiple carcinogenic compounds are determined by summing the chemical-specific risks to yield a pathway-specific lifetime incremental cancer risk. USEPA's guidelines (USEPA, 1990) state that the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site should not exceed a range of 10^{-6} to 10^{-4}.

Noncarcinogenic Risks. Noncarcinogenic risk estimates will be determined by dividing estimated chemical intakes (in units of mg/kg-day) by the appropriate RfD (in units of mg/kg-day). The resulting ratio is called the (HQ) hazard quotient. The HQs for individual HHCPCs within an exposure pathway are summed, resulting in a hazard index (HI) for that pathway. An HI less than or equal to 1 represents concentrations and levels of exposure that are generally considered to be without deleterious effects for a lifetime exposure, even for sensitive individuals. As the HI increases above 1, so does the risk of adverse effects. An HI above 1 will result in additional analyses to determine the likelihood of an adverse effect actually occurring if exposure were to occur.

Remedial Goal Options. The remedial goal options (RGOs) for chemicals and media of concern will be outlined and will include both applicable or relevant and appropriate requirements (ARARs) and health-based cleanup goals. The purpose of this information is to provide decision makers with options upon which to develop the remedial approach.

Consistent with USEPA Region IV guidance (USEPA, 1993b), if a given medium has a cumulative cancer risk greater than 10^{-4}, its noncarcinogenic HQ is 1 or greater, and/or ARARs are not exceeded, RGOs will be developed for that medium.

In accordance with FDEP (FDEP, 1995), any risks greater than 10^{-6} are worthy of further attention. Therefore, risks greater than 10^{-6} for individual chemicals in any media will also be identified, and RGOs will be developed for those chemicals. Chemicals need not be included if their individual carcinogenic risk contribution to the pathway is less than 10^{-6} or their noncarcinogenic HQ is less than 0.1. If a chemical is detected in groundwater and soil (either surface soil or subsurface soil), then the Florida leachability value will be presented as a separate column in the RGO table.

Media cleanup levels are risk-specific and medium- and exposure scenario-specific analyte concentrations. They are based on the site-specific exposure parameters (combined ingestion, dermal, and inhalation exposures) and the toxicity information used in the baseline risk assessment.

4.6 UNCERTAINTY ANALYSES. Uncertainties in the quantification of risk associated with the site are identified and their impacts on risk estimates are discussed in a separate section of the HHRA These uncertainties can arise from several sources. Some of the more often encountered uncertainties include: (1) uncertainties in the analytical procedures to accurately define the contaminant concentration at the site, (2) uncertainties in obtaining exposure point concentrations and their use as representatives of the reasonable maximum contaminant concentration, (3) uncertainties in exposure scenarios, (4) uncertainties in exposure factors used to calculate intake, (5) uncertainties in the appropriateness of toxicity values, and (6) the potential for synergistic or antagonistic interaction between HHCPCs.

The majority of the assumptions made in the risk assessment process are conservative; thus, the estimated risk is probably an overestimate of the actual risk associated with exposure at the site.

The uncertainty section may also include unusual site conditions or extenuating circumstances that may be pertinent to risk management decisions. Other factors such as the inadequacy of toxicity factors to describe all possible HHCPC-receptor interactions and individual differences within the human population may be included in this section.

5.0 BASELINE ECOLOGICAL RISK ASSESSMENT (BERA)

The BERA at NAS Whiting Field will evaluate actual or potential adverse effects to the ecosystem or ecosystem components associated with exposure(s) to contamination from the hazardous waste sites at OUs 3, 4, 5, and 6. The following sections describe the approach for the BERAs at NAS Whiting Field.

There are six primary components of the BERA process, including: (1) problem formulation, (2) hazard assessment, (3) exposure assessment, (4) effects assessment, (5) risk characterization, and (6) uncertainty analyses. Each component is described separately in the following subsections.

The BERA will be conducted in accordance with the "Risk Assessment Guidance for Superfund: Environmental Evaluation Manual" (USEPA, 1989c), and "Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document" (USEPA, 1989d). In addition, recent supplemental risk assessment guidance such as USEPA "Eco Update Bulletins" (USEPA 1991c: 1992d; 1992e) will be incorporated into this BERA, where appropriate. Figure 5-1 shows the framework for the proposed ecological risk assessment.

Decisions regarding overall risk to ecological receptors will be based on the weight of evidence from the results of both predictive and field methodologies.

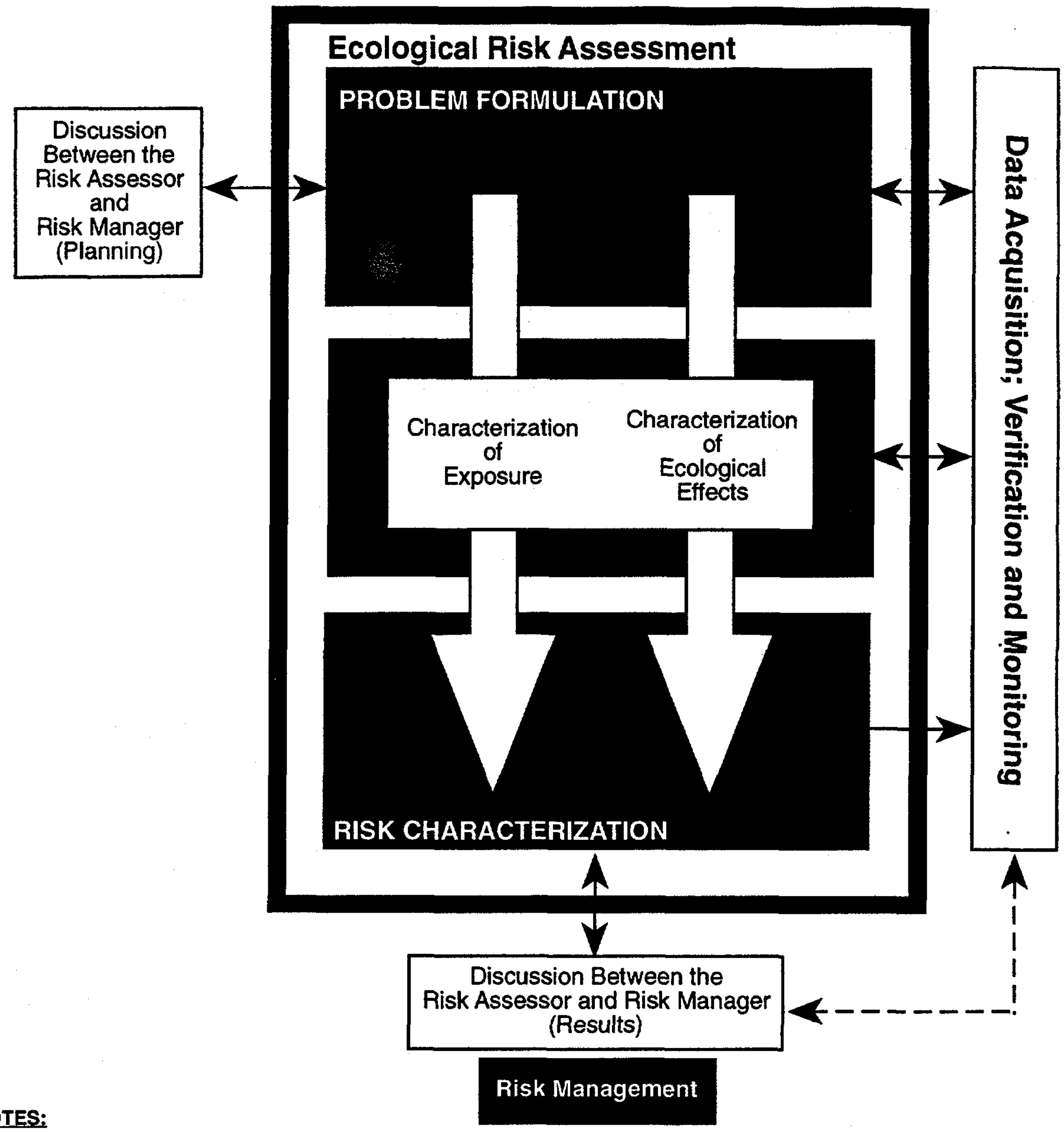
5.1 PROBLEM FORMULATION. This section presents a brief overview of the major contaminants and ecological receptors at OUs 3, 4, 5, and 6 at NAS Whiting Field. Information contained in this section was used to identify data gaps necessary for completion of the baseline ecological risk assessments at OUs 3, 4, 5, and 6.

5.1.1 Operable Unit 3 The four sites associated with OU 3 are located on the west side of the North Field at NAS Whiting Field. OU 3 consists of Site 1, Northwest Disposal Area; Site 2, Northwest Open Disposal Area; Site 17, Crash Crew Training Area; and Site 18, Crash Crew Training Area.

Site 1. Site 1 is an approximately 5-acre forested area located on the western side of North Field. No surface water or wetland exists in the immediate vicinity of the site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 1 include surface soil and groundwater. Analysis of three surface soil samples collected at the site indicates the presence of 1 VOC (xylenes), no SVOCs, 1 pesticide (dieldrin), and 17 inorganic analytes. Chromium, iron, and mercury were detected slightly in excess of two times the background concentration. This initial screening of contaminants at the site indicates that levels may be below those expected to result in adverse ecological effects.

Site 2. Site 2 is a former construction debris and wood landfill located on the western side of North Field. Potentially contaminated media at Site 2 include subsurface soil and groundwater. No surface water or wetland exists in the vicinity of the site. Based on the site history, it is not expected that the wood debris disposed of at Site 2 would pose a risk to



NOTES:
USEPA = U.S. Environmental Protection Agency
NAS = Naval Air Station

Source: USEPA, 1992

FIGURE 5-1
FRAMEWORK FOR ECOLOGICAL RISK ASSESSMENT

BASELINE RISK ASSESSMENT WORKPLAN
OPERABLE UNITS 3, 4, 5, AND 6

NAS WHITING FIELD
MILTON, FLORIDA

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ecological receptors at the site. No substantial contamination was detected at Site 2 during this RI.

Site 17. Site 17 is a grassy area located at the perimeter of the North Field flightline area. No surface water or wetlands are located in the vicinity of the site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 17 include surface soil, subsurface soil, and groundwater. Analyses of 34 surface soil samples collected at the site indicate the presence of 7 VOCs, 4 SVOCs, and 20 inorganic analytes. Total petroleum hydrocarbons (TPH) were detected at a maximum concentration of 19,300 mg/kg. Concentrations of several inorganic chemicals exceeded two times the background concentrations. Lead was detected at a maximum concentration of 117 mg/kg.

Based on the detected levels of TPH in surface soil, risks to terrestrial ecological receptors at the site may be a concern.

Site 18. Site 18 is a grassy area located at the western perimeter of the North Field flightline area. No surface water or wetlands are located in the vicinity of the site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 18 include surface soil, subsurface soil, and groundwater. Analysis of 47 surface soil samples collected at the site indicate the presence of 7 VOCs, 11 SVOCs, and 20 inorganic analytes. TPH was detected at a maximum concentration of 23,500 mg/kg. Concentrations of several inorganic chemicals exceeded two times the background concentrations for these chemicals. Copper was detected at a maximum concentration of 864 mg/kg, lead was detected at a maximum concentration of 168 mg/kg, and zinc was detected at a maximum concentration of 779 mg/kg.

Based on the high levels of TPH and inorganic chemicals detected in surface soil, risks to terrestrial ecological receptors at the site may be a concern.

5.1.2 Operable Unit 4 The OU 4 sites are located in the southwest corner of South Field at NAS Whiting Field. OU 4 consists of Site 15 (Southwest Landfill) and Site 16 (Open Disposal and Burning Area). A summary of exposure pathways and receptors is included in the following paragraphs:

Site 15. Site 15 is a 15-acre area of pine forest located on the southwestern side of South Field. No surface water or wetlands exist in the immediate vicinity of the site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 15 include surface soil and groundwater. Analyze of five surface soil samples collected at the site indicate the presence of 1 VOC (xylenes), 1 SVOC (bis(2-ethylhexyl)phthalate), and 15 inorganic chemicals. Only one sample contained concentrations of inorganic chemicals (copper and lead) slightly in excess of two times the background concentration. An initial screening of contaminants at the site indicates that levels may be below those expected to result in adverse ecological effects.

Site 16. Site 16 is a 10-acre area of forested pine. The Clear Creek Floodplain is located 100 to 500 feet to the west of Site 16 and receives surface water runoff from the site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants, as well as aquatic and benthic species.

Contaminated media at Site 16 include surface soil and groundwater. Analysis of three surface soil samples collected at the site indicate the presence of 1 VOC (xylenes), 1 SVOC (bis(2-ethylhexyl)phthalate), 3 pesticides, and 19 inorganic chemicals. Concentrations of barium, copper, lead, nickel, silver, and zinc exceeded two times the background concentrations for these chemicals. Lead was detected at a maximum concentration of 121 mg/kg.

Based on the presence of pesticides and inorganics in surface soil and proximity of the site to Clear Creek and to OU 7 (the Clear Creek Floodplain site), risks to aquatic receptors may be a concern.

5.1.3 Operable Unit 5 The six sites associated with OU 5 are located in the southern and southeastern sides of the South Field. OU 5 consists of Site 9, Waste Fuel Disposal Area; Site 10, Southeast Open Disposal Area A; Site 11, Southeast Disposal Area B; Site 12, Tetraethyl Lead Disposal Area; Site 13, Sanitary Landfill; and Site 14, Short-term Sanitary Landfill. A drainage ditch (ditch "Y") that lies within the Big Coldwater Creek watershed runs through the OU 5 site areas. Surface water is rarely present in the ditch. This ditch receives drainage from ditch "C-3" and is unlined at OU 5. The ditch flows southeast and is concrete-lined outside the boundary of NAS Whiting Field. Its pathway beyond State Road 87A has not been identified. A small wetland is associated with this drainage area within OU 5.

Site 9. To date, no contamination has been detected at Site 9.

Site 10. Site 10 is a 4-acre open site around some forested areas. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 10 include surface soil and groundwater. Analyses of five surface soil samples collected at the site indicate the presence of 1 VOC (xylenes), 11 SVOCs, 2 PCBs, 1 pesticide (4,4'-Dichlorodiphenyltrichloroethane, [DDT]), and 18 inorganic chemicals. Aroclor-1254 was detected in three out of five samples, with a maximum concentration of 0.31 mg/kg. Concentrations of several inorganic chemicals exceeded two times the background concentrations for these chemicals. Aluminum was detected at a maximum concentration of 37,000 mg/kg, and zinc was detected at a maximum concentration of 705 mg/kg.

Based on the high levels of inorganic chemicals and the presence of PCBs detected in surface soil, risks to terrestrial ecological receptors at the site may be a concern.

Site 11. Site 11 is a 3-acre site. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 11 include surface soil and groundwater. Analyses of five surface soil samples collected at the site indicate the presence of

13 SVOCs and 20 inorganic chemicals. All SVOCs were detected in the same sample. Concentrations of several inorganic chemicals exceeded two times the background concentrations for these chemicals. Lead was detected at a maximum concentration of 2,230 mg/kg.

Based on the presence of several polynuclear aromatic hydrocarbons and the high levels of lead detected in surface soil, risks to terrestrial ecological receptors at the site may be a concern.

Site 12. Site 12 is within an area of forested pine. Contaminated media at Site 12 include surface and subsurface soil. Analysis of six soil samples from Site 12 indicates the presence of 20 inorganic analytes. Lead concentrations from three samples exceeded twice the background average for lead, with a maximum concentration of 29.9 mg/kg. The initial screening of contaminants at Site 12 indicates that levels may be below those expected to result in adverse ecological effects.

Site 13. Site 13, the Sanitary Landfill, is an area of forested pine in the southeastern portion of NAS Whiting Field. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Analysis of five surface soil samples collected at the site indicates the presence of three SVOCs and 18 inorganic chemicals. Concentrations of several inorganic chemicals marginally exceeded two times the background concentrations for these chemicals.

Based on the presences of SVOCs and inorganic analytes detected in surface soil, risks to terrestrial ecological receptors at the site may be a concern.

Site 14. Site 14, the Short-term Sanitary Landfill, is within an area of pine forest in the southeastern portion of NAS Whiting Field. Ecological receptors at the site include terrestrial wildlife, terrestrial invertebrates, and plants.

Contaminated media at Site 14 include surface soil and groundwater. Analysis of three surface soil samples collected at the site indicates the presence of 1 VOC (xylenes), 2 SVOCs, and 16 inorganic chemicals. Concentrations of several inorganic chemicals marginally exceeded two times the background concentrations for these chemicals.

Based on the presence of organic and inorganic analytes detected in surface soil samples, risks to terrestrial ecological receptors at the site may be a concern.

5.1.4 Operable Unit 6 OU 6 consists of Site 31 (Sludge Drying Beds and Disposal Area), which is a series of separate areas designated as Areas A through F. These six areas are located near the NAS Whiting Field Wastewater Treatment Plant and along the South Field perimeter road. A summary of exposure pathways and receptors is included in the following paragraphs.

Surface soil is the sole contaminated medium at Site 31. Analyses of 24 surface soil samples collected at the site indicate the presence of 10 VOCs, 3 SVOCs, 10 PCBs, 5 pesticides, and 23 inorganic chemicals. Aroclor-1260 was detected at a maximum concentration of 1.4 mg/kg. Concentrations of several inorganic chemicals exceeded two times the background concentrations for these chemicals. Lead was detected at a maximum concentration of 1,890 mg/kg, mercury at a maximum of 8.8 mg/kg, and silver at a maximum concentration of 154 mg/kg.

Based on the high levels of inorganic chemicals detected in the soils, risks to terrestrial ecological receptors at the sludge drying bed disposal areas may be a concern.

Area A. Area A contains the NAS Whiting Field Sewage Treatment Plant, and the area is primarily industrial. No ecological risk evaluation is proposed in this area because no exposures to ecological receptors are expected.

Areas B, C, and D. These three areas are all open grasslands located southwest of the South Field flightline. A concrete-lined drainage ditch (ditch "W") that receives runoff from the South Field is located between Areas B and C. Reportedly, runoff from Areas B and C does not enter this drainage ditch. To the southeast of the ditch, a drainage swale begins in Area C and eventually discharges into Clear Creek. No surface water has been observed in Area C during site visits.

Maximum concentrations of PCBs, lead, mercury, and silver were detected within Area C.

Areas E and F. These two areas are located northeast of the South Field flightline area. Areas E and F are both open grasslands. A small drainage ditch, which drains toward OU 5, is located to the west of Areas E and F.

Initial screening indicated slight exceedances of background screening values for manganese, silver, and zinc at Site 31F. However, these levels may be below those expected to result in adverse ecological effects.

Based on the above overview, recommendations for the ecological risk assessment have been made for the following four groups of ecological receptors: terrestrial wildlife (mammals, birds, reptiles and amphibians), aquatic life (fish, amphibians, reptiles, invertebrates, and plants), terrestrial plants, and terrestrial invertebrates.

5.2 ECOLOGICAL HAZARD ASSESSMENT AND SELECTION OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN (ECPCs). The hazard assessment will include a review of analytical data and selection of ECPCs. ECPCs represent the analytes detected in environmental media (surface soil, surface water, and sediment) that are considered in the risk assessment process. The ECPCs are assumed to be associated with hazardous waste practices at OUs 3, 4, 5, and 6 and could present a potential risk for ecological receptors.

Pursuant to USEPA (1989c; 1989d) national guidance, analytical data for each site at NAS Whiting Field will be evaluated to determine their validity for use in risk assessment. Historical nonvalidated data will not be used in the ecological assessment. ECPCs will be selected using the analytical data summary statistics. For each site, ECPCs will be selected for each medium of concern. Analytes will be excluded as ECPCs if:

- they are common laboratory contaminants and site concentrations are less then 10 times the maximum detected in any blank,

- they are not common laboratory contaminants and site concentrations are less than five times the maximum amount detected in any blank,

- they are detected in 5 percent or less of the samples analyzed, or

- the maximum detected concentration is less than two times the average concentrations detected in respective background samples.

ECPCs for aquatic life for surface water and sediment will be screened based on an additional step. Analytes in sediment will be excluded as ECPCs if the maximum concentration detected is lower than the USEPA screening values and Florida standards and guidance values for sediment. Analytes in surface water will be excluded as an ECPC if the maximum concentration detected is lower than the USEPA screening values and Florida standards and guidance values for surface water.

Calcium, magnesium, potassium, and sodium will be excluded as ECPCs for surface water, surface soil, and sediment as they are considered to be essential nutrients. Iron is a natural, major component of soil and will not be considered an ECPC for surface soil or sediment. Iron is, however, potentially toxic in the aquatic environment and will be included in the ECPC selection process for aquatic receptors for surface water.

Tentatively identified compounds will be evaluated based on suspected presence at each site under consideration, migration potential via each of the identified exposure pathways, and the chemical's toxicity. A list of tentatively identified compounds of concern will be formulated after consideration of these factors. The tentatively identified compounds of concern will be evaluated qualitatively in the ecological assessment.

<u>5.3 ECOLOGICAL EXPOSURE ASSESSMENT</u>. Exposure assessment is the process of estimating or measuring the amount of an ECPC in environmental media to which an ecological receptor may be exposed. The following subsections discuss how contaminant exposures will be estimated or measured for aquatic life, terrestrial and wetland wildlife, terrestrial plants, and terrestrial invertebrates at OUs 3, 4, 5, and 6.

<u>5.3.1 Identification and Characterization of Ecological Receptors and Habitat</u>
Potential ecological receptors at OUs 3, 4, 5, and 6 include terrestrial and wetland wildlife, plants, and invertebrates. Wildlife receptors include reptiles, amphibians, birds, and mammals. Potential wetland receptors include plants, algae, invertebrates, amphibians, reptiles, and fish. Some potential receptors spend time in both aquatic and terrestrial habitats (amphibians for example). Wetland receptors are present in the Clear Creek floodplain adjacent to OU 4. Wetland receptors may also be present in a drainage ditch at Site 31C of OU 6, although this stream is intermittent and may not support aquatic life. Further identification of potential ecological receptors will be made following the qualitative field survey and literature review.

As part of the BERA, a literature review will be conducted to evaluate the major floral and faunal receptors and ecological community types likely to be encountered at NAS Whiting Field. Existing information sources related to flora, fauna, and ecological communities in the area will be reviewed, and standard taxonomic sources and references will be identified. Following the information review, a field reconnaissance program will be initiated to characterize the terrestrial, wetland, and aquatic habitats at NAS Whiting Field. The qualitative ecological survey will identify and verify major vegetative cover types and dominant taxa at OUs 3, 4, 5, and 6. Potential ecological receptors will be identified based on information obtained during the qualitative ecological field survey and literature review. Information will also be collected to describe the wetland communities present near Site 16 within OU 4.

Following the information review, a limited field reconnaissance program will be initiated to characterize the aquatic, wetland, and terrestrial habitats at and in the vicinity of each site. This field program will involve a site walkover by a wetland-aquatic specialist and a terrestrial ecologist who will identify and verify major vegetative cover types and dominant taxa at the site.

During the initial walkover, sites without major ecological exposure pathways will be identified. These sites will include sites that are paved, covered with buildings, or otherwise provide minimal ecological habitat. Unless future exposure pathways are identified at these sites (i.e., future groundwater discharge to surface water bodies), no additional ecological field characterization will be conducted at sites without complete ecological exposure pathways.

At those sites complete ecological exposure pathways, qualitative belt and/or line transect surveys of vegetative community types will be conducted; each identified cover type will be characterized through the use of a minimum of three transects per ecological cover type. Observations of wildlife use of the site will be collected during the qualitative vegetative survey.

At each site with complete ecological exposure pathways, limited habitat mapping will be completed. All cover types, including wetland, will be identified on not-surveyed-to-scale ecological cover type maps for each site. Maps will include known or suspected locations of rare and endangered species and critical habitats. Standard cover type descriptions such as those provided by the Florida Natural Areas Inventory will be used to describe cover types.

Observed evidence of ecological stress in plant populations (yellowing, wilting, insect infestations, etc.) and animal populations (disease, parasitism, death, and reduced diversity or abundance) will be noted. Any State or federally listed threatened rare, or endangered species identified during the survey will be documented.

<u>5.3.2 Identification of Exposure Pathways</u> Exposure pathways will be identified at each site based on information generated in the ecological survey. Exposure pathways describe how ecological receptors may come into contact with contaminated media and include: (1) the contaminant source, (2) the means of transport from source to environmental medium (soil, water, or air), (3) the point of receptor contact (soil, water, or food), and (4) the exposure route (e.g., ingestion, dermal contact, or inhalation).

<u>Wetland and Aquatic Receptors</u>. Wetland and aquatic environments potentially exposed to contamination from waste sites include the Clear Creek floodplain as it is impacted by Site 16 (OU 4) and a drainage ditch at Site 31C (OU 6).

Organisms potentially exposed to contamination include fish, invertebrates, algae, and other aquatic plants, reptiles, birds, mammals, and amphibians. Potential exposure pathways for aquatic receptors include direct contact with surface water and sediment. Aquatic receptors may also be exposed to contamination in sediment as the result of ingestion of the sediment. This pathway will, however, only be evaluated if information is available on the amount of sediment ingested by aquatic organisms and the toxicity of contaminants to aquatic life via the ingestion exposure route.

Terrestrial Wildlife. Terrestrial habitats at each of the 4 OUs will be identified and characterized on the basis of field surveys and other available information. The qualitative field surveys will include identification of vegetative cover types and any wildlife encountered. The primary potential exposure routes for terrestrial wildlife are ingestion of contaminated surface water or surface soil, and ingestion of food items that are contaminated as a result of accumulation of contamination from the soil or sediments. Exposures related to dermal contact are possible but will not be evaluated because fur, feathers, or chitinous exoskeletons limit the transfer of contamination across the dermis. Exposures related to inhalation of dust or vapors are also possible but will not be evaluated because this pathway is generally considered an insignificant route of exposure except in unusual circumstances, such as following a spill or release.

A subset of species identified during the literature review and qualitative field survey will be selected to represent the terrestrial wildlife populations inhabiting the OUs and surrounding areas. Representative species will be chosen to represent the species most likely to be exposed to high contaminant concentrations because of their position in the food web, diet (ingestion rate and food type), home range (contained within the area of soil contamination), and body size. The species selected are assumed to be representative of other species within the same trophic level.

For each of the representative species, information on life history will be collected, including diet, average body weight, food ingestion rates, water ingestion rates, home range, and exposure durations (percent of year that a receptor may reside at the site). Table 5-1 contains a preliminary list of terrestrial receptors to be evaluated at the OU 3, 5, and 6 sites.

Table 5-1
Toxicity Tests to Be Completed at Operable Units 3, 5, and 6

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
NAS Whiting Field
Milton, Florida

Target Species		Surface Soil				
Common Name	Scientific Name	OU 3		OU 5		OU 6
		Site 17	Site 18	Site 10	Site 11	Site 31C
Chironomid midge	*Chironomus tentans*	0	0	0	0	0
Amphipod	*Hyalella azteca*	0	0	0	0	0
Earthworm [1, 2]	*Eisenia foetida*	5 - 10	5 - 10	5 - 10	5 - 10	5 - 10
Lettuce seed [1]	*Lactuca sativa*	5 -10	5 - 10	5 - 10	5 - 10	10

[1] Based on the results of the screening level toxicity tests, surface soil dilution series testing may occur with these species.
[2] Earthworm bioaccumulation data will be collected at all selected sites.

Terrestrial Plants and Invertebrates. Terrestrial plants and soil invertebrates may be exposed to contamination in surface soil by direct contact with soil. Terrestrial invertebrates may also be exposed to contamination as a result of incidental ingestion of the soil.

5.3.2.1 **Chemical Exposure Levels** Exposure concentrations for ecological receptors at OUs 3, 4, 5, and 6 will include the maximum and average concentrations of ECPCs measured in surface water, sediment, or surface soil at respective sampling locations. When sufficient data are available in accordance with USEPA Region IV Guidance (USEPA, 1991a), the 95th percent upper confidence limit on the average will serve as the exposure point concentration (EPC). The actual amount of an ECPC taken in by a receptor species as the result of indirect or direct ingestion is dependent upon the habits of the species. A simple model will be used to predict dietary exposures for each receptor species.

5.3.3 Toxicity Testing No biological sampling or toxicity testing has been completed as part of the RI process at NAS Whiting Field. Recommendations for toxicity testing have been made based on the brief contaminant screening overview presented in the Problem Formulation section. Table 5-1 presents the toxicity tests proposed in this workplan.

Terrestrial. Laboratory toxicity tests that will be completed on surface soil samples collected from areas exhibiting stressed vegetation or surface staining. These toxicity tests will include a lettuce seed germination test and a 14-day earthworm survival test (Green et al., 1989). The objective of the screening level toxicity tests is to obtain laboratory data to evaluate the potential for adverse effects associated with exposure of the earthworm species (*Eisenia foetida*) and lettuce seed (*Lactuca sativa*) to NAS Whiting Field surface soils. Soil sampling for analytical chemistry analysis and toxicity testing will be conducted concurrently, allowing for identification and evaluation of chemical, physical, and biological stressors in the ecological risk assessment. Data from the toxicity tests will be used to evaluate ecological risks to plant and invertebrate species.

Fourteen-day subacute earthworm studies will be conducted to provide a screening level spatial distribution of toxicity at the following sites: Sites 10 and 11 within OU 5, and Site 31C within OU 6. Earthworm mortality, growth, and health assessments will be conducted on test days 0, 7, and 14. At test termination, mortality and percent weight loss or gain data for earthworms exposed to each soil sample shall be determined. Statistical analyses to assess the significance of any differences in survival and growth between the reference sample and/or negative control soil sample and the site soil samples shall be performed.

Analyses of contaminant concentrations in plant and/or animal tissue provide a direct measurement of contaminant exposure for ecological receptors. In order to determine bioaccumulation of pesticides or inorganic chemicals by terrestrial organisms, earthworms will be reared on NAS Whiting Field surface soils for an additional 14 days beyond the 14-day toxicity test described above. Following the 28-day study duration, earthworms from these samples will be frozen and shipped to an analytical laboratory for chemical analysis.

At the same OU 3, 4, 5, and 6 sites, 120-hour lettuce seed germination studies shall be conducted to provide a screening level spatial distribution of toxicity. At test termination, the percent germination for lettuce seeds shall be determined for each sample and the control(s). Statistical analyses to assess the significance of any differences in survival between the reference sample and/or negative control soil sample and the site soil samples shall be performed.

Depending on the results of the Phase I screening level bioassays, a limited dilution series bioassay study may be conducted using one surface soil sample from the original collected samples at OUs 3, 4, 5, and 6. The dilution experiments will be used to calculate no observed effect concentrations (NOECs) and Lowest Observed Effect Concentrations (LOECs) and, if necessary, the median lethal concentration [LC_{50}] to the test species evaluated in the Phase I investigation (i.e., *L. sativa* and *E. foetida*).

The dilution series will employ surface soil from the selected stations diluted with a range of reference surface soil. Potential surface soil dilutions include 100 percent, 50 percent, 25 percent, and 12.5 percent; however, the lower range of dilutions may not be required if NOECs and LOECs are determined at the higher end of the range. The results of the surface soil dilution series will be used to help establish remedial goals for NAS Whiting Field surface soil.

Aquatic. In order to determine effects of contaminated sediments from Site 16 on aquatic organisms within the Clear Creek floodplain, controlled whole sediment laboratory toxicity tests are proposed. The objective of the proposed toxicity testing is to obtain laboratory data to evaluate the potential for adverse effects associated with exposure of the freshwater invertebrate species *Hyallela azteca* (the amphipod) and *Chironomus tentans* (the chironomid midge) to whole sediment from Site 16. Criteria for selection of sediment samples will include presence of a sheen, odor, or other signs indicating possible presence of contamination.

Five short-term chronic toxicity tests for *Chironomus tentans* and *Hyallela azteca* will be conducted (with whole sediment samples and no dilutions) to provide a screening-level spatial distribution of sediment toxicity at Site 16. The American Society for Testing and Materials (ASTM) *Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates* (E 1383; ASTM, 1993) and the draft USEPA *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates* (USEPA, 1994c) shall be used as the laboratory standard. Specific test protocols outlined in USEPA (1994) for the amphipod (10-day growth and survival) and the midge (10-day growth and survival) shall be followed. Sediment samples for toxicity testing will be stored according to protocols established in the ASTM *Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing* (E 1391-90; ASTM, 1993). Sediment samples for analytical chemistry analysis and toxicity testing shall be conducted concurrently, allowing for identification and evaluation of chemical and physical stressors in the baseline ecological risk assessment.

Statistical analyses shall be performed to assess the significance of any differences in survival and growth between the reference sample and/or negative control sediment sample and the Site 16 whole sediment samples.

5.3.4 Tissue Analysis In addition to the 28-day earthworm bioaccumulation study, bioaccumulation and biomagnification of environmental contaminants in plant tissues may need to be evaluated at Site 31C based on surface soil concentrations of lead, mercury, and silver. Tissue contaminant burden analysis will provide information regarding those compounds that bioaccumulate and/or bioconcentrate in plants that serve as the base of terrestrial food chains. To evaluate plant tissue concentrations at Site 31C, collection of five plant specimens at the site is proposed. Plant tissues will be analyzed for TAL metals. An additional sample will be collected from a reference location in the vicinity of Site 31C.

5.4 ECOLOGICAL EFFECTS ASSESSMENT. The ecological effects assessment describes the potential adverse effects associated with the identified ECPCs to ecological receptors and reflects the type of assessment endpoints selected. The methods that will be used to identify and characterize ecological effects for aquatic and terrestrial receptors are described in the following subsections.

5.4.1 Identification of Endpoints An endpoint is an expected or anticipated effect of a contaminant on an ecological receptor. Assessment endpoints 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 endpoints selected at NAS Whiting Field are conservative, since the purpose of the assessment is to screen for any potential adverse effect to a receptor. Preliminary assessment endpoints have been identified for aquatic receptors, terrestrial wildlife, terrestrial plants, and terrestrial invertebrates, as described below. Table 5-2 summarizes the endpoints to be used in the ecological risk assessment.

Aquatic Receptors. The assessment endpoint for aquatic receptors is the survival and maintenance of a well-balanced benthic macroinvertebrate community structure and function. Survival and maintenance of fish and aquatic plant populations is a second assessment endpoint. The proposed measurement endpoints include laboratory toxicity test results that show reduced growth or adverse effects on reproduction, behavior, or mortality from exposure to contaminated sediment (see Subsection 5.2.3).

Terrestrial Wildlife. The assessment endpoint selected for terrestrial wildlife, plants, and invertebrates is the survival of terrestrial populations and communities within OUs 3, 4, 5, and 6. The measurement endpoints are laboratory toxicity test results reported in the literature that show reduced growth, adverse effects on reproduction, behavior, or mortality, as compared to media contaminant concentrations.

Terrestrial Plants and Invertebrates. The assessment endpoint selected for terrestrial plants and soil invertebrates is the survival, growth, and reproduction of terrestrial invertebrate and plant communities. The measurement endpoints include toxicity testing of earthworms and lettuce seeds with surface soil samples (see Subsection 5.2.3).

5.4.2 Selection of Toxicity Benchmark Values

Aquatic Receptors. Available toxicity benchmarks for each of the ECPCs in surface water will be identified. State of Florida Surface Water Quality Standards and Federal Ambient Water Quality Criteria (AWQC) will be considered. Additional

Table 5-2
Endpoints for Ecological Assessment of Operable Units 3, 4, 5, and 6

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field, Milton, Florida

Medium	Receptor	Assessment Endpoint	Measurement Endpoint
Surface Water	Aquatic life (invertebrates, fish, plants, and amphibians)	Survival and maintenance of benthic macroinvertebrate community structure and function.	Contaminant concentrations in surface water associated with adverse effects to growth, reproduction, or survival of aquatic organisms.
Sediment	Aquatic life (invertebrates, fish, plants, and amphibians).	Survival and maintenance of benthic macroinvertebrate community structure and function.	Field sampling and measurement of macroinvertebrate community structure and function.
		Survival and maintenance of fish, macroinvertebrate, and aquatic plant populations.	Contaminant concentrations in sediment associated with adverse effects to growth, reproduction, or survival of aquatic organisms.
			Toxicity testing of sediment collected downgradient of Site 16 within OU 4.
Surface Water, Sediment, and Surface Soil	Terrestrial and wetland wildlife	Survival of wildlife populations and communities.	Oral contaminant exposure concentrations representing adverse effects to growth, reproduction, or survival of mammalian or avian laboratory test populations.
Surface Soil	Terrestrial invertebrates	Survival of terrestrial invertebrate communities.	Survival of earthworms exposed to surface soil samples in laboratory toxicity tests.
			Contaminant concentrations in soils associated with adverse effects to growth, reproduction, or survival of terrestrial invertebrates.
Surface Soil	Terrestrial plants	Survival, reproduction, and growth of plant communities.	Germination of lettuce seeds exposed to surface soil samples in laboratory toxicity tests.
			Contaminant concentrations in soils associated with adverse effects to growth, reproduction, or survival of plants.

aquatic toxicity information for the ECPCs will be obtained from searches of the USEPA Aquatic Information Retrieval (AQUIRE) database.

Wildlife. Reference toxicity values (RTVs) will be determined for each ECPC for both avian and mammalian receptors. The RTV relates the dose of a respective ECPC in an oral exposure with an adverse effect. For each ECPC identified and each representative wildlife species selected, two RTVs will be identified. A lethal RTV will be selected that represents the threshold for lethal effects and is based on an oral LD_{50} (oral dose lethal to 50 percent of a test population). The lethal RTV is one-fifth of the lowest reported LD_{50} for the most closely related test species. One-fifth of an oral LD_{50} value is considered to be protective of lethal effects for 99.9 percent of individuals in a test population. An assumption will be made that the value represented by one-fifth of an oral LD_{50} would be protective of 99.9 percent of individuals within the terrestrial wildlife populations present at OUs 3, 4, 5, and 6 and represents a level of acceptable risk.

A sublethal RTV will also be identified that represents a threshold for sublethal effects. Sublethal effects are defined as those based on the measurement endpoint, impairment of reproduction, growth, or survival. When data are available, RTVs, will be derived separately for avian and mammalian species. If toxicity information is not available for an ECPC, it will not be possible to identify RTVs, and risks associated with the predicted exposure for the respective ECPC cannot be evaluated. The absence of toxicity information for an ECPC will be discussed as part of the uncertainty analyses.

Terrestrial Plants and Invertebrates. In addition to the lettuce seed germination study, terrestrial phytotoxicity data will be obtained from literature sources. Generally, data will be identified that represent significant phytotoxic endpoints, such as reduction in root weight or decreases in top weight. Because data for each ECPC may not be available, surrogate values may be assigned.

In order to assess potential effects of surface soil contaminants on terrestrial invertebrates (e.g., earthworms), toxicity data for earthworms will be obtained from the literature as well as from the site-specific toxicity studies. In general, toxicity data for reproductive effects, which are generally more sensitive toxicity endpoints than lethality effects, will be chosen as benchmarks.

5.5 RISK CHARACTERIZATION. The purpose of the Ecological Risk Characterization will be to combine the results of the exposure and effects assessments to characterize the ecological risks at OUs 3, 4, 5, and 6. This section will identify ecological receptors that might be at risk from site-related contamination. Risks will be characterized for aquatic and wildlife receptors.

Potential risks to wildlife will be described using the following HI approach. The estimated doses or exposure concentrations will be compared to benchmark values identified in the toxicity assessment. Hazard Quotients (HQs) will be calculated for each chemical by dividing the exposure concentration by the benchmark value. These HQs will be summed into a cumulative HI. As the HI increases in magnitude, the likelihood for adverse ecological effects increases. When the estimated HQ is less than 1, the contaminant exposure will be assumed likely to fall below the range considered to be associated with observable adverse effects for growth, reproduction, and survival (of the individual organism). When the HQ or HI is greater than 1, a discussion of the ecological significance will be included. When HIs are greater than 1, an evaluation of the HQs comprising the HI will be completed.

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 sub-lethal 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.

Risks for terrestrial and aquatic receptors at sites that undergo toxicity testing will be characterized based on a weight-of-evidence evaluation of the following factors:

- presence or absence of analytes in surface soil, surface water, or sediment samples;
- concentrations of analytes measured in surface soil, surface water, and sediment samples;
- responses of *E. foetida* and *L. sativa* in surface soil toxicity tests and *H. azteca* and *C. tentans* in the sediment laboratory toxicity tests;
- HIs calculated based on surface soil exposures to wildlife, plants, and invertebrates;
- concentrations of ECPCs in surface water relative to reported toxicity of the ECPC in laboratory tests (AQUIRE information), Federal AWQC, and State Water Quality Standards; and
- concentrations of ECPCs in sediment relative to available sediment quality guidelines.

The samples for surface soil and sediment toxicity testing and chemical analysis are planned to be collected concurrently and split for the two separate analyses; therefore, the chemical analyses results for the samples can be used to help interpret the contaminant exposures for the test species (*E. foetida* and *L. sativa* for surface soil; *H. azteca* and *C. tentans* for sediment). If toxicity is observed in any of the toxicity tests, simple linear regressions will be completed to determine if a correlation exists between the concentration of an analyte in sediment or soil samples and the adverse response in the toxicity test.

The ecological risk characterization section will also contain a discussion of visual observations of any ecosystem degradation or other symptoms of environmental stress observed during the qualitative ecological survey.

5.6 UNCERTAINTY ANALYSES. Uncertainties in the Ecological Risk Assessment (ERA) process will be identified and discussed. The emphasis of the uncertainty analyses will be to discuss the assumptions and data gaps of the ERA process that may influence the risk characterization results and assessment conclusions.

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APPENDIX A

HUMAN HEALTH

APPENDIX A-1

HUMAN HEALTH EXPOSURE EQUATIONS

Table A-1
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact Resident (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific		Chemical Specific	
Soil Ingestion Rate	IR_{soil}	200	100	mg/day	[2]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/µg	
Exposure Frequency	EF	350	350	days/year	[2]
Exposure Duration	ED	6	24	years	[2]
Exposure Time [1]	ET	16	16	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Noncancer		6	24	years	[2]
Surface Area	SA	767	5750	cm^2	[3]

See notes at end of table.

Table A-1 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Resident (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Inhalation Rate	IR_{air}	0.833	0.833	m^3/hour	[2]
Body Weight	BW	15	70	kg	[2]
Adherence Factor	AF	1	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[4]
Concentration in Air	CA	Chemical Specific		mg/m^3	See Appendix A-2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Appendix A-2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992.
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Notes:

mg = milligram.
% = percent.
kg = kilogram.
μg = microgram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-2
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Trespasser (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific		Chemical Specific	
Soil Ingestion Rate	IR_{soil}	100	100	mg/day	[2]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/µg	
Exposure Frequency	EF	30	24	days/year	Assumption
Exposure Duration	ED	11	19	years	[2]
Exposure Time [1]	ET	4	4	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Noncancer		11	19	years	[2]

See notes at end of table.

Table A-2 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact Trespasser (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Surface Area	SA	1136	5750	cm^2	[3]
Inhalation Rate	IR_{air}	0.833	0.833	m^3/hour	[2]
Body Weight	BW	40	70	kg	[2,5]
Adherence Factor	AF	1	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[4]
Concentration in Air	CA	Chemical Specific		mg/m^3	See Appendix A-2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Appendix A-2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992.
[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.
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Notes:

mg = milligram.
% = percent.
kg = kilogram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-3
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Site Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 356\ days/year}$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	118 [2]	mg/day	[3]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/µg	
Exposure Frequency	EF	12	days/year	Assumption
Exposure Duration	ED	25	years	[3]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[3]
Noncancer		25	years	[3]
Surface Area	SA	5750	cm^2	[4]
Inhalation Rate	IR_{air}	0.833	m^3/hour	[3]
Body Weight	BW	70	kg	[3]

See notes at end of table.

Table A-3 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Site Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Parameter	Symbol	Adult Value	Units	Source
Adherence Factor	AF	1	mg/cm^2-event	[4]
Absorption Fraction	ABS_d	Chemical Specific	unitless	[5]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Appendix A-2

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario;See Appendix A-2.

[2] Calculated based on the following assumptions from Hawley, J.K., 1985. Assessment of Health Risk From Exposure to Contaminated Soil. Risk Analysis, 5:(4):28.
- -inside surface area of the hand is 14% of total surface area of the hand
  - surface area of hand (male) - 840 cm^2 (USEPA, 1992 [4])
  - inside surface area of hand (male) - 0.14 x 840 cm^2 = 118 cm^2
- - adult ingests soils covering one-half of inside surface area of the hands two times per day
  - 0.5 x 118 cm^2 x 2/day = 118 cm^2;
- Use soil adherence factor of 1 mg/cm^2;
  - 118 cm^2/day x 1 mg/cm^2 = 118 mg/day

[3] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."

[4] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992

[5] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992

Notes:

mg = milligram.
% = percent.
kg = kilogram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-4
exposure Parameters for Surface and Subsurface Soil Ingestion, Inhalation, and Dermal Contact
Excavation Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	480	mg/day	[2]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/µg	
Exposure Frequency	EF	30	days/year	Assumption
Exposure Duration	ED	30	days	[2]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[2]
Noncancer		30	days	[2]
Surface Area	SA	5,750	cm^2	[3]
Inhalation Rate	IR_{air}	2.5	m^3/hour	[2]
Body Weight	BW	70	kg	[2]
Adherence Factor	AF	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific	unitless	[4]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Appendix A-2

See notes on following page.

Table A-4 (Continued)
Exposure Parameters for Surface and Subsurface Soil Ingestion, Inhalation, and Dermal Contact
Excavation Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Appendix A-2.

[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."

[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992

[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Notes: mg = milligram.
% = percent.
kg = kilogram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-5
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact
Occupational Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Soil	CS	Chemical Specific	Chemical Specific	
Soil Ingestion Rate	IR_{soil}	50	mg/day	[2]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor				
Inorganics	CF	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	kg/μg	
Exposure Frequency	EF	250	days/year	[2]
Exposure Duration	ED	25	years	[2]
Exposure Time [1]	ET	8	hours/day	Assumption
Averaging Time	AT			
Cancer		70	years	[2]
Noncancer		25	years	[2]
Surface Area	SA	2300	cm^2	[3]
Inhalation Rate	IR_{air}	0.833	m^3/hour	[2]

See notes at end of table.

Table A-5 (Continued)
Exposure Parameters for Surface Soil Ingestion, Inhalation, and Dermal Contact Occupational Worker (Adult)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Parameter	Symbol	Adult Value	Units	Source
Body Weight	BW	70	kg	[2]
Concentration in Air	CA	Chemical Specific	mg/m^3	See Appendix A-2
Adherence Factor	AF	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical Specific	unitless	[4]

References:

[1] Exposure Time is a parameter used only in Inhalation of Particulate Dust Scenario; See Appendix A-2.

[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."

[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992

[4] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Notes: mg = milligram.
% = percent.
kg = kilogram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-6
Exposure Parameters for Sediment Ingestion and Dermal Contact
Resident (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{sediment} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Sediment	CS	Chemical Specific		Chemical Specific	
Sediment Ingestion Rate	$IR_{sediment}$	200	100	mg/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/μg	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	6	24	years	[1]
Averaging Time	AT				
Cancer		70	70	years	[1]
Noncancer		6	24	years	[1]
Surface Area	SA	767	5750	cm^2	[2]
Body Weight	BW	15	70	kg	[2]
Adherence Factor	AF	1	1	mg/cm^2-event	[2]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[3]

References:

[1] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[2] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[3] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.

Notes: mg = milligram.
kg = kilogram.
μg = microgram.
cm^2 = square centimeter.

Table A-7
Exposure Parameters for Sediment Ingestion and Dermal Contact
Trespasser (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CS \times IR_{sediment} \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Sediment	CS	Chemical Specific		Chemical Specific	
Sediment Ingestion Rate	$IR_{sediment}$	100	100	mg/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
Inorganics	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Organics	CF	1×10^{-9}	1×10^{-9}	kg/μg	
Exposure Frequency	EF	45	45	days/year	Assumption
Exposure Duration	ED	11	19	years	[1]
Averaging Time	AT				
Cancer		70	70	years	[1]
Noncancer		11	19	years	[1]
Surface Area	SA	Site Specific	5,750	cm^2	[2]
Body Weight	BW	40	70	kg	[1,4]
Adherence Factor	AF	1	1	mg/cm^2-event	[2]
Absorption Fraction	ABS_d	Chemical Specific		unitless	[3]

References:

[1] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[2] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992
[3] USEPA, 1992. USEPA Region IV Guidance Memo February 10, 1992.
[4] USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; July 1989.

Notes: mg = milligram.
% = percent.
kg = kilogram.
μg = microgram.
cm^2 = square centimeter.

Table A-8
Exposure Parameters for Surface Water Ingestion and Dermal Contact
Resident (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CW \times IR_{surface\ water} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = PC_{event} \times CW \times CF1 \times CF2$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED \times EV}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 1-6)	Adult Value	Units	Source
Concentration in Surface Water	CW	Chemical Specific		Chemical Specific	
Surface Water Ingestion Rate	$IR_{surface\ water}$	0.13	0.13	liters/day	[1]
Conversion Factor					
	CF1	0.001	0.001	mg/µg	
	CF2	0.001	0.001	liters/cm^3	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	6	24	years	Assumption
Event Frequency	EV	1	1	events/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Noncancer		6	24	years	[2]
Surface Area	SA	Site Specific	5,750	cm^2	[3]
Body Weight	BW	15	70	kg	[2]
Diffusion Depth per Event	PC_{event}	Chemical Specific		cm/event	[4]

References:

[1] USEPA, 1988. Superfund Exposure Assessment Manual; EPA/540//1-88/001; April 1989.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992.
[4] Calculated per USEPA, 1992 [3].

Notes: mg = milligram.
kg = kilogram.
cm^2 = square centimeter.
m^3 = cubic meter.

Table A-9
Exposure Parameters for Surface Water Ingestion and Dermal Contact
Trespasser (Adult and Child)

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$INTAKE_{ing} = \frac{CW \times IR_{surface\ water} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$DA_{event} = PC_{event} \times CW \times CF1 \times CF2$$

$$INTAKE_{dermal} = \frac{DA_{event} \times SA \times EF \times ED \times EV}{BW \times AT \times 365\ days/year}$$

Parameter	Symbol	Child Value (Age 6-16)	Adult Value	Units	Source
Concentration in Surface Water	CS	Chemical Specific		Chemical Specific	
Surface Water Ingestion Rate	$IR_{surface\ water}$	0.13	0.13	liters/day	[1]
Fraction Ingested	FI	100%	100%	unitless	Assumption
Conversion Factor					
	CF1	0.001	0.001	mg/µg	
	CF2	0.001	0.001	liters/cm³	
Exposure Frequency	EF	45	45	days/year	Assumption
Exposure Duration	ED	11	19	years	[2]
Event Frequency	EV	1	1	events/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Noncancer		11	19	years	[2]
Surface Area	SA	Site Specific	5,750	cm²	[3]
Body Weight	BW	40	70	kg	[2,5]
Diffusion Depth per Event	PC_{event}	Chemical Specific		cm/event	[4]

References:

[1] USEPA, 1988. Superfund Exposure Assessment Manual; EPA/540/1-88/001; April 1988.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[3] USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January, 1992.
[4] Calculated per USEPA, 1992 [3].
[5] USEPA, 1989, Exposure Factors Handbook; EPA/600/8-89/043; May 1989.

Notes: mg = milligram. µg = microgram.
kg = kilogram. cm² = square centimeter.

Table A-10
Exposure Parameters for Groundwater Ingestion and Inhalation
Adult Residents

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

$$Intake_{ing} = \frac{CW \times IR_{groundwater} \times CF1 \times EF \times ED}{BW \times AT \times 365\ days/year}$$

$$INTAKE_{inh} = \frac{CA_{air} \times ET \times EF \times ED}{CF2 \times AT \times 365\ days/year}$$

Parameter	Symbol	Adult Value	Units	Source
Concentration in Groundwater	CW	Chemical Specific	µg/liter	
Water Ingestion Rate	IR_{water}	2	liters/day	[2]
Conversion Factor	CF1 CF2	0.001 24	mg/µg hours/day	
Exposure Frequency	EF	350	days/year	[2]
Exposure Duration	ED	30	years	[2]
Averaging Time	AT			
Cancer		70	years	[2]
Noncancer		30	years	[2]
Body Weight	BW	70	kg	[2]
Concentration Shower Air	CA_{air}	See Appendix A-3	µg/m^3	[3]
Exposure Time [1]	ET	0.2	hours/day	[4]

References:
[1] Exposure Time is a parameter used only in inhalation of volatiles while showering; See Appendix A-2.
[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
[3] This parameter is modeled; See Appendix A-3.
[4] USEPA, 1989. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A) EPA/540/1-89/002; December, 1989.

Notes: mg = milligram.
kg = kilogram.
µg = microgram.
m^3 = cubic meter.

APPENDIX A-2

INHALATION OF PARTICULATES FROM SOIL

INTRODUCTION

This evaluation has been conducted to estimate levels of site contaminants that would occur in ambient air as a result of wind erosion at NAS Whiting Field. To estimate atmospheric concentrations of fugitive air contaminants, a three step modelling process was conducted. In the first step, respirable particle-phase emission rates are calculated. In the second, contaminant emission rates on a unit basis are calculated. In the third phase, downwind ambient concentrations are estimated using air dispersion modeling. Each of these steps is discussed below. Calculations for the theoretical site are shown in the attached table (Table A-11).

STEP 1: ESTIMATION OF PM_{10} EMISSIONS FROM WIND EROSION

Emission rates for respirable particle-phase contaminants were estimated using equations developed by the USEPA for wind erosion by Cowherd and others (1985). Airborne respirable particulate matter is defined as particles with an aerodynamic diameter less than or equal to 10 micrometers (μm) and is denoted with the symbol PM_{10}. Ambient air concentrations were then estimated using air dispersion modeling.

The equations presented in Cowherd and others are intended to provide a methodology for rapid assessment of the inhalation exposure to respirable particulate emissions from surface contamination sites under emergency situations. Consequently, the models are based on a number of simplifying assumptions and yield order-of-magnitude estimates of atmospheric concentrations. The results of this quantitative assessment of potential inhalation exposure at this site should be reviewed with this fact in mind.

For estimating emissions from wind erosion for surface areas not completely covered by vegetation, two emission factor equations have been developed by Cowherd and others, 1985. Selection of the appropriate equation depends on whether the contaminated site's surface material is classified as having a "limited reservoir" or an "unlimited reservoir" of erodible surface particles. The critical feature of "unlimited" erosion potential is that contaminated soil is entrained at a lower wind velocity than for the "limited" case. Surface soil containing a high percentage of silts and lacking either vegetation or large nonerodible elements are assumed to contain an unlimited reservoir of surface erodible particles. This is based on the aggregate size distribution of surface particles, which is best determined with a sieve size analysis. In the absence of such an analysis at NAS Whiting Field, an unlimited reservoir was assumed. The application of the unlimited reservoir model to this site represents a conservative case as the surface soil is unlikely to contain a large percentage of silts because of the geological age of the soil (i.e., the majority of the silts have already been eroded).

A conservative estimate of the PM_{10} emission factor (E_{10}) for the contaminated surface with "unlimited" erosion potential was calculated using an emission factor derived by Gillette (1981) based on field measurements of highly erodible soil. The following equation was used:

$$E_{10} = 1x10^{-5}\ (1-V)\ \left(\frac{[u]}{u_t}\right)^3 F(x)$$

where

E_{10}= PM_{10} emission factor (g/m^2-sec)
$1x10^{-5}$= empirical constant (g/m^2-sec)

Table A-11			
Step 1: Calculate PM^{10} Emissions from Wind Erosion			
EQUATION 1			
E^{10} = (1x10-5) x (1-V) x ([u]/ut)3 x F(x)			Cowherd, Eqn. 4-4
where:			
	E^{10}	=	PM^{10} emission factor (g/m2-s)
	1 x 10-5	=	empirical constant
	V	=	fraction of the contaminated surface area with continuous vegetative cover
	[u]	=	mean annual wind speed (m/s) (Cowherd, Table 4-1)
	ut	=	threshold value of wind speed at 7 m (m/s)
	F(x)	=	function plotted in Cowherd, Fig. 4-3
	x	=	dimensionless ratio = 0.866 x ut/[u]
EQUATION 2			
ut = (1/0.4) x ln(z/z0) x u*			Cowherd, Eqn. 4-3
where:			
	z	=	height above surface (m)
	z0	=	roughness height (m)
	u*	=	friction velocity (m/s)
EQUATION 3			
for x>2:			
F(x) = 0.18 x (8x3 + 12x) x (exp(-x2))			Cowherd

Table A-11 (Continued)			
Step 1: Calculate PM^{10} Emissions from Wind Erosion			
Variable	Value	Units	Source
z	7	m	Cowherd
z0	0.02	m	Cowherd, Figure 3-6
u*	0.63	m/s	Assumption
ut	9.14	m/s	Calculated from Equation 2
[u]	3.8	m/s	Cowherd, Table 4-1, Jacksonville, Florida
x	2.13	unitless	Calculated from 0.886 x ut/[u]
F(x)	0.2	unitless	Calculated from Equation 3 or Cowherd Figure 4-3
V	0.6	fraction	Assumption based on site visit
E10	5.68 x 10-8	m/s	Calculated from Equation 1

Table A-11 (Continued)

Step 2: Calculate Contaminant Emission Rate

EQUATION 4

$Q^{10} = f \times E^{10} \times A$ — Cowherd, Eqn.

where:

Q^{10}	=	contaminant emission rate (ug contaminant/s)
f	=	fraction of PM^{10} with contaminant (mg contaminant/kg soil) (assumed to equal soil concentration in mg contaminant/kg soil)
E^{10}	=	PM^{10} emission rate (g PM^{10}/m2-s)
A	=	area (m2)
1	=	conversion (1000 μg contaminant/mg contaminant) x (kg PM^{10}/1000 g PM^{10})

Variable	Value	Units	Source
f	1	mg/kg	Assumption
A	33600	m2	Assumption
E^{10}	5.68 x 10 -8	g PM^{10}/m2-s	Calculated from Step 1 (Equation 1)
Q^{10}	1.91 x 10 -3	μg/s	Calculated from Equation 4

Table A-11 (Continued)

Step 3: Calculate Airborne Contaminant Concentration

EQUATION 5

$$C^{10} = \frac{Q^{10} \times a}{\text{Ventilation Rate}} \qquad \text{Box Model}$$

$$= \frac{Q10 \times a}{U \times H \times W}$$

where:

C^{10}	=	airborne contaminant concentration (μg/m3)
Q^{10}	=	contaminant emission rate (μg/s)
U	=	wind speed (same as [u] from Step 1) (m/s)
H	=	downwind mixing height (m)
W	=	width of area perpendicular to wind (m)
a	=	fraction of 24 hours during which activity occurs

EQUATION 6

H is calculated in an iterative fashion based on the desired value of X from the following equation:

$X = 6.25 \times (z0) \times [(H/z0) \times \ln(H/z0) - 1.58 \times (H/z0) + 1.58]$ Pasquill, 1975

where:

X	=	downwind distance from leading edge of area source to receptor (m)
H	=	downwind mixing height (m)
z0	=	roughness height (same as in Step 1) (m)

Table A-11 (Continued)			
Step 3: Calculate Airborne Contaminant Concentration			
Variable	Value	Units	Source
Q^A10	1.91 x 10 -3	ug/s	Calculated from Step 2 (Equation 4)
a	1	unitless	
U	2.45	m/s	Cowherd, Table 4-1, Jacksonville, Florida (same as [u] from Step 1)
H	0.276	m	Calculated in Equation 6
W	140	m/s	
z0	0.02	m	Cowherd, Figure 3-6 (same as Step 1)
X	1	m	Calculated from Equation 3 or Cowherd, Figure 4-3
C10	2.02 x 10 -5	ug/m3 per mg/kg	Calculated from Equation 6

V= fraction of the contaminated surface area with continuous vegetative cover
[u] = mean annual wind speed (m/s)
u_t = threshold value of wind speed at 7 m (m/s)
F(x) = function to estimate unlimited erosion
x= dimensionless ratio = 0.886 u_t/[u].

and

$$u_t=\frac{1}{0}.4x\ln\frac{z}{z_0}xu^*$$

where

u^*= friction velocity
z = height above surface (m)
z_0 = roughness height (m)

For values of x greater then 2:

$$F(x)=0.18\ (8\ x^3 + 12\ x)\ e^{-x^2}$$

All parameters in the above equation were calculated from site-specific data where possible. The values used in estimating the emission factor for wind erosion are given in Step 1 of Table A-11.

STEP 2. ESTIMATION OF CONTAMINANT EMISSION RATES

Contaminant-specific emission rates were estimated from (1) the PM_{10} emission factors, (2) the mass fraction of contaminant in PM_{10} emissions, and (3) the contaminated surface area. These parameters were used in the following equation to calculate contaminant emission rates (Q_{10}):

$$Q_{10} = 1\ x\ f\ x\ E_{10}\ x\ A$$

where

Q_{10}= contaminant emission rate as PM_{10} (μg/sec)
f = mass fraction of contaminant in PM_{10} emissions
(mg contaminant/kg PM_{10})
E_{10}= PM_{10} emission rate (g PM_{10}/m^2-sec)
A= contaminated surface area (m^2), and
1 = conversion factor (1000 μg contaminant/mg contaminant)*
(kg PM_{10}/1000 g PM_{10})

The values for f were estimated by assuming that the mass fraction of the contaminant in the inhalable particles emitted (PM_{10}) is equal to the mass fraction of the contaminant in the soil. The surface area available for wind erosion was assumed to be the area of the excavation for each scenario.

STEP 3. AIRBORNE CONTAMINANT CONCENTRATION

Air dispersion modeling is used to predict offsite contaminant air concentrations based on the PM_{10} emission rate. Many different forms of dispersion models exist for a variety of applications. For this situation, the box model was selected because it is most appropriate to use when receptors are less than 100 meters from the edge of an area source. The model overpredicts concentrations by a factor of approximately four to six when compared with the Gaussian dispersion model, ISCST, for the "downwind distances" to exposure points of interest in this assessment (McCarthy and Burbank, 1990). The box model is a good screening model for a public health risk assessment because the concentrations estimated with the box model are protective of public health. If no risk is indicated using box model concentrations, the potential for adverse impacts to public health are considered negligible.

The box model is a basic analytical and physical model representing diffusion from an area source. The box encloses the area source and is bounded by the ground as its base and the mixing height (H) of the mean vertical displacement of emissions, which is a function of atmospheric stability and downwind distance to the point of exposure. Within the box, mixing is assumed to be complete. The box has a width (W) equal to the width of the area source, and the box is aligned so that its length lies in the direction of the wind, which passes through its end with a constant velocity (U). The ventilation rate, defined as the volume of air passing through the box, is equal to U x H x W. The downwind mixing height (H) of the box is determined from the following equation presented by Pasquill (1975) for neutral stability:

$$X = 6.25 \; x \; z_0 \; [(\frac{H}{z_0}) \ln(\frac{H}{z_0}) - 1.58 \; (\frac{H}{z_0}) + 1.58]$$

where

- X = downwind distance from the leading edge of the area source to the receptor (m)
- H = downwind mixing height (m)
- z_0 = roughness height (m)

The roughness height, z_0, was selected to be 0.02 meters based on the roughness height of grassland provided by Cowherd and others, 1985. This roughness height provides a more conservative estimate of emissions than assuming nonvegetated conditions. The downwind distance to the receptor is measured to the closest exposure points for potentially exposed populations. For the purposes of this evaluation, a distance of 1 meter was assumed (the receptor is at the source). The ambient 24-hour contaminant concentration (C_{10}) was estimated by the following box model equation:

$$C_{10} = \frac{Q_{10} \; x \; a}{U \; x \; H \; x \; W}$$

where

C_{10}= concentration of contaminant at distance X ($\mu g/m^3$)
Q_{10}= particle-phase emission rate from wind erosion ($\mu g/sec$)
a= fraction of 24 hours during which emissions occur
U= average wind speed (m/sec)
H= downwind mixing height (m)

W= width of area perpendicular to wind (m)

The input values for this equation are shown in Step 3 in Table A-11. This results in a conservative estimate of the 24-hour average concentration of contaminants to which an individual may be exposed at the contaminant source on days in which wind erosion occurs. This concentration, the downwind contaminant concentration resulting from wind erosion, per unit of contaminant soil concentration (C_{10})is multiplied by the concentration of each CPC to obtain downwind contaminant concentrations.

REFERENCES

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Gillette, D.A., 1981, Production of Dust that May Be Carried Great Distances, in Desert Dust: Origin Characteristics, and Effect on Man; edited by T. Pewe; Geological Society of America Special Paper 186.

McCarthy, S.M., and B. Burbank (1990), Assessment of Fenceline Air Concentrations Associated with Construction Activities at Sites with Contaminated Soil, presented at American Waste Management Association - New England Section Conference, Wakefield, MA, February, 1990.

Pasquill, F. (1975), The Dispersion of Materials in the Atmospheric Boundary Layer - The Basis for Generalization, in Lectures on Air Pollution and Environmental Impact Analysis, American Meteorological Society, Boston.

U.S. Environmental Protection Agency (USEPA), 1988, Supplement B to Compilation of Air Pollutant Emissions Factors, Volume I: Stationary Point and Area Sources, USEPA Office of Air Quality Planning and Standards, AP-42, September, 1988.

APPENDIX A-3

CALCULATION OF AIR CONCENTRATIONS USING THE SHOWER MODEL

INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), calculated concentrations of volatile organic compounds (VOCs) in groundwater that could volatilize during a shower. After reviewing the literature, the model selected by ABB-ES to predict indoor (bathroom) concentrations is that presented by Foster and Chrostowski (1987). This theoretical approach is based on the experimental work of Andelman (1985). Andelman measured air concentrations of trichloroethylene and chloroform in a bench-scale shower assembly. Foster and Chrostowski (1987) developed a model from these experimental data. ABB-ES modified the input parameters from the bench-scale design to be representative of a typical bathroom.

CALCULATIONS

Parameter values used in the following equations can be found in Table A-12.

The equation used to calculate air concentrations in the bathroom is shown below:

$$C(voc) = \frac{S}{R} \times (e^{RD_s} - 1) \times e^{-Rt}$$

where

C(voc)	= concentration of VOC in bathroom ($\mu g/m^3$)
S	= VOC generation rate ($\mu g/m^3$-min)
R	= air exchange rate (min^{-1})
D_s	= duration of shower (min)
t	= time at which concentration is being calculated (min)

R, the air exchange rate, is calculated as the volumetric flowrate through the bathroom (m^3/min) divided by the volume of the bathroom (m^3).

S, the VOC source generation rate, is calculated based on the concentration of the contaminant in the water, emission of compound from a droplet, flowrate of water, and volume of room for dilution. S is calculated from the following series of equations:

$$S = \frac{C_{wd} \times FR}{SV}$$

where

C_{wd}	= concentration in water droplet ($\mu g/\ell$)
FR	= flow rate in shower (l/min)
SV	= shower volume (m^3)

Table A-12
Empirical Constants for the Shower Model

Baseline Risk Assessment Workplan
Operable Units 3, 4, 5, and 6
Naval Air Station Whiting Field
Milton, Florida

Constant	Symbol	Value	Unit	Source
Liquid-film mass transfer for CO_2	$Kl(CO_2)$	20	cm/hr	Calculated
Gas-film mass transfer for H_2O	$Kg(H_2O)$	3,000	cm/hr	Calculated
Molar gas constant x temperature	RT	0.024	atm-m^3/mole	
Reference temperature	T1	293	K	
Temperature of shower water	Ts	318	K	Assumption
Viscosity of water at shower temperature	us	0.6178	cp	Calculated
Viscosity of water at reference temperature	u1	0.65	cp	Calculated
Shower droplet free-fall time	ts	1.5	sec	Assumptions
Droplet diameter	d	1	mm	Foster and Chrostowski, 1987
Flow rate in shower	FR	20	ℓ/min	Assumption
Volume of shower area	SV	12	m^3	Assumption
Air exchange rate	R	0.03	min-1	Calculated
Time in shower	Ds	12	min	USEPA, 1989b
Time at which concentration is being calculated	t	12	min	Assumption

Foster, S.A. and P.C. Chrostowski, 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower.

C_{wd} is calculated as follows:

$$C_{wd} = C_{wo} \times [1 - e^{(\frac{-K_{al} \times t_s}{60d})}]$$

where

C_{wo} = concentration in groundwater ($\mu g/\ell$)
K_{al} = temperature correction of the mass transfer coefficient, K_L. ((cm/hr)
t_s = shower water droplet free-fall time (sec)
d = droplet diameter (mm)

The term $K_{al}/60d$ combines both the rate of transfer and the available interfacial area across which volatilization can occur. The value 1/60d equals the specific interfacial area, 6/d, for a spherical shower droplet of diameter d multiplied by conversion factors (hr/3600 sec and 10 mm/cm).

K_{al} is calculated according to:

$$K_{al} = K_L \times [\frac{T_1 \times u_s}{T_s \times u_1}]^{-0.5}$$

where

K_L = mass-transfer coefficient (cm/hr)
T_1 = reference temperature (K)
u_s = viscosity of water at reference temperature (cp)
T_s = temperature of shower water (K)
u_1 = viscosity of water at shower temperature (cp)

K_L is calculated according to:

$$K_L(voc) = \frac{1}{\frac{1}{k_l(voc)} + \frac{RT}{H \times k_g(voc)}}$$

where

$k_l(voc)$ = chemical-specific liquid mass-transfer coefficient (cm/hr)
$k_g(voc)$ = chemical-specific gas mass-transfer coefficient (cm/hr)
RT = molecular gas constant (R) x temperature (T) (atm-m^3/mole)
H = Henry's law constant (atm-m^3/mole)c

The input values of k_l and k_g are based on the mass transfer coefficients of CO_2 and water. They are calculated for the particular compound of interest according to the following equations:

$$k_l(voc) = k_l(CO_2) \times [\frac{44}{MW(voc)}]^{0.5}$$

$$k_g(voc) = k_g(H_2O) \times [\frac{18}{MW(voc)}]^{0.5}$$

where

$k_l(CO_2)$ = liquid mass-transfer coefficient for carbon dioxide (cm/hr)
$k_g(H_2O)$ = gas mass-transfer coefficient for water (cm/hr)
MW(voc) = molecular weight of VOC

ASSUMPTIONS

Several assumptions were made to complete this modeling effort. The more important ones involve the volume of the bathroom and the air exchange rate (see Equations 1 and 2). A bathroom volume of $12m^3$ was assumed. For the purposes of this model, it was also assumed that the air between the shower area and the rest of the bathroom was well mixed. The volumetric flowrate through the bathroom was assumed to be 0.4 m^3/min, which gives an effective air exchange rate of 1.8 air changes/hour. Few measurements have been done on ventilation rate in bathrooms. ABB-ES considers this value to be a conservative estimate given that most homes have air exchange rates of 0.5 to 2.0 changes/hour. Bathrooms may have higher ventilation rates than the entire house due to the effect of local exhaust fans, if present, or the opening of windows.

Another assumption is implicit in the use of Equation 1. This equation calculates VOC concentrations at time (t), which is assumed to equal the duration of shower use (D_S). Thus, the resulting concentrations represent maximum concentrations at the end of the shower. In reality, an individual would experience an integrated exposure that would gradually increase during shower usage and decrease again after the water was turned off. ABB-ES made the simplifying assumption that the peak concentrations would persist for the duration of exposure. This is a conservative assumption that is protective of public health.

REFERENCES

Andelman, J.B., 1985, Inhalation Exposure in the Home to Volatile Organic Contaminants in Drinking Water; *Sci. Total Environ.*; Vol. 47, pp. 443-460.

Foster, S.A. and P.C. Chrostowski, 1987, Inhalation Exposures to Volatile Organic Contaminants in the Shower; paper presented at the 80th Annual Meeting of the Air Pollution Control Association; New York, New York; June 1987.

APPENDIX A-4

DERMAL GUIDANCE SUMMARY

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO WATER

The absorbed dose is calculated per the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report, January 1992. The permeability constant approach is used for dermal exposures to contaminants in water.

The **steady state approach for inorganics** is used here. The dose absorbed per unit area per event is:

$$DA_{event} = PC_{event} \times C_w \times CF_1 \times CF_2$$

where:

DA_{event} = Dose absorbed per unit area per event (mg/cm^2-event)

$$PC_{event} = K_{pw} \times t_{event}$$

PC_{event} = Diffusion depth per event (cm/event)
K_{pw} = Permeability constant from water (cm/hr)
C_w = Concentration of chemical in water ($\mu g/\ell$)
t_{event} = Duration of a single event (hr/event)
CF_1 = Units conversion factor (liter/ 10^3 cm^3)
CF_2 = Units conversion factor (mg/ 10^3 μg)

The **"unsteady-state approach for organics"** is used here. The dose absorbed per unit area per event is:

$$DA_{event} = PC_{event} \times C_W \times CF_3 \times CF_4$$

$$PC_{event} = 2 \times K_p \times (6 \tau t_{event} / \pi)^{0.5}$$

where: $t < t^*$

and

$$DA_{event} = PC_{event} \times C_W \times CF_5 \times CF_6$$

$$PC_{event} = K_p \times ((t_{event} / (1 + B)) + 2\tau ((1 + 3B) / (1 + B))$$

where

$t > t^*$ and

where

K_p = Permeability constant from water (cm/hr)
C_w = Concentration of chemical in water ($\mu g/\ell$)
τ = $l_{sc}^2 / 6 D_{sc}$ (hr)
l_{sc} = Thickness of stratum corneum (10 um)
D_{sc} = Stratum corneum diffusion coefficient (cm^2/hr)
t_{event} = Duration of a single event (hr/event)
π = Pi (dimensionless)
t^* = Time to reach steady state (hr)
B = Octanol water partition coefficient divided by 10^4 (dimensionless)
CF_3 = Units conversion factor ($mg/10^3\ \mu g$)
CF_4 = Units conversion factor ($liter/10^3\ cm^3$)
CF_5 = Units conversion factor ($mg/10^3\ \mu g$)
CF_6 = Units conversion factor ($liter/10^3\ cm^3$)

For a given compound, the values for B, K_p τ, and t^* can be found in Table 5-8 of the dermal guidance document (USEPA, 1992).

Once the dose per event (DA_{event}) is calculated, the dermally absorbed dose (DAD) for use in risk calculations can be derived as follows:

Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$DAD_{adult} = DA_{event} \times EV \times EF \times ED \times SA\ /\ BW \times AT$$

For children, to account for changing surface areas and bodyweights, the dermally absorbed dose is calculated as follows:

$$DAD_{child} = (DA_{event} \times EV \times EF\ /\ AT) \sum_{i=m}^{n} (SA_i \times ED_i\ /\ BW_i)$$

where

EV = Event frequency (events/day)
EF = Exposure frequency (days/year)
AT = Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i = Surface area exposed at age i (cm^2)
ED_i = Exposure duration at age i (years)
BW_i = Bodyweight at age i (kg)

Bathing or Swimming Exposure. For bathing and swimming, USEPA recommends that whole body surface area be used to represent skin surface area available for contact with water. For adults, using 50^{th} and 95^{th} percentile whole body SA values, the default SA values are 20,000 cm^2 and 23,000 cm^2 (Table A-13). For children, the default values for each age group would be equal to the 50th percentile and 95^{th} percentile whole body SA values. Estimated bodyweights are the average of the 50^{th} percentile female and male weights (Table A-13).

Table A-13
Exposure Parameters for Dermal Contact With Water

Age	Total Surface Area (cm^2)				Body Weight (kg)			Derivation of DAevent (Dose absorbed / unit area / event)			
	Bathing and Swimming		Wading (25% Total Surface Area)								
	Male 50th Percentile[1]	Male 95th Percentile[1]	Male 50th Percentile	Male 95th Percentile	Male 50th Percentile[2]	Female 50th Percentile[2]	Average of Male and Female	Swimmer 50th Percentile	Swimmer 95th Percentile	Wader 50th Percentile	Wader 50th Percentile
1<23	5398	6104	1350	1526	11.5	10.5	11	490.7	554.9	122.7	138.7
2<3	6030	6820	1508	1705	13.4	12.6	13	463.8	524.6	116.0	131.2
3<4	6640	7640	1660	1910	15.3	14.6	14.95	444.1	511.0	111.0	127.8
4<5	7310	8450	1828	2112.5	17.4	16.4	16.9	432.5	500.0	108.1	125.0
5<6	7930	9180	1983	2295	19.3	18.8	19.05	416.3	481.9	104.1	120.5
6<7	8660	10600	2165	2650	21.9	21	21.45	403.7	494.2	100.9	123.5
7<8	9360	11100	2340	2775	24.4	23.5	23.95	390.8	463.5	97.7	115.9
8<9	10000	12400	2500	3100	27.3	27.3	27.3	366.3	454.2	91.6	113.6
9<10	10700	12900	2675	3225	29.7	29.6	29.65	360.9	435.1	90.2	108.8
10<11	11800	14800	2950	3700	34.5	34.3	34.4	343.0	430.2	85.8	107.6
11<12	12300	16000	3075	4000	36.4	40	38.2	322.0	418.8	80.5	104.7
12<13	13400	17600	3350	4400	42.1	45.2	43.65	307.0	403.2	76.7	100.8
13<14	14700	18100	3675	4525	47.7	48.6	48.15	305.3	375.9	76.3	94.0
14<15	16100	19100	4025	4775	55.5	52.8	54.15	297.3	352.7	74.3	88.2
15<16	17000	20200	4250	5050	60.2	53.9	57.05	298.0	354.1	74.5	88.5
16<17	17600	21600	4400	5400	63.6	55.3	59.45	296.0	363.3	74.0	90.8
17<18	18000	20900	4500	5225	65.7	58.3	62	290.3	337.1	72.6	84.3
18<75	20000	23000	5000	5750	75.9	61.5	68.7	291.1	334.8	72.8	83.7
Child - 6 years old (Sum ages 1<7)								2651.3	30066.6	662.8	766.7
Child from 2 to 8 years (Sum ages 2<8)								2551.4	2975.2	637.8	743.8
Child from 6 to 16 years (Sum ages 6<17)								3690.4	4545.3	922.6	1136.3
Adult - 24 years old (18<75 multiplied by 24)								6986.9	8034.9	1746.7	2008.7
Adult - 30 years old (Sum Child+ Adult)								9638.2	11101.6	2409.5	2775.4

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3).
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 5A-3).
[3] SAs based on equation SA = K x BW(2/3). K calculated from age 2<3 data.

Values of

$$\sum_{i=m}^{n} (SA_i \times ED_i / BW_i)$$

for commonly used age ranges are presented in Table A-14.

Table A-14
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed While Bathing or Swimming[1]

Age Range	Duration of Exposure to Water	Sum of terms for Average Case	Sum of Terms for Reasonable Maximum Exposure
		(50th Percentile)	(95th Percentile)
	(Bathing or Swimming)	(area x duration/bodyweight)	(area x duration/bodyweight)
		(cm^2-yr/kg)	(cm^2-yr/kg)
1 thru 6	6 years	2651.3	3066.6
2 thru 8	6 years	2551.4	2975.2
6 thru 16	11 years	3690.4	4545.3
18 thru 41	24 years	6986.9	8034.9
1 thru 30	30 years	9638.2	11101.6

[1] See Table A-13.

Wading Exposure. For wading, it is assumed that the entire surface area of the feet, lower legs, and hands is exposed to the surface water during the entire exposure event. This assumption is for shallow water situations. Averaging surface areas over the 6 childhood years yields the following: hands represent 5.5 percent of total body surface area, lower leg represents 12.8 percent of total body surface area, and the feet represent 7 percent of total body surface area. Therefore, the feet, lower legs, and hands represent approximately 25 percent of total body surface area, for children ages 1 through 6 (Table A-15). This value is the same value which USEPA identifies as the percent of total body surface area which is available for soil contact (USEPA, 1992). This value, 25 percent of total body surface area, is used here to represent surface area available for waders of all ages. Table A-16 presents the wading information for typically evaluated age groups.

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO SOIL

The absorbed dose is calculated per the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report, January 1992. The calculation of the estimated dermally absorbed dose per unit area per event is:

$$DA_{event} = C_{soil} \times \bar{AF} \times ABS \times CF$$

where

DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
C_{soil}	=	Contaminant concentration in soil (mg/kg)
AF	=	Adherence factor of soil to skin (mg/cm^2-event)
ABS	=	Absorption fraction (dimensionless)
CF	=	Units conversion factor (10^{-6} kg/mg)

Table A-15
Surface Area Exposed to Surface Water for Waders (Child)

Age	Mean Percentage (%) of Whole Body Surface Area			95th Percentile Whole Body Surface Area[3] (cm^2)	Estimated Surface Area (cm^2) (Mean % Whole Body SA x Whole Body SA)			Estimated SA for Hands, Lower Legs, and Feet Ages 1 thru 6 (cm^2)
	Hands[1]	Lower Legs[2]	Feet[1]		Hands[1]	Lower Legs[2]	Feet[1]	
1<2	5.68	12.8	6.27	46104	346.7	781.3	382.7	1510.7
2<3	5.3	12.8	7.07	6820	361.5	873.0	482.2	1716.6
3<4	6.07	12.8	7.21	7640	463.7	977.9	550.8	1992.5
4<5	5.7	12.8	7.29	8450	481.7	1081.6	616.0	2179.3
5<6	5.7	12.8	7.29	9180	523.3	1175.0	669.2	2367.5
6<7	4.71	12.8	6.9	10600	499.3	1356.8	731.4	2587.5
Mean (Age 1 thru 6)	5.5	12.8	7.0	8132	449.4	1040.9	569.6	2060.0

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4-3).
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4-2).
The percent of whole body surface area for the lower legs is taken from Table 4-2 (adults) because no value for children is reported.
[3] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3)
[4] See Table A-13.

Table A-16
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed While Wading[1]

Age Range	Duration of Exposure to Water (Wading)	Sum of terms for Average Case (50th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)	Sum of Terms for Reasonable Maximum Exposure (95th Percentile) (area x duration/ bodyweight) (cm^2-yr/kg)
1 thru 6	6 years	662.8	766.7
2 thru 8	6 years	637.8	743.8
6 thru 16	11 years	922.6	1136.3
18 thru 41	24 years	1746.7	2008.7
1 thru 30	30 years	2409.5	2775.4

[1] See Table A-13.

Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$DA_{adult} = DA_{event} \times EF \times ED \times SA \ / \ BW \times AT$$

For children, to account for changing surface areas and bodyweights, the dermally absorbed dose is calculated as follows:

$$DA_{child} = (DA_{event} \times EF \ / \ AT) \sum_{i=m}^{n} (SA_i \times ED_i \ / \ BW_i)$$

where

EF	=	Exposure frequency (events/year)
AT	=	Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Bodyweight at age i (kg)

For the typical case, USEPA recommends SA for head and hands only and for the "reasonable worst case," the SA of the head, hands, forearms, and lower legs as the SA available for contact with soil. USEPA simplifies these assumptions by saying that 25 percent of the total body surface area would be available for soil contact. For adults, using 50^{th} and 95^{th} percentile whole body SA values, the default SA values are 5000 cm^2 and 5800 cm^2 (Table A-17). For children, the default values for each age group would be equal to 25 percent of the 50^{th} percentile and 95^{th} percentile whole body SA values. Estimated bodyweights are the average of the 50^{th} percentile female and male weights (Table A-17).

Values of

$$\sum_{i=m}^{n} (SA_i \times ED_i \ / \ BW_i)$$

for commonly used age ranges are presented in Table A-18.

Table A-17
Exposure Parameters for Dermal Contact With Soil

Age	Total Surface Area (cm^2)		SA Available for Soil Contact (cm^2) (.25 x Total Surface Area)		Body Weight (kg)			Derivation of DAevent (Dose absorbed/unit area/event)	
	Male 50th Percentile[1]	Male 95th Percentile[1]	Male 50th Percentile	Male 95th Percentile	Male 50th Percentile[2]	Female 50th Percentile[2]	Average of Male and Female	50th Percentile	95th Percentile
1<23	5398	6104	1350	1526	11.5	10.5	11	122.7	138.7
2<3	6030	6820	1508	1705	13.4	12.6	13	116.0	131.2
3<4	6640	7640	1660	1910	15.3	14.6	14.95	111.0	127.8
4<5	7310	8450	1828	2113	17.4	16.4	16.9	108.1	125.0
5<6	7930	9180	1983	2295	19.3	18.8	19.05	104.1	120.5
6<7	8660	10600	2165	2650	21.9	21	21.45	100.9	123.5
7<8	9360	11100	2340	2775	24.4	23.5	23.95	97.7	115.9
8<9	10000	12400	2500	3100	27.3	27.3	27.3	91.6	113.6
9<10	10700	12900	2675	3225	29.7	29.6	29.65	90.2	108.8
10<11	11800	14800	2950	3700	34.5	34.3	34.4	85.8	107.6
11<12	12300	16000	3075	4000	36.4	40	38.2	80.5	104.7
12<13	13400	17600	3350	4400	42.1	45.2	43.65	76.7	100.8
13<14	14700	18100	3675	4525	47.7	48.6	48.15	76.3	94.0
14<15	16100	19100	4025	4775	55.5	52.8	54.15	74.3	88.2
15<16	17000	20200	4250	5050	60.2	53.9	57.05	74.5	88.5
16<17	17600	21600	4400	5400	63.6	55.3	59.45	74.0	90.8
17<18	18000	20900	4500	5225	65.7	58.3	62	72.6	84.3
18<75	20000	23000	5000	5750	75.9	61.5	68.7	72.8	83.7
Child - 6 years old (Sum ages 1<7)								662.8	766.7
Child from 2 to 8 years (Sum ages 2<8)								637.8	743.8
Child from 6 to 16 years (Sum ages 6<17)								922.6	1136.3
Adult - 24 years old (18<75 multiplied by 24)								1746.7	2008.7
Adult - 30 years old (Sum Child+ Adult)								2409.5	2775.4

[1] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 4B-3)
[2] USEPA, 1989. Exposure Factors Handbook. EPA/600/8-89/043 (Table 5A-3)

Table A-18
Summary of Age Adjusted, Bodyweight-Normalized Surface Area Exposed to Soil[1]

Age Range	Duration of Exposure to Soil	Sum of terms for Average Case (50th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)	Sum of Terms for Reasonable Maximum Exposure (95th Percentile) (area x duration/bodyweight) (cm^2-yr/kg)
1 thru 6	6 years	662.8	766.7
2 thru 8	6 years	637.8	743.8
6 thru 16	11 years	922.6	1136.3
18 thru 41	24 years	1746.7	2008.7
1 thru 30	30 years	2409.5	2775.4

1 See Table A-17.

REFERENCES

U.S. Environmental Protection Agency (USEPA), 1989, Exposure Factors Handbook; Office of Health and Environmental Assessment, Washington, D.C.; USEPA/600/8-89/043; 1989.

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