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FINAL REMEDIAL INVESTIGATION REPORT VOLUME 1 OF 11 SITE 41 NAS PENSACOLA  
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ENSAFE/ALLEN AND HOSHALL

**FINAL REMEDIAL INVESTIGATION REPORT  
SITE 41 — OPERABLE UNIT 16 — NAS PENSACOLA WETLANDS**

**NAVAL AIR STATION  
PENSACOLA, FLORIDA**

**SOUTHNAVFACENGCOM  
CONTRACT NUMBER: N62467-89-D-0318**

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**Prepared for:**



**Comprehensive Long-Term  
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## List of Abbreviations

The following list contains many of the acronyms, initials, abbreviations, and units of measure used in this report.

1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-Dichloroethene
4,4'-DDD	4,4'-Dichlorodiphenyldichloroethane
4,4'-DDE	4,4'-Dichlorodiphenyldichloroethylene
4,4'-DDT	4,4'-Dichlorodiphenyltrichloroethane
ABB	Asea Brown Boveri
ABS <sub>GI</sub>	Gastrointestinal absorption factor
AL	Action Level
ARARs	Applicable and Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AVGAS	Aviation gas
BEDS	Biological effects dataset
BEHP	Bis(2-ethylhexyl)phthalate
BEQs	Benzo(a)pyrene Equivalents
BCF	bioconcentration factor
bls	below land surface
BNA	Base-neutral/acid extractable
BRA	Baseline Risk Assessment
BSAF	Biota Sediment Accumulation Factor
BTEX	Benzene, toluene, ethylbenzene, xylene
BW	Body Weight (mean body weight of receptor in kg)
C <sub>t</sub>	Fish tissue contaminant concentration
CCRREM	Canadian Council of Resource and Environment Ministers
CDF	Chlorinated dibenzofuran
CDI	Chronic Daily Intake
CEC	Cation-Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COC	Chemical of Concern
COPC	Chemical of Potential Concern
cPAH	Polycyclic Aromatic Hydrocarbon
Cr III	Trivalent Chromium
CSAP	Comprehensive Sampling and Analysis Plan
CTL	Cleanup Target Level
%D	Percent Difference
DD	Decision Document
DOC	Dissolved Organic Carbon
DQO	Data Quality Objective

E/A&H	EnSafe/Allen & Hoshall
E&E	Ecology and Environment, Inc.
ECD	Electron Capture Detector
EFDSOUTH	Southern Division, U.S. Navy, Naval Facilities Engineering Command
EnSafe	EnSafe Inc.
EqP	Equilibrium Partitioning Quotient
ERA	Ecological Risk Assessment
ERED	U.S. Army Corps of Engineers Environmental Residue Effects Database
ERL	Effects Range Low
ERM	Effects Range Mean
f	Fraction of diet composed of fish tissue
FAC	Florida Administrative Code
FCM	Food Chain Multiplier
FDEP	Florida Department of Environmental Protection
FNAI	Florida Natural Areas Inventory
FOTW	Federally Owned Treatment Works
f <sub>oc</sub>	Organic Carbon Content Fraction
FS	Feasibility Study
g/cm <sup>3</sup>	Grams per Cubic Centimeter
g/mole	Grams per Mole
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
ICP	Inductively Coupled Plasma
ICS	Interference Check Sample
IDL	Instrument Detection Limit
IR	Installation Restoration/Food ingestion rate of receptor
IRA	Interim Removal Action
IRIS	Integrated Risk Information System
IS	Internal Standard
IWTP	Industrial Wastewater Treatment Plant
K <sub>d</sub>	Normalized Partition Coefficient/Distribution Coefficient
K <sub>oc</sub>	Organic Carbon/Water Partitioning Coefficient
K <sub>ow</sub>	Octanol/Water Partitioning Coefficient
kg	Kilograms
kg BW/day	Kilograms of body weight per day
kg/day	Kilograms per day
kg/L	Kilograms per liter

LCS	Laboratory Control Sample
LOAEL	Lowest-Observed-Adverse-Effects-Level
LUCIP	Land Use Control Implementation Plan
MATC	Maximum acceptable toxicant concentration
MCAWW	Methods for Chemical Analysis of Water and Wastes
mg/kg	Milligrams per Kilogram
mg/kg/day	Milligrams per Kilogram per Day
mg/kg-day <sup>-1</sup>	Kilograms per day per milligram
ml	Milliliter
MNA	Monitored Natural Attenuation
MS/cm	Millisiemens per centimeter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	Mean Sea Level
NACIP	Navy Assessment and Control of Installation Pollutants
NAS	Naval Air Station
NATTC	Naval Air Technical Training Center
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity
NFA	No Further Action
NOAA	National Oceanic and Atmospheric Administration
NRCC	National Research Council of Canada
NSTP	National Status and Trends Program
OERR	Office of Emergency and Remedial Response
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PBS	Pensacola Bay System
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PEL	Probable Effects Level
PEM	Performance Evaluation Mixture
pH	Hydrogen Ion Concentration
ppm	Parts per million
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
PWC	Public Works Center
QA	Quality Assurance
QC	Quality Control
RAIS	Risk Assessment Information System
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
Redox	Oxidation/Reduction
RfD	Reference Dose (mg/kg-day)
RG0	Remedial Goal Options

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPD	Relative Percent Difference
RRF	Relative Response Factor
%RSD	Percent Relative Standard Deviation
RV	Refinement Value
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SEV	Screening Ecotoxicity Value
SF	Slope Factor
SFF	Site Foraging Factor
SMP	Site Management Plan
SOP/QAM	Standard Operating Procedures and Quality Assurance Manual
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SQAG	Sediment Quality Assessment Guidelines
SQG	Sediment Quality Guideline
SQT	Sediment Quality Triad
SSL	Sediment Screening Level
SSV	Sediment Screening Value
SV	Screening Value
SVOC	Semivolatile Organic Compound
TAC	Test Acceptability Criteria
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TEC	Threshold Effects Concentration
TEF	Toxicity Equivalence Factor
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TPAH	Total Polycyclic Aromatic Hydrocarbons
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbon
TTC	Trophic Transfer Coefficient
TtNUS	Tetra Tech NUS, Inc.
µg/kg	Micrograms per Kilogram
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WQC	Water Quality Criteria

## **SITE 41 (OPERABLE UNIT 16) NAS PENSACOLA WETLANDS EXECUTIVE SUMMARY**

A remedial investigation was conducted for Naval Air Station (NAS) Pensacola Site 41, The NAS Pensacola Wetlands, assessing the nature and extent of contaminants resulting from Navy activities and Installation Restoration (IR) program sites discharging to wetlands within the NAS Pensacola boundary and assessing human health and ecological risk. Site 41 encompasses the approximately 81 wetlands or wetland complexes, both tidal and nontidal, that are within the base boundary. These wetlands are either palustrine or estuarine and drain directly into either Pensacola Bay or Bayou Grande. The investigation was conducted in various phases. Phase I was an analysis of existing data to identify those wetlands of greatest concern and identify sample locations for Phase II. Samples collected during Phase II showed metals, pesticides, polychlorinated biphenyls, and semivolatile and volatile organic compounds in particular wetlands. Phase III samples for toxicity, bioaccumulation, and diversity analysis were collected in wetlands thought to pose a risk from toxicological and bioaccumulative effects to estuarine and marine fauna. Phase IV was conducted to confirm surface water exceedances and to collect additional data for mercury in fish and sediment and sediment chemistry and toxicity in Wetland 5B.

As a result of Phase II, wetlands were ranked as either Red, Orange, or Blue based on detected concentrations in sediment. Red-coded wetlands had contamination that appeared directly related to nearby IR sites and had consistent exceedances of SSVs and reference levels. The nine red-coded wetlands identified were Wetlands 64, 5, 3, 4D, 16, 18, 10A, 12, and W1. Contaminants detected in these wetlands were also considered to be possible sources of ecological risk. Orange-coded wetlands had limited contamination above SSVs and reference levels which in some cases did not appear to be related to nearby IR sites. The six orange-coded wetlands identified were Wetlands 1, 15, 6, 63A, 48, and 49. Blue-coded wetlands had contaminants which in most cases were below benchmark values, or which did not appear to be site-related. The 12 blue-coded wetlands included Wetlands 10B, 13, 17, 19, 52, 56, 57, 58, 63B, 72, 79, and W2.

For Phase III of the field investigation, the wetlands were further subdivided according to the nature and extent of sediment contamination and several physical characteristics that could affect contaminant fate and habitat use. By subdividing these wetlands, any risk quantified in one wetland could be extrapolated to determine potential risk in other wetlands in that group. Because Wetland 64 is considered to be unique among the other wetlands, it was grouped by itself in Group A. Group B included Wetlands 3 and 5A. Group C included Wetlands 4D, 15, 16, 18A/B and 63A. Wetlands 16 and 18 were chosen as the representative wetlands for Group C. Group D included Wetlands 10, 6, 5B, W1, and 1, as these wetlands appear as man-made drainage ditches and are in developed areas of the base. Group E included Wetlands 48 and 49, and because of

their intermittent levels of surface water, neither was expected to have a significant ecological concern. Based on HQs and potential receptor species, wetlands in Groups A, B, and C (Wetlands 16 and 18 only in Group C) were selected for sampling priority in Phase III. Groups D and E, along with those wetlands not placed in a group, were not considered for Phase III.

Assessment endpoints studied during Phase III included survival, growth and reproduction of macroinvertebrates associated with the benthic environment (Wetlands 64, 3, 5A, 16, and 18); protection of fish viability using the fathead minnow (*Pimephales promelas*) (Wetlands 3 and 5A); and health of piscivorous birds (great blue heron — Wetland 18 only). Decision making triad analyses were used to round-out the ecological assessment of each wetland studied in Phase IIB/III, to determine if the ecological impacts to sediment and surface water were acceptable or not. At wetlands determined to have chemicals of potential concern (COPCs), a human health risk evaluation was conducted.

As summarized in Table 16-1, the following wetlands are recommended for an FS:

- Wetland 3
- Wetland 5A
- Wetland 64
- Wetland 10 (contingent on confirmatory sampling at location 033M00401)

The following wetlands are being assessed under the FDEP petroleum program, therefore CERCLA has no authority to proceed:

- Wetland 12 (Bilge Water Spill)
- Wetland W1 (UST 18)

All other wetlands are recommended for NFA based on the weight of evidence from the various techniques used to analyze the data and that Navy policy prohibits investigation of wetlands not directly linked to Navy CERCLA/RCRA sites.

## 1.0 INTRODUCTION

As part of the U.S. Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) program, a Remedial Investigation (RI) was completed at Site 41, the Naval Air Station (NAS) Pensacola wetlands. This site is listed in the Site Management Plan (SMP) of the Installation Restoration (IR) program for NAS Pensacola (Naval Facilities Engineering Command Southeast [NAVFAC Southeast] formerly Southern Division Naval Facilities Engineering Command), U.S. Navy, Naval Facilities Engineering Command, 2003). Site 41 encompasses all of the wetlands potentially impacted by site activities, both tidal and nontidal, within the NAS Pensacola boundary. Field work for the RI took place during multiple events: (1) Phase I was performed during August 1994; (2) Phase II (formerly called IIA) was performed from November 1995 through January 1996; (3) Phase III (formerly called IIB/III) was performed during August and September 1997; (4) additional sediment and whole prey fish tissue sampling was performed at Wetland 64 in August 2001; and (5) confirmation sampling was conducted at Wetlands 5B, 6, 10, 15, 17, 19A, 63A, and 72 in March 2004. This RI Report has been developed by EnSafe Inc. (EnSafe) as contracted by NAVFAC Southeast under Contract Number N62467-89-D-0318/CTO-36.

This investigation was completed in accordance with the primary site documents. These include the *Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Site 41, NAS Pensacola Wetlands* (EnSafe/Allen and Hoshall [E/A&H], 1995f); the *Final RI/FS Sampling and Analysis Plan (SAP), Site 41, NAS Pensacola Wetlands* (E/A&H, 1995g); the *Final Comprehensive Sampling and Analysis Plan for Naval Air Station Pensacola (CSAP)* (E/A&H, 1994); and the *Final RI/FS SAP Addendum, Site 41* (E/A&H, 1997d).

EnSafe initiated the investigation to meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) program, which administers the investigation and cleanup of former hazardous-waste sites. This RI report summarizes the activities, results, and conclusions of the investigation and provides the basis for a future feasibility study (FS) to be completed at the site.

The RI objectives are outlined as follows:

- To determine the sources, nature, magnitude, and horizontal extent of sediment and surface water contamination associated with the identified IR sites
- To evaluate human health and ecological risk posed by contaminated media onsite through the baseline risk assessment (BRA) process

## **1.1 Project Organization**

The RI was organized into four events. Phase I focused on a qualitative review of each wetland and development of a sampling strategy, including selecting sample locations for Phase II of the investigation.

Event One, Phase I, included:

- Site reconnaissance
- Review of data from previous investigations
- Review of site history, past and present activities, potential sources of contamination, locations of any known surface spills, and historical outfalls or other releases
- Habitat and biota survey
- Review of potential endangered species habitat
- Review of fisheries information
- Review of aerial photographs, topographic maps, and wetland maps

Event Two, Phase II, included:

- Verification of whether suspected contamination identified during Phase I actually existed
- Collection of sediment and surface water samples in wetlands of concern and analysis for chemical and physical parameters
- Selection of sample locations according to those with greatest probability of contamination (i.e., high total organic carbon [TOC], small grain size)
- Tabulated and review of data after sample collection

Event Three, Phase III, included:

- Further analysis of certain wetlands based on contaminant exceedances of sediment screening values and surface water quality criteria
- Linking contamination identified in Phase II to possible toxicological or bioaccumulative effects
- Deciding which wetlands and contaminants appeared to pose an unacceptable ecological or human health risk
- Collecting and analyzing sediment and surface water samples for acute and chronic toxicity, chemical and physical parameters, and benthic diversity
- Collecting and analyzing fish tissue samples for contaminant body burden and contaminant food-chain transfer potential

Event Four, 2001 and 2004 Investigations, included:

- Addressing data gaps identified during data interpretation
- Confirmation sampling based on select Phase II results

## **1.2 Scope of Report**

This RI report summarizes the activities, results, and conclusions of the investigation and provides the basis and justification for an FS if needed and Record of Decision (ROD). The report is divided into sections, which address the major phases of the RI. The actions and results of each phase, how these results affected the actions taken in subsequent phases, and how the results formed the basis for determining risk are detailed. Individual wetlands are separated by operable unit potential impacting them and are presented in Sections 10 through 15. The report also details the data collection and analytical methods used during the investigation.

## **2.0 ENVIRONMENTAL SETTING**

This section describes the physical and ecological setting of the Florida Panhandle and the NAS Pensacola wetlands. This information was incorporated into the Phase I portion of the RI.

### **2.1 Regional Ecological Setting**

According to Wolfe et al. (1988), the Florida Panhandle's wide variety of surface waters and physiographic regions leads to an ecological diversity found in few other areas of the United States. Watersheds of the panhandle support a diverse array of habitats and vegetative communities. Bottomland hardwoods and wetlands predominate in river floodplains. Pines, mixed with a variety of other shrubs, prevail in upland areas. Barrier islands support dune vegetation communities and salt marshes. Bays supporting sea grass meadows and oyster reefs are present in intertidal and subtidal areas.

Seven major rivers in the region discharge into seven estuaries formed at the mouths of the rivers. The Florida Panhandle is a crossroads where animals and plants from the Gulf Coastal Plain reach their eastward distributional limits, and where many northern species reach their southern limits. Many peninsular Florida species are also distributed in this area. Due to the wet temperate climate of the region, the panhandle area may support a higher diversity of species than any other similarly sized territory in the United States (Wolfe et. al, 1988).

The high annual rainfall and low, gently sloping terrain create numerous wetlands in the region. Bogs, swamps, marshes, wet prairies, and wet flatwoods provide a diversity of wetland types that support a wide variety of flora and fauna. Terrestrial vegetation includes mostly second-growth pine forests and encroaching hardwoods (Wolfe et. al, 1988).

The Florida Panhandle's estuaries and near-shore marine habitats are among the greatest natural and economic assets of the region. Important commercial organisms (such as oysters and fish) abound in these areas and contribute to the region's economy. Coastal salt marsh habitats provide critical nursery, feeding, and refuge habitat for these important commercial species. Seagrass beds within estuaries also are vital to the seafood industry (Wolfe et. al, 1988).

### **2.2 Physical Setting**

NAS Pensacola is in the Gulf Coast lowlands physiographic province on a peninsula bound by Pensacola Bay to the south and east and Bayou Grande to the north. The main topographic feature is a bluff that parallels the southern and eastern shorelines of the peninsula. Landward of the bluff is a gently rolling upland with elevations up to 40 feet above mean sea level (msl) (U.S. Geological Survey

[USGS], 1970a,b). In the eastern part of the base, a low and nearly level marine terrace lies east of the bluff with elevations of approximately 5 feet or less above msl, constituting the areas of the former Chevalier Field and Magazine Point.

Site 41 encompasses approximately 81 wetlands and wetland complexes throughout the base. Most wetlands on base are estuarine and drain directly into either Pensacola Bay or Bayou Grande. Less prevalent, exclusively freshwater wetlands on base are not tidally influenced and drain into other wetlands. The wetlands identified at NAS Pensacola are shown on Figure 2-1 (figures are located at the end of each section).

### **2.3 Ecological Setting at NAS Pensacola**

NAS Pensacola, which occupies approximately 5,800 acres, is bound by Bayou Grande to the north and Pensacola Bay to the east and south. To the west, the land changes to less developed swampy lowlands, forests, and beaches. NAS Pensacola's eastern portion is largely developed with military and industrial facilities and historical/cultural sites. Most of the installation's activities are on the eastern side of the base.

NAS Pensacola is the setting for numerous aquatic and terrestrial habitats, from coastal strand and estuarine environments along the bay and bayou to inland pine flatwood communities. Wetland environments include a broad spectrum of both estuarine and palustrine (freshwater) wetlands, many in states of recovery as they undergo reforestation or return to their natural condition.

#### **Vegetation Communities**

NAS Pensacola's natural vegetation communities fall into several broad categories (U.S. Fish and Wildlife Service [USFWS], 1987):

1. Coastal dune scrub communities are associated with shorelines and subject to high-energy waves.
2. Pine flatwood communities in coastal lowlands are characterized by trees tolerant to various soil moisture conditions. Tree species in flatwood communities are short, with a wide variety of small shrubs and herbaceous plants in the understory.
3. Hardwood/pine communities are highly diverse and are considered biologically productive ecosystems.

4. Sand pine scrub communities on well-drained sandy soil contain sand pines, oaks, and various shrubs.
5. Bay swamps, which are wetlands with titi and cypress, are known to contain permanent standing water and high accumulations of organic peat.
6. Freshwater marshes occur as grass/sedge/rush/herb communities in areas with high soil saturation or standing water.
7. Estuarine coastal marshes consist of salt-tolerant plants able to establish themselves in shifting sands. Estuarine coastal marshes, including salt marshes, occur along low-energy shorelines and in tidal bayous.

### **Wildlife**

NAS Pensacola habitats provide potential ranges for a wide variety of animal life such as deer, squirrel, opossum, raccoon, fox, beaver, and bobcat. The station's beaches serve as resting, feeding, and nesting areas for various shorebirds. Ospreys have been observed nesting along undeveloped shoreline areas of the Big Lagoon, southeast of the Forrest Sherman Airfield. Numerous small mammals, amphibians, and reptiles also inhabit the base. The coastal marsh, submerged grass bed, and shallow water habitats at NAS Pensacola help support fishery communities within the Pensacola Bay estuarine complex. Approximately 180 species of bony fishes form the basis of the Pensacola Bay fish community (USFWS, 1987).

### **Threatened and Endangered Species**

Appendix A of the *Comprehensive Natural Resources Management Plan for NAS Pensacola and Outlying Field Bronson* (USFWS, 1987) lists the rare, threatened, and endangered species that may be found within NAS Pensacola boundaries. EnSafe investigations of different areas at NAS Pensacola have identified the osprey, great blue heron (as well as other shorebirds), gopher tort, snapping turtle, Godfrey's golden aster, Carolina lilaopsis, white-top pitcher plant, and narrow-leaved sundew (E/A&H, 1995f). Some of these species are considered candidates for listing as rare, threatened, or endangered by the Florida Natural Areas Inventory (FNAI, 2003). Candidate species are not yet officially listed and thus have no legally protected status.

## **Wetlands at NAS Pensacola**

Wetlands are organized by those found in the western and eastern portion of the base. For risk evaluation, each wetland is considered equally attractive for recreational use. This assumption is important in quantifying human health risk, which is addressed by wetland in Section 10.

### ***Western Portion***

The western portion of the base contains heavily forested or marginally altered zones west of Sherman Field. The area contains palustrine forested wetlands, or forested wetlands mixed with scrub-shrub vegetation. Also west of Sherman Field are runway overrun areas, which have been cleared of trees and are dominated by scrub-shrub vegetation. Many of these altered areas appear to be dry but contain common wetland plant species. Portions of the forested and scrub-shrub areas have standing water and saturated soil; these conditions support emergent wetland plant species, some of which are considered threatened. Several drainage ditches that drain surface runoff from the airfield and surrounding areas also support wetland species. These ditches are a part of the NAS Pensacola storm water drainage system for the western portion of the base, and receive surface runoff from numerous outfalls located across a roughly 420-acre area that includes Sherman Field and areas occupied by the NAS Pensacola Public Works Center (PWC). The ditches drain into either Bayou Grande or the Intercoastal Waterway/Pensacola Bay.

Additional palustrine wetlands, as well as estuarine wetlands and aquatic beds, are present in the shoreline areas to the south and southwest of Sherman Field. Estuarine emergent wetlands are present in the inlets off the Intercoastal Waterway/Pensacola Bay, with palustrine emergent species in the more brackish upper-water reaches. Submerged aquatic plant beds can be found in the larger coves and immediate offshore areas. Areas of saturated soil inland from the shoreline accommodate palustrine forested and scrub-shrub wetlands, sometimes mixed with emergent plants. Standing water in the same area supports trees, shrubs, and emergent/floating leaf vegetation. Small inlets to Bayou Grande north of Sherman Field support estuarine emergent wetlands. Many of the estuarine emergent wetlands are fed by palustrine wetlands, especially where the inlet is fed by drainage ditches or intermittent streams.

### ***Eastern Portion***

About one-third of the wetlands are in the more developed eastern portion of the NAS Pensacola peninsula, and these are almost exclusively smaller remnant features. These wetlands may have been heavily impacted by base activities (Ecology and Environment Inc. [E&E], 1992). There are isolated palustrine wetlands near Site 1, the Sanitary Landfill, directly west of the NAS Pensacola golf course. Several ponds on the golf course drain into Bayou Grande and support palustrine

wetlands inland from the bayou and estuarine wetlands along the bayou shoreline. Areas near the former Chevalier Field/current Naval Air Technical Training Center (NATTC) and the wastewater treatment plant contain several small wetlands. Many occur as palustrine forested wetlands in small, isolated wooded areas. Emergent wetland plants occur in several drainage ditches that form a part of the NAS Pensacola storm water drainage system for the eastern portion of the base. These ditches receive surface runoff from numerous outfalls located across a roughly 300-acre area that includes the NATTC and developed areas to the south and southwest, the Bachelor Officers' Quarters and Officer housing area, and the Air Traffic Control School and former Naval Aviation Depot (NADEP) Dynamic Components Division complex along Murray Road. The drainage ditches direct surface runoff from these areas into the Yacht Basin, which is west of the Magazine Point Peninsula. There are estuarine and palustrine emergent wetlands at the upper end of the Yacht Basin, which is connected to Bayou Grande. Two isolated emergent wetlands lie on the eastern fringe of the NATTC/former Chevalier Field area, next to the former Dredge Spoil Fill Area (Site 14). These two wetlands also receive surface runoff via storm water outfalls from the eastern and southeastern portions of the NATTC/former Chevalier Field.

#### **2.4 Area Climate**

The Pensacola area has a mild, subtropical climate with average annual temperatures ranging from 55°F in the winter to 81°F in the summer. Daily temperatures can be more extreme, ranging from less than 7°F in the winter to more than 102°F in the summer. Convective thunderstorms, which occur on approximately half the summer days, can cause a precipitous drop in temperature of 10° to 20° in a matter of minutes (E&E, 1992).

Rainfall averages approximately 60 inches a year, with the highest amounts in July and August, when thunderstorms occur almost daily. Thunderstorms resulting in 3 to 4 inches of rain in an hour are common. Rainfall is lowest during spring and fall (4 inches average per month). In general, spring and fall rains are less intense, last longer, and produce less surface runoff but higher rates of infiltration and net recharge (E&E, 1992). Based on climatological data, November is the driest month of the year, with an average rainfall of 3.2 inches.

Winds, which prevail from the north during the winter and the south during the summer, are generally moderate in velocity, except during thunderstorms. A difference in the ocean-land temperature produces the sea-breeze effect, a daily clockwise rotation in the surface wind direction near the coast.

In addition, hurricanes and tornadoes can substantially damage the near-shore environment. Hurricanes Erin and Opal made landfall in Pensacola in August and October 1995, respectively.

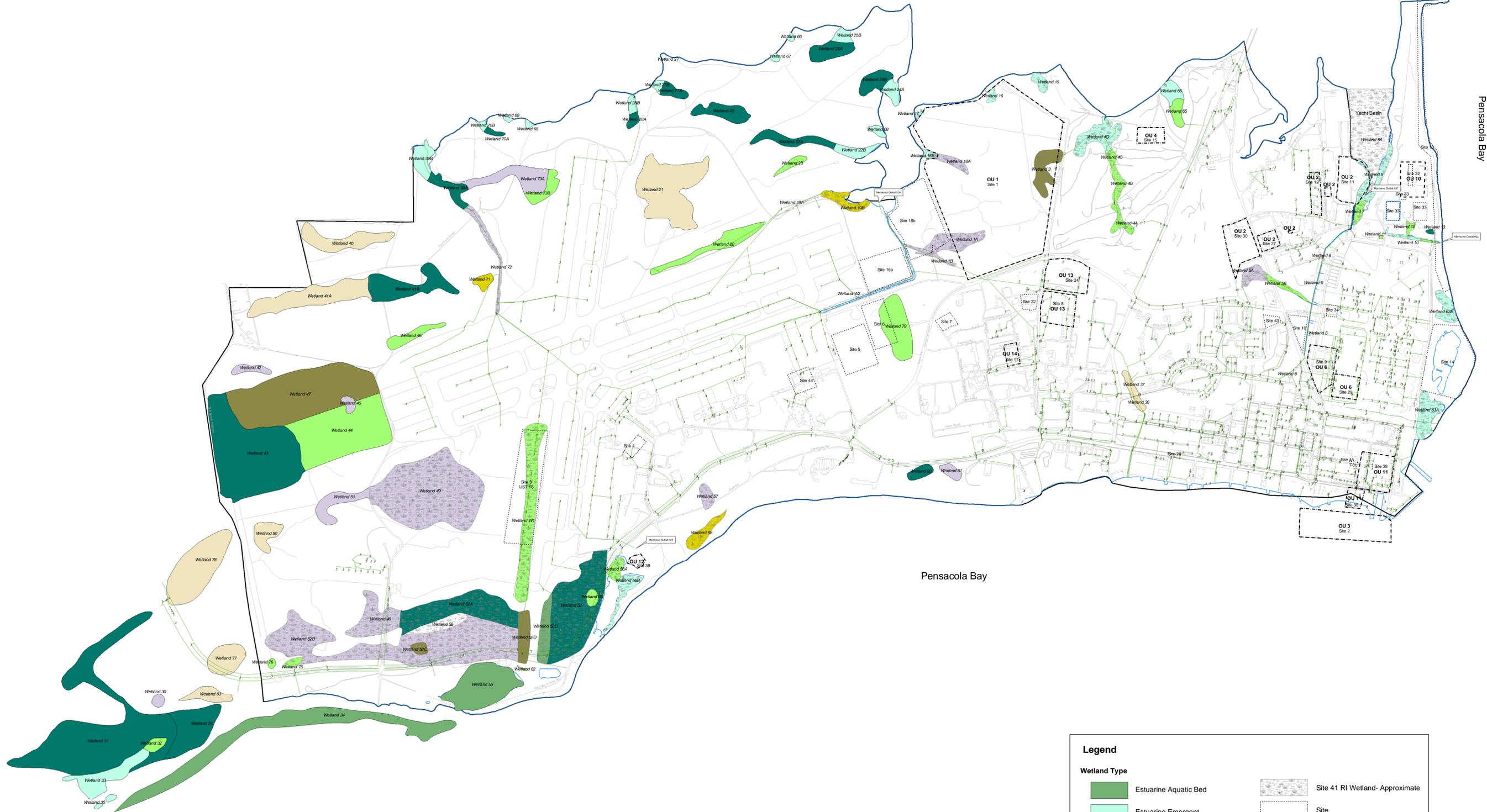
Hurricane Georges made landfall about 50 miles west of Pensacola near Mobile, Alabama, in September 1998. Hurricane Ivan made landfall west of Pensacola near Gulf Shores, Alabama, in September 2005, and Hurricane Dennis made landfall east of Pensacola near Navarre Beach, Florida in July 2005.

Figure 2-1 NAS Pensacola Wetlands and Associated Sites

Bayou Grande

Pensacola Bay

Pensacola Bay

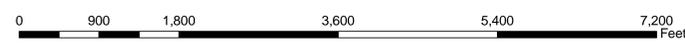


**Legend**

	Estuarine Aquatic Bed		Site 41 RI Wetland- Approximate
	Estuarine Emergent		Site
	Palustrine Emergent		Operable Unit (OU)
	Palustrine Forested		NASP Boundary
	Palustrine Forested/Emergent		Road
	Palustrine Forested/Scrub Shrub		Shoreline
	Palustrine Scrub Shrub		Storm Water Pipe
	Palustrine Scrub Shrub/Emergent		Storm Water Inlet
			Storm Water Outfall



**FIGURE 2-1**  
**NAS Pensacola Wetlands and**  
**Associated Sites**  
 Final Remedial Investigation Report  
 Site 41  
 NAS Pensacola, FL



### **3.0 PHASE I METHODS AND RESULTS**

Phase I focused the Site 41 investigation toward those wetlands considered to be of greatest concern and determined sample locations for Phase II. The Phase I tasks and recommendations are described below.

#### **3.1 Document Review**

Before visiting the wetlands to select sample locations, existing information was reviewed to better focus the investigation on those wetlands with the greatest apparent risk potential. This review was performed using the following information:

- Data from terrestrial site investigations associated with the wetlands of concern
- Site history, past and present activities, and potential sources of contamination
- Reported locations of any known surface spills, historical outfalls, or other releases
- Existing habitat and biota surveys that identify vegetation patterns, endangered species habitat, fisheries information, and other special concerns
- Aerial photographs, topographic maps, and wetland maps

This information was used to identify potential wetlands of concern, possible risk from contaminants in those wetlands, likely contaminant pathways, and key potential ecological receptors.

#### **3.2 Site Reconnaissance**

The site reconnaissance was performed during August 1994 to physically survey each wetland on base, compare site observations with the data gathered during the document review, and select suitable sample locations in identified wetlands of concern. Sample locations were biased to areas of likely contamination near outfalls and natural drainage features, and to areas of preferential contaminant deposition (i.e., low grain size, high TOC).

The Phase I document review and site reconnaissance identified other important features needed to complete the RI. The identification of potential contaminants of concern (COCs) and potential receptors enabled development of measurement and assessment endpoints, a general conceptual model, and the wetland-specific conceptual models. Measurement endpoints were selected to best represent key exposure and effects pathways in relation to assessment endpoints and the conceptual model. In

turn, these endpoints and models provided the technical basis for choosing toxicity, diversity, and bioaccumulation analyses in a subsequent phase to link contaminant levels with observed effects.

### **3.3 Phase I Results**

Phase I results included the identification of wetlands that required further study and the justification for the Phase II sampling approach. Sediment and surface-water sample locations were also selected for those wetlands. This information is detailed extensively in Section 4 of the *Final RI/FS SAP for Site 41* (E/A&H, 1995g). Table 3-1 (derived from E&E, 1992 — tables are located at the end of each section) summarizes the sites at NAS Pensacola that were initially suspected of impacting particular wetlands. Site locations are shown on Figure 2-1. Based on additional investigations, Sites 25, 27, 43, and 44 were added; these are described in Section 3.4.

Section 2 of the *Final RI/FS SAP for Site 41* (E/A&H, 1995g) describes the general conceptual model and identifies the measurement and assessment endpoints developed based on Phase I activities. Following a review of the data collected during Phase II, assessment and measurement endpoints were re-evaluated and revised. A wetland-specific conceptual model was developed for each wetland selected for further study. The revised endpoints, conceptual models, and the justification for their selection are provided in the *Final RI/FS SAP Addendum, Site 41, Wetlands* (E/A&H, 1997d).

### **3.4 Additional Sites**

Sites 25, 27, 43, and 44 were evaluated after completion of the original Phase I site reconnaissance. Sites 25 and 27 are part of Operable Unit (OU) 2 (EnSafe, 1997b). Field investigations for these sites were conducted between 1993 and 1995. Sampling and analysis to evaluate potential impacts from these sites were incorporated into Phase II. A site investigation has not yet been performed for Site 44. Sites 25, 27, and 43 are discussed below.

#### **Site 25**

Site 25, the radium spill area, is a reported radium spill in a concrete-paved area immediately east of the radium decontamination building (Building 780). An unpaved area containing scrapped helicopters is approximately 35 feet east of the building.

The spill reportedly occurred in 1978 on the area when a corroded drum broke open, spilling approximately 25 gallons of radioactive waste. Drainage from this area appears to flow east, toward the unpaved scrap yard.

Soil samples revealed a wide range of primary/secondary metals and semivolatile organic compound (SVOC) contamination, but no radium was found. Groundwater samples collected at the site contained metals, chlorinated solvents, benzene, and xylene (EnSafe, 1997b).

Another location of concern at Site 25 is the storage yard behind Building 225, which was formerly used as a metal prefabricating shop by the NAS PWC. Groundwater from the site contained metals and tetrachloroethylene (PCE). Activities in and around this building are the likely sources of groundwater contamination. Wetland 64, within the Yacht Basin, is potentially impacted by this site (EnSafe, 1997b).

### **Site 27**

Site 27 is a former radium dial shop in Building 709, approximately 150 feet west of Site 25. The building contained a number of operations, including a carburetor repair shop, propeller shop, paint shop, maintenance shop, and various instrument shops (including a radium paint room) and operated from 1940 to 1976. All or most of the chemical wastes appear to have been dumped down building drains, which lead to the sanitary sewer. Building 709 was dismantled in 1976, and the remaining concrete pad is being used as a parking lot. Approximately 1,500 gallons of radioactive waste was reported to be disposed of through drains in the floor of the building each year. These drains led to the sanitary sewer system. A portion of the drainpipe was excavated to 18 inches below ground surface and found to emit radiation at a rate of 1.2 milliroentgen per hour (mR/hr).

Wells previously installed by ABB Inc. to support the removal of underground storage tanks (USTs) at this location were included in the site investigation. Soil contaminants at Site 27 included aluminum, arsenic, cadmium, chromium, iron, mercury, and dieldrin. Groundwater results revealed drinking water standard exceedances for primary/secondary metals, SVOCs, and volatile organic compounds (VOCs). VOC exceedances included chlorinated solvents such as PCE, trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), and benzene, toluene, ethylbenzene, and xylene (BTEX). The former USTs are likely contributors of contamination in these wells. Based on site topography, Wetland 5 may have been impacted by Site 27 activities (EnSafe, 1997b).

### **Site 43**

Site 43 is an area of drums and other debris near the corner of Murray and Taylor Roads, across from Site 10. The area was identified and fenced off from the public in January of 1994. The site was investigated in 2001, and an interim removal action (IRA) was performed in 2002 (CH2MHill, 2003b). The IRA included the removal of the upper 6 inches of soil and any exposed metal debris, followed by backfilling with a low-permeability material. However, contaminated soil remained above

leachability criteria; therefore, this screening site has been elevated to an RI status. A human-health risk-assessment and ecological risk-assessment is planned.

#### **Site 44**

This site was transferred from the Florida Petroleum Program to the IR program because chlorinated solvents were detected in groundwater. The site, near an active hangar (Building 3221) on Forrest Sherman Field, is currently used by the nearby aviation museum for aircraft storage and restoration. Further investigation has not been performed at this site, which could potentially impact downgradient Wetlands 79, 52, and W2.

### **3.5 Site Investigation Update**

As shown in Table 3-1 and discussed in Section 3.4, many of the sites identified as potential sources of wetland contamination have either been remediated, are pending remediation under the state petroleum program, are pending further investigation, or have been designated as sites requiring no further action (NFA).

Investigations of the NFA sites are considered complete under the IR program, indicating no excess ecological risk was found at these sites. However, historical contamination associated with these sites may have impacted downgradient wetlands. NFA site activities are summarized below and are detailed in their respective RI or preliminary site-characterization reports.

Appendix A contains data tables from the site reports for those terrestrial sites that are adjacent to the wetlands investigated under Site 41.

#### **Site 4**

In the 1950s, rubble from the former Fort Barrancas was disposed in this area. The rubble included timber, pipes, mattresses, and other wastes. None of the wastes was documented as being incinerated before disposal. Inorganic constituents exceeding preliminary remediation goals (PRGs) in site soil were similar to those identified at previously investigated sites in the eastern portion of NAS Pensacola (E/A&H, 1997e). The detected PAH contaminants are likely associated with routine activities such as automobile traffic or the asphalt pavement (E/A&H, 1997e). The USEPA Region 4 (USEPA Region 4, 1997b) and FDEP (FDEP, 1997c) approved remedial alternative for Site 4 was no action.

#### **Site 5**

Site 5 was a cover material source for Site 1, the Sanitary Landfill. Concentrations detected during the Site 5 investigation were below PRGs (E/A&H, 1995a). A previous UST investigation at Site 3221NE,

adjacent to the northwest corner of Site 5, showed that the contaminants there were not associated with Site 5 (E/A&H, 1995a). Site 3221NE will be addressed under the Florida Petroleum Program. The USEPA (USEPA Region 4, 1995a) and FDEP (FDEP, 1995a) approved remedial alternative for Site 5 was no action.

### **Site 6**

Site 6 is an active construction-rubble-debris landfill subject to State of Florida solid waste regulations. Therefore, the site was not investigated under the IR program. FDEP concurred with the finding in 1997 (FDEP, 1997d).

### **Operable Unit 6: Sites 9, 29, and 34**

Site 9 was the station disposal site for the old Navy Yard. The earliest records show that disposal occurred here from 1917 until sometime during the 1930s. It is unknown what was disposed here besides domestic refuse. Soil and groundwater contamination were delineated during the OU 6 RI (E/A&H, 1997f). Soil contamination at each site was removed. At Sites 9 and 29, soil contamination appeared to be limited to small, isolated constituent concentrations (E/A&H, 1997f). Therefore, a removal action of the metal and PAH-contaminated soils was performed in 1998. Dieldrin-contaminated surface and subsurface soil was removed from Site 9B in 1995.

Elsewhere at Site 9, soil contamination was limited to isolated inorganics, PAHs, and pesticides in surface and subsurface soil. At Sites 29 and 34, dieldrin- contaminated surface and/or subsurface soil was removed in 1995 (E/A&H, 1997f).

Much of the rest of the OU 6 area was covered with fill material, buildings, or asphalt pavement during construction of the NATTC. The selected remedial alternative for the OU 6 sites was NFA, with the ROD (EnSafe, 2000), approved by the USEPA in 1999 (USEPA Region 4, 1999) and FDEP in 2001 (FDEP, 2001).

### **Site 10**

Site 10, Commodore's Pond, was used in the mid-1800s for underwater storage of wooden timbers for shipbuilding. There is no evidence of hazardous-material use, storage, or disposal at this site.

Several detections of dieldrin above its PRG were noted in soil, resulting in the contaminated soil being removed (E/A&H, 1995b). Based on two groundwater sampling events, dieldrin did not appear to be leaching to nor impacting shallow groundwater. Detected concentrations in groundwater were

below federal and state standards for drinking water (E/A&H, 1995b). The USEPA (USEPA Region 4, 1996b) and FDEP (FDEP, 2000) approved remedial alternative for Site 10 was NFA.

### **Site 13**

The site extends along the eastern waterfront of the base, including Magazine Point and the waterfront of the eastern side of Chevalier Field. Wetland 10 may have been impacted by Site 13.

Site 13 is the Magazine Point Rubble Disposal Area consisting of the construction debris piles and fill along the eastern clay road on Pensacola Bay and the recent dredge-spoil dumping ground at the northern tip of Magazine Point. The site was used to dispose of various clean fill materials, including building rubble, bricks, metal, concrete, and wood. There is no evidence of any hazardous-materials disposal. Detected concentrations of some parameters were identified sporadically in soil associated with the dredge-spoil material (E/A&H, 1995h). Low to not-detected concentrations of all contaminants except sodium (naturally occurring) were present in Site 13 monitoring wells (E/A&H, 1995h). Site 13 was approved for "no action" in 1996 by EPA (USEPA Region 4, 1996a) and FDEP (FDEP, 1995h).

### **Site 14**

This site was created between 1975 and 1977 by depositing spoils from dredging operations in Pensacola Bay. Samples of the basin's dredge material, collected during the Site 14 investigation, contained metals and organic compounds, notably PCBs (E/A&H, 1995c). However, soil contamination appeared limited to the site interior and did not appear to have spread outside its boundaries (E/A&H, 1995c). Site-specific groundwater contamination does not appear to be present (E/A&H, 1995c). Therefore, potential contaminant migration into Wetland 63A or Wetland 63B is of minimal concern.

After the berms of the site were collapsed into the sediment basins, eliminating potential exposure pathways, Site 14 was approved by USEPA (USEPA Region 4, 1996c) and FDEP (FDEP, 1996a) for NFA.

### **Site 16**

Site 16 occupies approximately 30 acres of a sparsely vegetated, open field immediately northeast of Sherman Field. It was reportedly used between the late 1960s and 1973 for the disposal of pruning and tree-trimming refuse. However, the area may have been used for garbage incineration and ash disposal. There was no evidence of chemical usage onsite. A visual inspection showed evidence of brush and several pieces of metal onsite (E/A&H, 1997a).

Inorganic constituents exceeding PRGs in site soil were similar to those identified at other sites in the area (E/A&H, 1997a). Elevated soil PAH concentrations likely originated from a source not related to site activities (E/A&H, 1997a). Detected concentrations of aluminum and iron in groundwater were below their respective reference concentrations at all locations but one for each constituent (E/A&H, 1997a). The USEPA (USEPA, 1997c) and FDEP (FDEP, 1997a) approved alternative for Site 16 was "no action."

### **Site 36**

Site 36, the Industrial Wastewater Treatment Plant (IWTP) sewer line, is approximately 1 mile wide by 5.5 miles long in a broad area within the southeastern portion of the activity. The sewer flows towards the IWTP in the northeastern corner of Site 36. Portions of this line traversed near Wetlands 5A/B, 6, 7, 8, 63A, and 64. Resources downgradient of Site 36 are adjacent wetlands and Pensacola Bay. In 1995 the segment of the sewer line extending from Site 38 through OU 6 to the IWTP was flushed. Since much of the site area near wetlands is paved or covered by buildings or fill material, leaching and sediment transport were not considered to be viable pathways for constituent transport (E/A&H 1997b). Groundwater transport, the only viable transport pathway, contained low concentrations of contaminants (E/A&H 1997b). The USEPA (USEPA Region 4, 1997a) and FDEP (FDEP, 1997b) approved remedial alternative for Site 36 was NFA.

### **Site 39**

Site 39, the Oak Grove Campground, is an area of stained soil and debris exhibiting a hydrocarbon odor. It is not known how this stain originated, but it is suspected that campers may have poured used motor-oil onto the ground. Records indicated that a saw mill was once located near this site. Analytical results indicated the stain was petroleum-based (E/A&H, 1995e). A removal action was performed between July 25 and July 29, 2004. Approximately 864 tons of soil were removed from the site and replaced with clean fill. Groundwater was also sampled during the investigation (E/A&H, 1995e). Tetrachloroethene and 1,1-dichloroethane (first round of sampling) and tetrachloroethene (second round of sampling) were the only organic compounds present in groundwater. These VOCs were only in the top of the uppermost aquifer zone; all VOC concentrations were below drinking-water standards. Aluminum and iron exceeded secondary drinking-water standards concentrations were aluminum and iron. In addition, arsenic, barium, calcium, lead, magnesium, and vanadium exceeded their respective NAS Pensacola reference (background) concentrations. In the lower portion of the uppermost aquifer, only iron exceeded a secondary drinking-water standard. Concentrations of aluminum, iron, calcium, and sodium are comparable with NAS Pensacola reference concentrations or those for ambient groundwater quality of the Sand and Gravel aquifer in this area. In addition, calcium, iron, magnesium, and sodium are essential nutrients and are only toxic at extremely high concentrations. Due to the limited contamination

found in the remedial investigation and the removal of the stained soil, the site did not warrant the detailed evaluation of remedial alternatives associated with a feasibility study. The proposed plan (E/A&H, 1995d) and ROD (E/A&H, 1995e) presented a “no-action” alternative that was approved by USEPA (USEPA Region 4, 1995b) and FDEP (FDEP, 1995b).

### **3.6 Petroleum Sites**

In addition to the IR sites, petroleum sites also have the potential to impact NAS Pensacola wetlands. The sites, tanks, contents, and identified groundwater contaminants are summarized in Table 3-2. Petroleum site locations are shown in Figure 2-1. Their potential impact to individual wetlands is discussed in the Section 10.

### **3.7 Prioritization and Recommendations for Phase II Sampling Locations**

Based on the results of the Phase I investigation, the wetlands were prioritized for Phase II sampling as listed in Table 3-3, with those perceived to be the most susceptible to contamination given the highest sampling priority. Generally, wetlands at the eastern side of the base have highest priority. This includes wetlands in the Yacht Basin and Operable Unit (OU) 10. Wetlands 5, 6, and 64, associated with Site 30, and the wetlands associated with Site 1 are also high priority. Table 3-3 shows the order of all wetlands to be sampled and number of samples selected.

In all cases, sample locations were selected based on conditions found during the site reconnaissance. Sample locations were selected in areas thought most likely influenced by surficial contaminant runoff or groundwater contaminant influences. It has been established that groundwater flow mimics topography at NAS Pensacola; by planning sample locations based on topography, likely areas of groundwater and surface water influence can be determined. All sample locations were selected in areas of high sedimentation or topographic depressional areas where contaminants would likely accumulate from immediate and long-term influences. Some sample locations were selected at the wetland area nearest the site to capture any immediate influences. Other locations were selected in areas of ponding or high sedimentation, where it is suspected that long-term groundwater influences would be at their maximum and where organic carbon and fine-grained sediment distribution would most likely retain any contaminants. Final sediment sample locations are shown on the figures presented in Sections 10 through 15 with the wetland investigation findings.

**Table 3-1  
Sources and Pathways of IR Site-Related Contamination  
Potentially Impacting Site 41**

<b>Source (Site)</b>	<b>Site Name</b>	<b>Known or Suspected Contaminants</b>	<b>Years of Operation</b>	<b>Potential Pathway(s)</b>	<b>Specific Wetland(s)<sup>a</sup> Potentially Impacted</b>	<b>Selected Remedial Alternative for Source</b>
1 (OU 1)	Sanitary Landfill	Metals, TRPHs, VOCs, PAHs, phenols	30 (1950-1980)	Groundwater, surface runoff	1-4, 15-18, W2b	Land Use Control Implementation Plan (LUCIP) for soil to restrict intrusive activities; MNA with a groundwater interception trench upgradient Wetland 3
3 (UST 18)	Crash Crew Training Area	Metals, TRPHs, VOCs, PAHs, phenols	42 (1955-1997)	Surface runoff into storm water drain	39, 52, 54, 62, 72, W1 <sup>b</sup>	Additional Assessment is ongoing.
4	Army Rubble Disposal Area	Unknown	Unknown	Groundwater	52, 56-58	NFA-1997
5	Borrow Pit	Unknown	Unknown	Groundwater, surface runoff	79, 55, W2 <sup>b</sup>	NFA-1995
6	Fort Redoubt Rubble Disposal Area	Unknown	Unknown	Groundwater, surface runoff	79, W2 <sup>b</sup>	NFA-1997
9 (OU 6)	Navy Yard Disposal Area	Metals, TRPHs, PAHs	13 (1917-1930s)	Groundwater, surface runoff	6-8, 64	NFA-1999
10	Commodore's Pond	Metals, TRPHs, PAHs, phenols	Unknown (1800s)	Groundwater, surface runoff	6-8, 64	NFA-1996
11 (OU 2)	North Chevalier Disposal Area	Metals, TRPHs, VOCs, PAHs, phenols	Unknown (1930s-present)	Groundwater, surface runoff, direct discharge	7-8, 64	Pending
12 (OU 2)	Scrap Bins	Metals, TRPHs, PAHs, phenols, PCBs	60 (early 1930s-present)	Storm water drainage	6-8, 64	Pending
13	Magazine Point Rubble Disposal Area	TRPHs, VOCs, PAHs, phenols <sup>c</sup>	Unknown	Groundwater	10	NFA-1996
14	Dredge Spoil Fill Area	Metals, TRPHs, VOCs, PAHs, phenols	19 (1975-1994)	Groundwater, storm water overflow	63B	NFA-1996
16	Brush Disposal Area	Metals	Unknown (1960s-present)	Groundwater, surface runoff	19, W2 <sup>b</sup>	NFA-1997

**Table 3-1  
 Sources and Pathways of IR Site-Related Contamination  
 Potentially Impacting Site 41**

Source (Site)	Site Name	Known or Suspected Contaminants	Years of Operation	Potential Pathway(s)	Specific Wetland(s) <sup>a</sup> Potentially Impacted	Selected Remedial Alternative for Source
19	Fuel Farm Pipeline Leak Area	Metals, TRPHs, PAHs, VOCs	Single incident (1958)	Groundwater, surface runoff	49, 52, 54	Contaminated Soil Excavation and Disposal. Groundwater remediation using nutrient injection treatment technology.
23	Chevalier Field Pipeline Leak Area	Metals, TRPHs, PAHs, phenols	Two incidents (1965, 1970)	Groundwater, surface runoff	6-8	NFA 2001
25	Radium Spill Site	Metals, VOCs	Single incident (1978)	Groundwater	64	Pending
27	Radium Dial Shop Sewer	Metals, VOCs	1940-1976	Groundwater	5	Pending
29 (OU 6)	Soil South of Building 3460	Metals, TRPHs, PAHs, VOCs	Unknown (1970s-1980s)	Groundwater	6-8, 64	NFA-1999
30 (OU 2)	Buildings 649 and 755	Metals, TRPHs, VOCs, PAHs, phenols	30 (1940s-1970s)	Groundwater, surface runoff, direct discharge	5-8, 64	Pending
32,33,35 (OU 10)	Industrial Wastewater Treatment Plant	Metals, VOCs, BNAs	24 (1973-1997)	Groundwater, surface runoff	7-13	Soil NFA; Groundwater recovery system
34 (OU 6)	Solvent North of Building 3557	Metals, TRPHs, PAHs, phenols	Single incident (1984)	Groundwater	6-8, 64	NFA — 1999
36	Industrial Waste Sewer	Metals, TRPHs, VOCs, PAHs, phenols	24 (1973-1997)	Groundwater	5-13, 63	NFA — 1997
37	Sherman Field Area	Metals, TRPHs, VOCs, PAHs	Single Incident (1983)	Groundwater	48, 52, 54	Multi phase extraction for removal of free product and remediation of contaminated soil
39	Oak Grove Campground	TRPHs, VOCs	Unknown	Groundwater	56	NFA — 1994
43	Demolition Debris Disposal Area	Metals	Unknown	Groundwater	5, 6	Pending

**Table 3-1  
 Sources and Pathways of IR Site-Related Contamination  
 Potentially Impacting Site 41**

Source (Site)	Site Name	Known or Suspected Contaminants	Years of Operation	Potential Pathway(s)	Specific Wetland(s) <sup>a</sup> Potentially Impacted	Selected Remedial Alternative for Source
44	Solvent near Bldg 3221	VOCs	Unknown	Groundwater	79,52,W2	Pending

**Notes:**

- a = Wetland number corresponds USEPA wetland inventory (USEPA, 1991a)
- b = Wetlands not identified in USEPA wetland inventory (USEPA, 1991a)
- c = Suspected source of these contaminants is the former Industrial Wastewater Treatment Plant (Sites 32, 33, and 35). *Source:* Modified from E&E, 1992.

**Table 3-2  
Petroleum Sites Potentially Impacting NAS Pensacola Wetlands**

<b>Map Label</b>	<b>Site Name</b>	<b>Tanks/Size</b>	<b>Contents</b>	<b>Groundwater Contaminants</b>
UST A	3221 SW	1/1,000 Gal	Waste Oil, PD-680	TCE, PCE, Methylene Chloride
UST B	PWC Site 4	Sludge Disposal	Waste Oil, Jet Fuel	Petroleum Hydrocarbons
UST C	PWC Site 1	Pipeline	JP-5	Petroleum Hydrocarbons
UST D	Building 604	Unknown	TCE	Chlorinated Solvents
UST E	DFM Pipeline	Pipeline	Diesel	None
UST F	607NE	2/500 Gal	Waste Oil, Jet Fuel	Lead
UST G	2662W	1,000 Gal	Used Oil, Jp-5	BTEX
UST H	3557	2/500 Gal	Waste Oil	None
UST I	3220	Multiple Tanks/Unknown Size	Diesel, Waste Oil, TCE	Unknown
UST J	3450W	Multiple/1,000 Gal	Gasoline	TCE, 1,1,1-trichloroethane
UST K	PWC Site 3/3810N	1/500 Gal	Fuel Oil	TRPHs, PAHs
UST L	3644	2/8,000 Gal	Diesel	Petroleum Hydrocarbons
UST M	709N,S	3/2,000 Gal	Fuel Oil	Unknown
UST N	647, 648, 649, 692	3/1,000 Gal, 3/500 Gal	Waste Oil, Kerosene	Unknown
UST O	UST 18	Open Pits	Jet Fuel, Waste Oil	BTEX, Lead
UST P	Sites 1 to 13	AVGAS Line and 12 Tanks/500 Gal	Jet Fuel	Lead, Petroleum Hydrocarbons
UST Q	Radar Site 3255	1/300 Gal	Diesel	Petroleum Hydrocarbons
UST R	3221 NE	1/500 Gal	Waste Oil, Water Tainted JP-5	None
UST S	Site 19	Pipeline	Jet Fuel	Petroleum Hydrocarbons
UST T	Site 20	1/1,511,580 Gal, AST	JP-5	Petroleum Hydrocarbons
UST U	Site 26	Unknown	Jet Fuel	Petroleum Hydrocarbons
UST V	Site 23	Unknown	Jet Fuel	Petroleum Hydrocarbons

**Table 3-2**  
**Petroleum Sites Potentially Impacting NAS Pensacola Wetlands**

<b>Map Label</b>	<b>Site Name</b>	<b>Tanks/Size</b>	<b>Contents</b>	<b>Groundwater Contaminants</b>
UST W	Site 26	Unknown	Jet Fuel	Petroleum Hydrocarbons
UST X	Site 27	Unknown	Jet Fuel	Petroleum Hydrocarbons

**Notes:**

- <sup>a</sup> = Wetland number corresponds to USEPA wetland inventory (USEPA, 1991a)
- <sup>b</sup> = Wetlands not identified in USEPA wetland inventory (USEPA, 1991a)
- <sup>c</sup> = Suspected source of these contaminants is the former Industrial Wastewater Treatment Plant (Sites 32, 33, and 35)
- LUCIP = Land Use Control Implementation Plan
- MNA = Monitored Natural Attenuation
- NFA = No Further Action
- OU = Operable Unit
- PAHs = Polycyclic Aromatic Hydrocarbons
- PCBs = Polychlorinated Biphenyls
- TRPHs = Total Recoverable Petroleum Hydrocarbons
- UST = Underground Storage Tank
- VOCs = Volatile Organic Compounds

*Source:* Derived from E&E, 1992.

**Table 3-3  
Phase II Wetlands Sampling Priority**

<b>Wetland</b>	<b>Number of Samples Planned</b>	<b>Justification</b>
Wetlands 7, 8, and 64 (Yacht Basin)	24 Sediment 5 Surface Water	Based on previous investigations, the Yacht Basin may have received contaminants from many sites, including 9 through 13, 29, 30, 36, and OU 10 and from activities within the Yacht Basin itself. Contaminants have likely migrated via surface water or groundwater. Some outfalls present will be sampled, but transects are also required to cover such a large area.
Wetland 5	9 Sediment 5 Surface Water	Wetland 5 has been impacted, probably by Site 30. Previous investigations, including an immediate removal action, have taken place in this wetland. See text describing previous results.
Wetland 6	11 Sediment 3 Surface Water	Wetland 6 has possibly been contaminated from most of the sites that have impacted the Yacht Basin. Sample locations were selected based on surface outfalls.
Wetland 1	4 Sediment 2 Surface Water	Limited sampling of this wetland was performed by USEPA and by E/A&H. Sample locations are selected to characterize the extent of potential contaminants in other areas of the wetland.
Wetland 3	6 Sediment 2 Surface Water	Samples have been collected in this wetland by USEPA and E/A&H. Sample locations are selected to characterize the extent of potential contaminants in other areas of the wetland.
Wetland 4D	5 Sediment 3 Surface Water	Previous data exists for Wetland 4D only. Samples will help characterize the extent of potential contaminants in other areas of the wetland.
Wetland 15	4 Sediment 2 Surface Water	USEPA has collected samples here, but additional data are needed to confirm whether any influences exist from Site 1.
Wetland 16	3 Sediment 2 Surface Water	USEPA and E/A&H have collected samples in this wetland. It appears to be Impacted by Site 1. Additional samples are needed to characterize the extent of contamination.
Wetland 17	3 Sediment 1 Surface Water	USEPA collected samples in this wetland. It does not appear to be impacted by Site 1, but additional samples will be needed to confirm this.
Wetland 18	4 Sediment 2 Surface Water	USEPA and E/A&H have both collected samples. Wetland 18 appears to be impacted by Site 1. Additional data are required to characterize the extent of potential contaminants in other areas.
Wetlands 10A/10B, 11, 12, and 13	6 Sediment 3 Surface Water	This wetland was sampled by E/A&H and is suspected of being impacted by OU 10. Sample locations are selected to characterize the extent of potential contaminants in other areas of this wetland.
Wetland 63A	5 Sediment 2 Surface Water	Potential impacts from Chevalier Field and Building 3380. Little is known about this area.
Wetland 63B	4 Sediment 2 Surface Water	Potential impacts from Chevalier Field. Little is known about this area.

**Table 3-3  
 Phase II Wetlands Sampling Priority**

<b>Wetland</b>	<b>Number of Samples Planned</b>	<b>Justification</b>
Wetland W1	3 Surface Water	Three sediment samples were collected in this wetland as part of the Site 3 investigation. Thirteen additional sediment samples were collected from the grated catch basins, but are not considered as part of this investigation, since the pathway to the receptors is not complete. Surface water samples are needed to help characterize the extent of contamination.
Wetland 48	1 Sediment 1 Surface Water	This sample was selected in an area immediately adjacent to a small culvert that drains into Wetland 52. Any contaminants detected here will likely be impacting areas further downgradient.
Wetland 52A (Eastern Portion)	1 Sediment 1 Surface Water	Suspected groundwater and surface water impacts from Site 3 (UST 18). Sample location is in an area of high groundwater recharge into a relatively fast-moving stream.
Wetland 52A (Western Portion)	4 Sediment 2 Surface Water	Potential impacts from Site 4. Little is known about this site.
Wetland 72	2 Sediment 1 Surface Water	Potential surface water impacts from Site 3. Samples will be collected at a large culvert that is the apparent origin of this wetland.
Wetland 57	1 Sediment 1 Surface Water	Potential impacts from Site 4. Little is known about this site.
Wetland 58	1 Sediment 1 Surface Water	Potential impacts from Site 4. Little is known about this site.
Wetland 19	3 Sediment 2 Surface Water	Site 16 has potentially impacted this wetland. Sample locations were selected in areas of ponding and high sediment deposition.
Wetland W2	3 Sediment 1 Surface Water	Potential impacts from Site 16.
Wetland 56A	1 Sediment 1 Surface Water	The Site 39 RI has concluded that contamination is limited to a small area and is not impacting any offsite locations. However, Site 4 may be impacting this wetland.
Wetland 79	3 Sediment 1 Surface Water	Potential impacts from Site 5 and Site 6. Little is known about these sites.
Wetland 49	2 Sediment 1 Surface Water	Possible impacts from Site 19, which is located within wetland boundaries.
Wetland 27	3 Sediment 2 Surface Water	Control wetland used for reference comparison.

**Table 3-3**  
**Phase II Wetlands Sampling Priority**

<b>Wetland</b>	<b>Number of Samples Planned</b>	<b>Justification</b>
Wetland 32	3 Sediment 2 Surface Water	Control wetland used for reference comparison.
Wetland 33	3 Sediment 2 Surface Water	Control wetland used for reference comparison.

#### **4.0 PHASE II, III, AND IV (CONFIRMATION SAMPLING) METHODS**

The phased RI process, which includes investigation of sediment, surface water, and biota for the Site 41 wetlands, is described in the *Final RI/FS Work Plan, Site 41* (E/A&H, 1995f), *Final RI/FS SAP, Site 41* (E/A&H, 1995g), and *Final RI/FS SAP Addendum* (E/A&H, 1997d). Each document and phase of the investigation was approved by the Navy, USEPA, FDEP, and National Oceanic and Atmospheric Administration (NOAA) before sampling was conducted.

#### **4.1 Phase II**

##### **Sampling Rationale**

As stated in the *Final RI/FS SAP, Site 41* (E/A&H, 1995g) and summarized in Section 3, Phase I identified wetlands requiring further sampling and analysis in Phase II. The prioritization of sediment sampling locations was presented in Table 3-3. The number of samples and analytical methods for sediment chemistry are listed for each wetland in Table 4-1 (tables are located at the end of each section). The number of samples and analytical methods for surface water chemistry are listed for each wetland in Table 4-2.

##### **Sediment Sampling Procedures**

Phase II samples for chemical and physical analysis were collected from the wetlands of concern from November 1995 through January 1996. Most sample locations in each wetland were identified using the global positioning system (GPS). However, some sediment samples included in the Phase II data set were collected during previous RIs completed at sites adjacent to Site 41 and were not surveyed with GPS. These samples included 24 sediment samples collected and analyzed from Wetlands 1, 3, 6, 10, 16, and 18 in 1994.

Sampling procedures for Phase II were performed in accordance with the *Final RI/FS SAP, Site 41* (E/A&H, 1995g). Sediment samples for chemical, physical, and toxicological analyses were collected from 0 to 6 inches depth with a stainless-steel hand auger, scoop, or mini-Ponar grab in accordance with Section 4 or Section 7 of the *Final CSAP* (E/A&H, 1994). The only deviation in Phase II from the Site 41 SAP involved field adjustments of sample locations based on site conditions (i.e., lack of accessibility to certain areas of a wetland).

##### **Surface Water Sampling Procedures**

Surface water samples for chemical analyses were collected by submerging the sample bottle or using a Kemmerer sampler according to procedures outlined in Section 7.4.1 of the *Final CSAP* (E/A&H, 1994). Eleven surface water samples collected during other site investigations were incorporated into the

Phase II data set. Turbidity, hydrogen ion concentration (pH), conductivity, and salinity measurements collected during the Phase II surface water sampling are presented in Table 4-3.

### **Analytical Methods**

All sediment and surface water samples collected during the Phase II event were submitted for laboratory analysis of VOCs, SVOCs, pesticides/PCBs, and metals. In addition, total organic carbon, and grain size analysis were conducted on sediment samples.

## **4.2 Phase III**

### **Sampling Rationale**

Twenty-six potentially contaminated wetlands were identified based on the Phase II sampling results. These 26 wetlands were assigned to one of three groups: red, orange, or blue. Assigning a wetland color was based on a subjective determination of contaminant distribution and exceedances of reference values and sediment and water-quality benchmarks. The groupings are defined as the following:

**Red:** Contamination appears related to an IR site with consistent exceedance of reference values and benchmarks. Wetlands assigned the red designation are Wetlands 64, 5A/5B, 3, 4D, 16, 18(A and B), 10, 12, and W1.

**Orange:** Contamination may be related to an IR site. However, limited contaminants exceed reference values or benchmarks, or the contaminants exceed benchmarks but do not appear to be site-related. Wetlands assigned the orange designation are Wetlands 1 (A and B), 15, 6, 63A, 48, and 49.

**Blue:** Isolated or no contaminants are detected. Those detected are, in most cases, below reference values and/or benchmarks and do not appear to be related to an IR site. Wetlands assigned the blue designation are Wetlands 13, 17, 19 (A and B), 52, 56, 57, 58, 63B, 72, 79, and W2.

After reviewing Phase II sediment and surface water contaminant distribution and other characteristics in the red- and orange-coded wetlands (as discussed in Section 6.2), the red- and orange-coded wetlands were further subdivided according to their nature and extent of sediment contamination and their similarity of several physical characteristics that could affect contaminant fate and habitat use (including salinity, depth of surface water, TOC, and riparian habitat). Blue-coded wetlands were not considered, as the detected parameters were determined not to be site-related.

Surface water exceedances were evaluated, but they appeared isolated and not IR site related. The surface water samples were not filtered, and many were highly turbid. By subdividing these wetlands, any risk quantified in one wetland could be extrapolated to determine potential risk in other wetlands in that group. The groupings and rationale for selection are summarized below:

**Group A, Wetland 64:** This estuarine wetland is unique, primarily because it receives runoff from a large area of the base and has high concentrations of several metals, PAHs, and pesticides. The sediment in this wetland has high TOC values.

**Group B, Wetlands 3 and 5A:** These wetlands have similar physical characteristics and contaminants, although Wetland 3 had relatively little PAH contamination compared to Wetland 5A. These wetlands have similar species that live and feed in them.

**Group C, Wetlands 4D, 15, 16, 18A, 18B, and 63A:** These wetlands are adjacent to and tidally influenced by either Pensacola Bay or Bayou Grande. The types of receptors present in these wetlands are expected to be similar to each other. Wetlands 16 and 18 were selected to represent Group C because they had the highest levels of contamination in comparison with the other Group C Wetlands.

**Group D, Wetlands 1, 5B, 6, 10, and W1:** These wetlands appear as man-made drainage ditches, several of which are located in developed areas of the base. Due to their channelized features and/or proximity to developed areas, they have limited ecological receptors. These wetlands are comparable in physical characteristics and types of chemical contamination.

**Group E, Wetlands 48 and 49:** These freshwater wetlands are on the western side of the base and do not appear to be impacted by any IR sites. Both are palustrine forested wetlands subject to periodic, intermittent flooding.

Table 4-4 shows Wetland Groups A through E and the characteristics used to categorize the red-and orange-coded wetlands included in these groups. Note that red- and orange-coded wetlands may be combined into the same group.

Based on HQs and potential receptor species, Wetland 64 from Group A, Wetlands 3 and 5A from Group B, and Wetlands 16 and 18 from Group C were selected for the highest sampling priority in Phase III. If contamination in Wetlands 16 and 18 was determined to be at levels producing adverse

ecological effects, then techniques can be used to predict the potential for effects in the remaining Group C wetlands (4D, 15, and 63A) such as back-calculation or regression analysis.

Both Group D and E wetlands contained elevated levels of contaminants, mostly pesticides; however, these groups were not considered for Phase III sampling. The Group D wetlands were not considered further primarily because they are channelized drainage ditches within the NAS Pensacola storm water drainage system which receive continual impacts from storm water and are actively maintained by base maintenance personnel. The Group E Wetlands, 48 and 49, were not sampled because both are heavily influenced by seasonal fluctuations in rainfall and appeared dry for much of the year (they do not appear to have prolific aquatic communities). Wetlands 48 and 49 also do not appear to be impacted by any IR sites.

In 1997, the Phase III assessment was conducted at selected locations in Wetlands 3, 5A, 16, 18B, 33, and 64. Sample locations were selected in areas of the wetlands exhibiting relatively high, medium, and low levels of contamination. The gradient sampling was proposed to yield a better idea of relative risk in certain portions of the wetland. Wetland 75, which is not related to an IR site, was also sampled during Phase III as a reference wetland but was subsequently determined not to be suitable and is not included in this document. Phase III was conducted to further characterize risk at the Site 41 wetlands; therefore, sediment chemistry, toxicity, benthic community analysis and bioaccumulation samples were collected for analysis in August and September 1997 as outlined in the approved *Final RI/FS SAP Addendum* (E/A&H, 1997d).

### **Phase III Sample Locations**

***Wetland 64*** — Sediment samples for toxicity, chemistry, TOC, grain size, and benthic diversity were collected at locations 041M6404, 041M6405, and 041M6406. Fish tissue samples were also collected. Two discrete surface water samples were also collected near sediment locations 041M6401 and 041M6402 and sediment locations 041M6402 and 041M6405.

***Wetland 5*** — Sediment samples for toxicity, chemistry, TOC, grain size, and benthic diversity were collected at locations 041M5A04, 041M5A05, and 041M5A06. Discrete surface water samples for chemistry and toxicity testing were also collected at those locations.

***Wetland 3*** — Sediment samples for toxicity, chemistry, TOC, grain size, and benthic diversity were collected at locations 041M0302 and 041M0307. A surface water sample was collected for chemistry and toxicity testing at 041W0301.

**Wetland 18B**— Sediment was collected at location 041M18B01 for toxicity, chemistry, TOC, grain size, and benthic diversity analysis. In addition, prey fish were collected for whole body tissue analysis.

**Wetland 16**— Sediment was collected at location 041M1601 for toxicity, chemistry, TOC, grain size, and benthic diversity analysis.

### **Sediment, Surface Water, and Biota Sampling Procedures**

Sediment and surface water samples were collected for chemistry and toxicity testing following the procedures described for Phase II. Sediment samples for benthic diversity testing were collected as composites of three grab samples within 10 feet of each sample location to account for spatial variability.

Using new fish traps, native foraging fish species from Wetlands 64 and 18 were collected for tissue analysis during Phase III. Control specimens were collected from reference Wetland 33. All traps were baited with commercial dog food and placed on the wetland floor. The traps were checked periodically, and the fish were collected and thermally preserved.

Within Wetland 64, two fish traps were placed near Phase II sediment sample locations 041M6404, 041M6405, and 041M6406. Within Wetland 18, one trap was placed at its mouth in an area likely to be frequented by fish. Two traps were placed in Wetland 33, and one was placed in Wetland 75.

After the 10-day period, the fish species were identified, placed in resealable plastic bags, and labeled with the sample number on the outside of the plastic bag and on an inside tag. The samples were transported on dry ice to the analytical laboratory, where they were processed and analyzed for whole body contaminant levels.

### **Analytical Methods**

All sediment samples collected during Phase III were analyzed for SVOCs, pesticides/PCBs, metals, TOC, and grain size. Surface water samples were collected for VOC, SVOC, pesticide/PCB, and metals analysis. Although Phase III sediment samples were collected at the same locations as Phase II, deviations in sediment chemistry were expected due to changes in site conditions during the time between the sampling events. The number of samples and analytical methods for sediment chemistry are listed for each wetland in Table 4-1. The number of samples and analytical methods for surface water chemistry are listed for each wetland in Table 4-2.

### 4.3 2001 Confirmation Sampling/Phase IV

#### Rationale

Because fish were not analyzed for mercury during Phase III, this sampling event was conducted to develop site-specific biota sediment accumulation factor (BSAF) for use in modeling mercury. Although mercury was the primary contaminant of concern, the scope of the investigation was expanded to include pesticides/PCBs, SVOCs and metals. The BSAF is calculated using results from co-located sediment and prey fish samples. Data from the Phase II and III sampling events were evaluated to identify a range of TOC and mercury concentrations. TOC ranges for Wetland 64 are shown below.

TOC Ranges	
Range	Wetland 64
Low	< 1%
Medium	1-4%
High	> 4%

Mercury concentrations were also evaluated, and the following criteria were established to represent low, medium, and high TOC concentrations, as shown on the next page.

Mercury Ranges	
Range	Wetland 64
Low	ND
Medium	0.3 ppm
High	> 0.3 ppm

A matrix was developed for Wetland 64 that compared TOC and mercury data from each site to find sample locations meeting the above criteria. For Wetland 64, locations were not found for combinations of low TOC and high mercury concentrations or medium TOC and high mercury concentrations. All other combinations for Wetland 64 were found. A total of seven sample locations were selected for Wetland 64 as summarized in Table 4-5.

#### Sampling Procedures

Seven sediment samples were collected at locations 041M6402, 041M6403, 041M6405, 041M6406, 041M6407, 041M6411, and 041M6424 in Wetland 64 during August 2001. Sediment samples were collected using the appropriate means (Eckman dredge, Ponar dredge, stainless-steel scoop, etc.), depending on water depth and site accessibility. A polygon pattern with three sampling points situated approximately 10 yards apart was established at each sample location. At each of the

three sampling points, three sediment samples (0 to 6 inches in depth) were collected and composited for laboratory analysis. The sampling followed procedures specified in the technical memorandum for this event (EnSafe, 2001).

One bait trap was also deployed at each location for fish collection. Dry dog food was used as bait for the traps (a sample of which will be collected for laboratory analysis). Fish were collected for whole body tissue analysis (for lipid content and mercury). The target fish species for trapping was the Gulf killifish (*Fundulus grandis*). The fish collected in the trap were examined in the field, with the largest organisms selected for analysis. The collected fish were retained in a tank for at least 24 hours before shipment to the laboratory to allow time for undigested food to pass through their system.

### **Analysis**

The fish samples were submitted to STL Savannah of Savannah, Georgia for analysis of percent lipids, metals, PCBs, pesticides and SVOCs.

#### **4.3.1 Wetland 5B — Confirmation Sampling**

##### **Rationale**

In 2004, further sampling was conducted at Wetland 5B to fill an identified data gap for the delineation of cadmium in sediment near location 041M5B02. Five locations were sampled in Wetland 5B and one sediment sample collected from Wetland 19A in March 2004. Two sediment samples were collected upstream and two sediment samples were collected downstream at 50-foot and 100-foot intervals. Location 041M5B02 was also resampled. Wetland 19A was also sampled during this event to serve as a reference wetland because of its similar characteristics for Wetland 5B.

##### **Procedures**

The sampling followed sampling procedures specified in the technical memorandum for this event (EnSafe, 2004a). Because the surface water was shallow, the sediment samples were collected at each location using a hand auger. Samples were containerized, labeled, and shipped to the appropriate laboratory for analysis.

##### **Analysis**

Collected samples were submitted for sediment chemistry analysis at STL Savannah and toxicity testing at TRAC Laboratory. Sediment samples were analyzed for SVOCs, pesticides/PCBs, and metals. Toxicity was assessed using 10-day survival and growth tests using the amphipod, *Hyalella azteca* (USEPA, 2000a).

### **4.3.2 Surface Water Resampling**

Also in March 2004, surface water samples were collected from Wetlands 6, 10, 17, 19, 63A, and 72 for laboratory analysis specified in the memorandum. The sampling was conducted to confirm previous findings as outlined in Table 4-6. Surface water samples could not be collected from Wetland 13, 15, or 58 because surface water was not present. In addition, Wetland 16 was inadvertently sampled for metals, including mercury.

### **4.4 Sample Management**

All environmental samples were preserved, labeled, packed, and shipped under strict chain-of-custody procedures, in accordance with Section 12 of the *Final CSAP* (E/A&H, 1994). All temperature-sensitive sample shipments not analyzed locally were put on ice and sent via an overnight express courier to the appropriate laboratory. The laboratory was notified the day of shipment. Sample containers and preservatives for each type of analysis are listed in Table 4-7.

### **Quality Assurance/Quality Control Samples**

Quality assurance/quality control (QA/QC) samples for chemical analysis were collected to ensure the quality of field and laboratory procedures by confirming the level of reproducibility attainable in the sampling and analytical process, the quality of equipment decontamination, the quality of source waters and materials, sample exposure to ambient contamination during handling, and the level of laboratory precision. All field QA/QC samples were collected in accordance with Section 15 of the *Final CSAP* (E/A&H, 1994).

QA/QC samples for the toxicity, bioaccumulation, and diversity analyses were not collected because the laboratories performing these analyses followed their own internal quality procedures to ensure data usability.

### **Ancillary Data**

Ancillary data pertinent to sampling activities were collected for each sampling event. Field information included personnel identification, sampling time, location, weather conditions, test equipment and sample containers used, sampling methods, physical/chemical parameters measured, problems encountered, and procedural deviations. The data were recorded in bound field logbooks.

### **Decontamination**

All sampling equipment used to collect chemical and toxicity data was decontaminated following procedures outlined in Section 11 of the *Final CSAP* (E/A&H, 1994).

### **Sample Identification**

Due to the need to distinguish multiple wetlands within a single site designation, sample identification procedures were modified from those presented in the *Final CSAP* (E/A&H, 1994). The new sample identification scheme was used only for sediment and surface water samples and affected the fifth through eighth characters. The fifth and sixth characters referred to the wetland number, and the seventh and eighth characters referred to the sample number within that wetland. Because all sediment samples were collected from 0 to 6 inches deep, the last two characters were "-01." For example, sediment sample location 2 within Wetland 3 during the Site 41 investigation was designated "041M030201." For wetland numbers three characters long (18A, 18B, etc.), the wetland number was given in the fifth, sixth, and seventh characters. For example, sediment sample location 3 in Wetland 18A was designated "041M18A301."

All QC samples followed the identification procedure described above. The matrix identification numbers were consistent with the *Final CSAP* (E/A&H, 1994).

### **Sample Containers and Preservation**

All laboratory-provided containers were precleaned and certified, as specified in Chapter 12 of the *Final CSAP* (E/A&H, 1994). All samples were preserved with ice to  $4^{\circ}\pm 2^{\circ}\text{C}$  before shipment in accordance with the *Final CSAP* (E/A&H, 1994) except the samples for toxicity analysis and benthic diversity. The samples for toxicological studies were couriered on ice directly to the local laboratory twice a day during sample collection, where they were stored at  $4^{\circ}\text{C}$  before analysis. The samples for benthic diversity were preserved in 10% formalin and did not require temperature preservation to ensure sample integrity.

### **4.5 Analytical Parameters**

Site 41 samples were collected for chemical, physical, toxicity, and/or diversity analysis. Chemical analyses provided a basis for determining the nature and extent of site contamination and contaminant bioaccumulation potential. Physical analyses helped assess the potential bioavailability of contaminants within the source media by evaluating the amount of total organic carbon and grain size of the sediment. Toxicity and diversity tests helped quantify effects to endpoint species.

The number of Site 41 samples collected and the analytical requirements for Phases II and III are summarized in Table 4-8. Phase II sediment and surface water analytical results are presented in Appendix B. Phase III sediment, surface water, and biota analytical results are presented in Appendix C. Sample results from 2001 and 2004 are presented in Appendix D. TAI Environmental Sciences Inc., of Mobile, Alabama, followed an internal laboratory procedure for species enumeration

using standard dissection microscope techniques. This procedure is included in Appendix E, and the results of their findings are included in Appendix F. Procedures for toxicity analysis are included in Appendix G.

In addition to the CLP method analyses during Phase II, a duplicate group of sediment samples was analyzed for metals by a modified method that used hydrofluoric acid for metals digestion instead of nitric acid, which is used in the CLP method. This modified method is cited in Section 5, Data Validation. The hydrofluoric acid digestion was performed at FDEP's request as a test case to compare the two digestion techniques. The results from the two methods were very comparable; therefore, only the CLP method data have been presented for evaluation in this report. These two methods are compared in Appendix H.

Sediments were also analyzed for physical parameters. Sediment samples were analyzed for TOC according to USEPA Method SW 846-9060, and grain size according to American Society for Testing and Materials (ASTM) Method D422 (ASTM, 1990). These analyses were conducted by Ceimic Laboratories of Narragansett, Rhode Island, during Phase II and STL Savannah Laboratories of Savannah, Georgia, during Phase III and confirmation sampling phases.

#### **4.6 Global Positioning System**

GPS was used to identify sample locations at Site 41. At NAS Pensacola, the GPS unit required a stationary reference receiver that was placed at a surveyed location and continually recorded signals from satellites. Before field sampling, a rover unit was initialized. A stop-and-go survey was performed by pausing for a few seconds at each sampling location (identified by stakes labeled with the sample identification number). Using the hand-held controller, the user recorded and appropriately described each point. This process of initialization and subsequent recording is termed a "chain." At each day's end, the memory cards were downloaded.

One advantage of using GPS for mapping water-based sampling locations is that resampling at the same location (+ 0.1 meter) is possible.

#### **4.7 Deviations**

Additional research into laboratory techniques was performed after the SAP addendum was finalized and distributed. Initially, the 10-day *Hyalella azteca* test for survival, growth, and reproduction was planned to be performed on sediment samples collected from Wetlands 5A and 3 during Phase III. However, based on the recommendation of the contract laboratory, the 28-day *Chironomus tentanstest* (ASTM Method E1706-95B) for survival and emergence was performed instead. USEPA and

FDEP concurred with this analysis change. The 10-day Hyalella test was discontinued because 10 days was considered insufficient to obtain adequate growth and reproduction response, both key measurement endpoints for this test. The longer test enabled the chronic endpoints to be measured more effectively.

In addition, full TCL/TAL analysis was originally proposed for the analysis of prey fish in Phase III. Due to a sampling error, the fish tissue was analyzed for pesticides/PCBs, SVOCs, and Appendix IX metals. This analysis did not include mercury, a parameter that has a potential to bioaccumulate. To address this data gap, sediment and prey fish samples were collected from Wetland 64 in 2000.

Several surface water samples collected during the Phase II sampling effort exceeded water-quality criteria for metals, which may have been attributable to high turbidity of the surface water collected. To determine if turbidity was the cause of the metal exceedances, surface water from several wetlands was resampled in 2004 (Wetlands 6, 10, 15, 17, 19A, 63A, and 72). Both total and dissolved metals analysis was performed. Wetlands 13, 15, and 58 had no surface water; therefore, no samples were collected. Though the technical memorandum for the surface water resampling (EnSafe, 2004b) specified that water quality parameters (i.e., turbidity, specific conductance, pH, and temperature) were to be collected during the sampling, this was not accomplished due to sampler error.

Sample location 041M5A01 could not be resampled during Phase III because the area no longer contained surface water. In addition, confirmation samples of surface water in 2004 could not be collected at location 041M1501 and 041M7201 because of the lack of surface water.

**Table 4-1  
Summary of Sediment Samples and Analysis by Wetland**

Wetland	Fresh/Estuarine?	Metals	PAHs	PCBs	Pesticides	SVOC	TOC	TPH	VOC	Grain Size	HF Metals	AVS/SEM
<b>Phase II</b>												
10	F	7	7	7	7	7	3	N/A	7	3	1	N/A
12	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
13	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
15	E	4	4	4	4	4	4	N/A	3	4	N/A	N/A
16	E	4	4	4	4	4	3	N/A	4	3	1	N/A
17	E	3	3	3	3	3	3	N/A	3	3	N/A	N/A
18A	F	4	4	4	4	4	3	N/A	3	3	N/A	N/A
18B	E	1	1	1	1	1	1	N/A	1	1	N/A	N/A
19A	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
19B	E	1	1	1	1	1	1	N/A	1	1	N/A	N/A
1A	F	3	3	3	3	3	2	N/A	3	2	N/A	N/A
1B	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
3	F	10	10	10	10	10	7	N/A	10	7	1	N/A
48	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
49	F	3	3	3	3	3	3	N/A	3	3	N/A	N/A
4D	E	5	5	5	5	5	5	N/A	5	5	1	N/A
52	F	5	5	5	5	5	5	N/A	5	5	N/A	N/A
56	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
57	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
58	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
5A	F	7	7	7	7	7	7	N/A	7	7	N/A	N/A
5B	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
6	F	12	11	12	12	11	11	N/A	12	11	N/A	N/A
63A	E	5	5	5	5	5	5	N/A	5	5	1	N/A
63B	E	4	4	4	4	4	4	N/A	4	4	N/A	N/A
64	E	24	24	24	24	24	24	N/A	24	24	1	N/A
72	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
W1	F	3	3	3	3	3	3	3	3	3	N/A	N/A
W2	E	3	3	3	3	3	3	N/A	3	3	N/A	N/A
25	F	3	3	3	3	3	3	N/A	3	3	N/A	N/A
27	E	2	2	2	2	2	2	N/A	2	2	N/A	N/A
32	F	3	3	3	3	3	3	N/A	3	3	N/A	N/A
33	E	3	3	3	3	3	3	N/A	3	3	N/A	N/A
<b>Phase III</b>												
16	E	1	1	1	1	1	1	N/A	1	1	N/A	N/A
18B	E	1	1	1	1	1	1	N/A	1	1	N/A	N/A
3	F	2	2	2	2	2	2	N/A	2	2	N/A	N/A
5A	F	3	3	3	3	3	3	N/A	3	3	N/A	N/A
64	E	3	3	3	3	3	3	N/A	3	3	N/A	N/A
75	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
33	E	2	2	2	2	2	2	N/A	2	2	N/A	N/A
<b>2001 Sampling</b>												
64	E	7	7	7	7	7	7	N/A	N/A	N/A	N/A	7
<b>Phase IV/2004 Sampling</b>												
19A	F	1	1	1	1	1	1	N/A	1	1	N/A	N/A
5B	F	5	5	5	5	5	5	N/A	5	5	N/A	N/A

**Notes:**

The number under each analytical method indicated the number of samples analyzed for that wetland.

N/A = Not Analyzed

E = Estuarine

F = Freshwater

**Table 4-2  
Summary of Surface Water Samples and Analysis by Wetland**

Wetland	Fresh/Estuarine?	Metals	Pesticides/PCBs	SVOCs	TPH	VOC
<b>Phase II</b>						
10	F	4	4	4	N/A	4
12	F	1	1	1	N/A	1
13	F	1	R	1	N/A	1
15	E	2	2	2	N/A	2
16	E	3	3	3	N/A	3
17	E	1	1	1	N/A	1
18A	F	2	2	2	N/A	2
18B	E	1	1	1	N/A	1
19A	F	1	1	1	N/A	1
19B	E	1	1	1	N/A	1
1A	F	1	1	1	N/A	1
1B	F	1	1	1	N/A	1
3	F	7	7	7	N/A	7
48	F	1	1	1	N/A	1
49	F	2	2	2	N/A	2
4D	E	2	2	2	N/A	2
52	F	2	2	2	N/A	2
56	F	1	1	1	N/A	1
57	F	1	1	1	N/A	1
58	F	1	1	1	N/A	1
5A	F	6	6	6	N/A	6
5B	F	1	1	1	N/A	1
6	F	3	3	3	N/A	3
63A	E	1	1	1	N/A	1
63B	E	2	2	2	N/A	2
72	F	1	1	1	N/A	1
W1	F	6	6	6	3	6
W2	E	1	1	1	N/A	1
25	F	2	2	2	N/A	2
27	E	1	1	1	N/A	1
32	F	2	2	2	N/A	2
33	E	2	2	2	N/A	2
<b>Phase III</b>						
3	F	1	1	1	N/A	1
5A	F	3	3	3	N/A	3
64	E	2	2	2	N/A	2
75	F	1	1	1	N/A	1
33	E	1	1	1	N/A	1
<b>Phase IV/2004 Confirmation Sampling</b>						
10	F	1	N/A	N/A	N/A	N/A
16	E	1	N/A	N/A	N/A	N/A
17	E	1	N/A	N/A	N/A	N/A
19A	F	1	N/A	N/A	N/A	N/A
6	F	1	N/A	N/A	N/A	1
63A	E	1	N/A	N/A	N/A	N/A
72	F	1	N/A	N/A	N/A	N/A

**Notes:**

The number under each analytical method indicated the number of samples analyzed for that wetland.

N/A = Not Analyzed

R = Rejected

F = Freshwater

E = Estuarine

**Table 4-3**  
**Site 41 Phase II Surface Water Sample pH, Turbidity,**  
**Specific Conductance, and Salinity Measurements**

<b>Wetland</b>	<b>Sample Location</b>	<b>pH</b>	<b>Turbidity</b>	<b>Specific Conductance</b>	<b>Salinity</b>
1	041W00101	6.70	2	0.231	0.00
3	041W030101	6.41	12	0.257	0.00
	041W030201	5.78	470	0.44	0.01
	041W030301	5.99	690	0.404	0.01
	041W030401	5.96	3	0.261	0.01
4D	041W4D101	6.55	0	3.31	0.15
	041W4D401	6.02	0	12.6	0.76
5A	041W5A101	6.30	21	0.169	0.00
	041W5A201	6.10	38	0.146	0.00
	041W5A401	6.31	12	0.166	0.00
	041W5A501	6.03	144	0.21	0.00
12	041W120101	6.21	1	3.94	0.20
13	041W130101	6.13	>1,000	1.31	0.06
15	041W150101	6.01	>1,000	1.20	0.05
	041W150201	6.98	0	1.74	0.08
16	041W160101	6.86	10	19.6	1.17
	041W160201	7.01	17	20.0	1.26
17	041W170101	6.78	0	24.7	1.49
18	041W18A201	5.47	188	0.231	0.0
	041W18B101	5.02	9	0.55	0.02
19	041W19A201	6.20	41	0.103	0.0
	041W19B101	5.57	19	0.676	0.35
25	041W250101	6.24	2	0.931	0.04
	041W250301	5.76	0	1.4	0.06
27	041W270101	6.35	282	18.8	1.11
32	041W320101	4.02	1	0.256	0.00
	041W320301	4.06	2	0.367	0.10
33	041W330101	5.11	1	2.48	0.12
	041W330301	4.91	1	4.20	0.21
48	041W480101	3.96	3	0.078	0.00
49	041W490101	5.21	25	0.054	0.00
	041W490301	4.95	25	0.079	0.00
52	041W52A101	4.63	65	0.052	0.00
	041W53E301	5.86	27	0.063	0.00
56	041W56A101	5.48	6	0.124	0.00
57	041W570101	6.44	280	0.455	0.01
58	041W580101	6.73	0	0.135	0.00
63A	041W63A201	6.79	10	24.2	14.5

**Table 4-3**  
**Site 41 Phase II Surface Water Sample pH, Turbidity,**  
**Specific Conductance, and Salinity Measurements**

Wetland	Sample Location	pH	Turbidity	Specific Conductance	Salinity
63B	041W63B201	6.35	5	0.638	0.02
	041W63B401	6.13	13	0.011	0.00
64	041W640501	6.81	10	2.72	0.07
	041W640601	7.69	10	17.0	10.9
	041W640701	7.73	10	4.61	0.51
	041W640901	7.82	10	21.4	12.9
	041W641001	7.73	4	22.2	13.3
	041W641101	7.99	3	22.7	13.7
	041W641201	8.24	10	22.1	12.9
	041W641301	8.06	13	22.1	13.2
	041W641401	7.54	5	22.4	13.5
	041W641501	8.29	10	21.9	13.1
	041W641601	8.04	22	22.2	13.3
	041W641701	8.12	26	22.3	13.5
	041W642001	8.22	24	22.6	13.7
	041W642101	7.95	9	21.8	13.1
	041W642201	7.27	3	22.6	13.6
	041W642301	8.00	3	22.8	13.7
041W642401	8.04	4	22.8	13.7	
72	041W720101	6.21	9	0.476	0.01
W1	041WW10101	5.43	10	0.61	0.00
	041WW10201	5.22	102	0.042	0.00
	041WW10301	6.09	5	0.035	0.00
W2	041WW20201	6.22	6	0.35	0.04

**Note:**

Turbidity, conductivity, pH, and salinity measurements were not recorded for Wetlands 6 or 10 during the Phase II sampling

Table 4-4  
 Wetland Groupings  
 Red- and Orange-Coded Wetlands

Wetland Characteristic	64	5A	3	4D	15	16	18A	18B	63A	10	6	5B	1	W1	48	49
Estuarine	A			C	C	C		C	C							
Fresh		B	B				C			D	D	D	D	D	E	E
TOC > 1%	A	B	B	C	C	C	C	C				D	D	D		
TOC < 1%									C	D	D				E	E
Metals	A	B	B	C	C	C	C	C	C	D	D	D	D	D		
SVOC	A	B		C									D			
Pest/PCB	A	B	B	C	C	C	C	C	C	D	D		D	D	E	E
Shallow (<3')	A	B	B	C	C		C	C	C	D	D	D	D	D	E	E
Deep (>3')						C										
Predominant Silt	A		B		C		C	C								
Predominant Sand		B		C		C			C	D	D	D	D	D	E	E
<i>Juncus</i> sp.	A				C			C								
Cattails		B	B						C							
Hardwoods		B	B			C	C	C					D			
Mowed Grass				C						D	D			D	E	E
Disturbed Vegetation	A			C	C	C			C	D	D	D		D		
Viable Benthos	A															

**Note:**  
 The letter on the table refers to the designated wetland grouping and whether that characteristic was present for a particular wetland.

Table 4-5  
 Mercury and TOC Matrix  
 For Additional Sampling at Wetland 64

Site 40				
Matrix Combinations		TOC Concentrations		
		Low	Medium	High
Mercury Concentrations	Low	040MZ237 TOC C 0.15% Hg C 0.8 ppm	N/A	040MZ401 TOC C 5.6% Hg C ND
	Medium	040MZ316 TOC C 0.09 Hg C 0.14	040MZ216 TOC C 7.2% Hg C 0.28 ppm	040MZ247 TOC C 4.0% Hg C 0.28 ppm
	High	N/A	040MZ244 TOC C 3.9% Hg C 0.64 ppm	040MZ130 TOC C 3.9% Hg C 2.2 ppm
Wetland 64				
Matrix Combinations		TOC Concentrations		
		Low	Medium	High
Mercury Concentrations	Low	041M6407 TOC C 0.48% Hg C 0.1 ppm	041M6406 TOC C 2.81% Hg C 0.12 ppm	041M6402 TOC C 4.42% Hg C 0.17 ppm
	Medium	041M6424 TOC C 0.74% Hg C 0.3 ppm	041M6411 TOC C 4.01% Hg C 0.3 ppm	041M6405 TOC C 8.35% Hg C 0.27 ppm
	High	N/A	N/A	041M6403 TOC C 19.4% Hg C 0.88 ppm

**Notes:**

N/A = Not Applicable  
 ppm = Parts per million (ppm) or milligrams per kilogram (mg/kg)

**Table 4-6**  
**Phase II Sample Locations, Exceedances and Sampling Rationale for Surface Water**  
**NAS Pensacola Site 41**

Wetland	Sample Location	Original Turbidity Reading (NTU)	Parameters Exceeded	HQs	Rationale
6	041W0610 041W0610	No data	Mercury 1,1-DCE	HQ 73.33 HQ 2.5	Resample surface water at 041W0610 for VOCs and metals
10	033W0001	No data	Cadmium	HQ 6.71	Resample surface water for metals at 033W0001
13	041W1301	>1000	Metals	Several $\geq$ 1	Resample surface water at 041W1301 for metals
15	041W1501 041W1501	>1000	Mercury Metals	HQ 78.33 Several $\geq$ 1	Resample surface water for metals at 041W1501
17	041W1701	0	Thallium	HQ 2.59	Resample surface water at 041W1701 for thallium only
19	041W19A1	41	Metals	Several $\geq$ 1	Resample surface water at 041W19A1 for metals
58	041W5801 041W5801	0	Aluminum Lead	HQ 83.85 HQ 4.33	Resample 041W5801 for metals
63A	041W63A2	10	Lead	HQ 53.39	Resample 041W63A2 for metals
72	041W7201	9	Silver	HQ 62.86	Resample 041W7201 for metals

**Note:**

NTU = Nephelometric Turbidity Unit

Table 4-7  
 Phase II/III Sample Containers and Preservation by Medium and Analysis

Medium	Analysis	Sample Container	Preservative
<b>Phase II/III</b>			
Surface Water	CLP TCL VOCs	40-ml glass vial	4° C — HCL, pH<2
Surface Water	CLP TCL SVOCs, CLP TCL Pesticides/PCBs	1-liter amber bottle	4° C
Surface Water	CLP TAL Metals	1-liter Nalgene bottle	4° C — HNO <sub>3</sub> , pH<2
Surface Water	Cyanide	1-liter Nalgene bottle	4° C — NaOH, pH>10
Surface Water	Hardness	120-ml polyethylene bottle	4° C — HNO <sub>3</sub> , pH<2
Sediment	CLP TCL VOCs	60-ml glass jar	4° C
Sediment	CLP TCL Pesticides/PCBs	250 ml amber bottle	4° C
Sediment	CLP TCL SVOCs	250 ml amber bottle	4° C
Sediment	CLP TAL metals/cyanide	120-ml glass jar	4° C
Sediment	Grain Size	500-ml plastic jar	4° C
Sediment	TOC	120-ml sterile polyethylene bottle	4° C
Sediment	Species enumeration to genus level for sediment macroinvertebrates	1-liter plastic bottles	10% formalin
Sediment	Midge larvae <i>Chironomus tentans</i> 28-day survival/growth	200-ml plastic jar	4° C
Sediment	Marine amphipod <i>Leptocheirus plumulosus</i> 10-day acute toxicity	1-gallon plastic container	4° C
Sediment	Marine polychaete <i>Neanthes arenacoedentata</i> 20-day chronic growth and fecundity	1-gallon plastic container	4° C
Surface Water	Fathead minnow <i>Pimephales promelas</i> 28-day survival and growth	2.5-gallon plastic container	4° C
Fish Tissue	Contaminant residues in whole body prey fish tissue (PAHs, pesticides/PCBs, and lead)	Aluminum foil/plastic bags	4° C

Table 4-7  
 Phase II/III Sample Containers and Preservation by Medium and Analysis

Medium	Analysis	Sample Container	Preservative
<b>2001 Wetland 64</b>			
Sediment	Acid Volatile Sulfide/Simultaneously Extractable Metals	250-ml plastic	4° C
Sediment	Total Organic Carbon	125-ml glass	4° C
Sediment	Metals	250-ml plastic	4° C
Sediment	Pesticides/PCBs	500-ml glass	4° C
Fish	Contaminant residues in whole body prey fish tissue (SVOCs, Metals, and pesticides/PCBs)	Aluminum foil/plastic bags	4° C
Fish	% Lipid	Aluminum foil/plastic bags	4° C
<b>Wetland 5B 2004</b>			
Sediment	Metals	250-ml plastic jar	4° C
Sediment	SVOCs, Pesticides/PCBs	9-oz glass jar	4° C
Sediment	VOCs	125-ml glass jar/septa	4° C
Sediment	Marine amphipod <i>Hyalalea azteca</i> 10-day acute toxicity	Two 1-liter plastic cont.	4° C
<b>Wetlands 6, 10, 13, 15, 17, 19, 58, 63A, and 72 Surface Water Confirmation Sampling</b>			
Wetland 6	VOCs	40-ml glass vial	4° C — HCL, pH<2
Wetland 6 and all other samples	Total Metals	1-liter Nalgene bottle	4° C — HNO <sub>3</sub> , pH<2
Wetland 6 and all other samples	Dissolved Metals	1-liter Nalgene bottle	4° C — HNO <sub>3</sub> , pH<2

**Notes:**

- CLP = Contract Laboratory Program
- ml = Milliliter
- PAH = Polycyclic Aromatic Hydrocarbon
- PCB = Polychlorinated Biphenyl
- SVOC = Semivolatile Organic Compound
- TAL = Target Analyte List
- TCL = Target Compound List
- TOC = Total Organic Carbon
- VOC = Volatile Organic Compound

**Table 4-8  
 Analytical Parameters and Number of Samples**

Medium	Number of Stations	Analysis	Method
<b>Phase II</b>			
Sediment	122	VOCs, SVOCs, pesticides/PCBs, metals including cyanide	TCL/TAL
Surface Water	51	VOCs, SVOCs, pesticides/PCBs, metals including cyanide	TCL/TAL
<b>Phase III</b>			
Sediment	13	VOCs, SVOCs, pesticides/PCBs, metals including cyanide	TCL/TAL
Surface Water	9	VOCs, SVOCs, pesticides/PCBs, metals including cyanide	TCL/TAL
Sediment	6	Midge larvae <i>Chironomus tentans</i> survival and emergence (10/28 days)	ASTM E 1706-95B
Sediment	7	Marine amphipod <i>Leptocheirus plumulosus</i> mean survival (10 days)	ASTM E 1367-92
Sediment	7	Marine polychaete <i>Neanthes arenaceodentata</i> survival and growth (20 days)	PSEP, 1991
Surface Water	5	Fathead minnow <i>Pimephalespromelas</i> survival and growth (7 days)	EPA/600/4-89/001
Sediment	11	Species Richness/Diversity	See Appendix E
Fish	6	Whole body contaminant residue	SVOCs, Pesticide/PCBs and Appendix IX metals
<b>2000 Wetland 64</b>			
Sediment	7	VOCs, SVOCs, pesticides/PCBs, metals	Low Concentration SOW CLP
Sediment	7	TOC	Walkley Black
Fish	7	Lipid Content	
Fish	7	Mercury	Low Concentration SOW CLP
<b>2004 Wetland 5B</b>			
Sediment	5	VOCs, SVOCs, pesticides/PCBs, metals	Low Concentration SOW CLP
Sediment	5	Amphipod <i>Hyallaela azteca</i> mean survival (10 days)	EPA-600/R-99/064
<b>2004 Surface Water Confirmation Sampling</b>			
Surface Water	1	VOCs	SW-846 8260B
Surface Water	6	Metals	SW-846 Methods 6010B/7470a/7471A

**Notes:**

- TCL = Target Compound List Organic
- TAL = Target Analyte List Metals
- ASTM = American Society for Testing and Materials
- PSEP = Puget Sound Estuary Program

## 5.0 DATA VALIDATION

### 5.1 Phase II and III Data

Site 41 data were validated by EnSafe personnel and Heartland Environmental Services Inc. of St. Charles, Missouri. The analytical work was conducted by Ceimic Laboratories, Narragansett, Rhode Island, and STL Savannah Inc., Savannah, Georgia. Sample analyses were performed in accordance with the following guidance documents:

- Naval Energy and Environmental Support Activity (NEESA) Level D QA/QC guidelines as stated in *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation and Restoration Program (NEESA 02.2-047B)*, June 1988 (NEESA, 1988).
- *USEPA Contract Laboratory Program CLP, Statement of Work (SOW) for Organic Analysis, Multi-Media, Multi-Concentration*, USEPA Office of Solid Waste and Emergency Response (OSWER) (CLP Organic SOW), OLM02.1, 1994 (USEPA, 1994d).
- *USEPA CLP, SOW for Inorganic Analysis, Multi-Media, Multi-Concentration (CLP Inorganic SOW)*, USEPA OSWER, ILM03.0, 1993 (USEPA, 1993a).
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)* (3rd ed.) USEPA OSWER, revised July 1992 (USEPA, 1992).
- *Methods for Chemical Analysis of Water and Wastes (MCAWW)*, USEPA Environmental Monitoring and Support Laboratory, EPA-600/4-79-020, March 1983 (USEPA, 1983).

Data were validated using the following documents:

- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, Office of Emergency and Remedial Response (OERR) 9240.1-05, EPA 540/R-94/012 (USEPA, 1994a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, OERR 9240.1-05-01, EPA540/R-94/013 (USEPA, 1994b).

The end of this section includes a list of data validation qualifiers. Appendix I provides detailed validation reports completed by EnSafe and Heartland Environmental Services.

Samples for Phase II and Phase III were collected at Site 41 from November 1995 through August 1997. All samples were received by the laboratory in good condition and with proper custody documentation. Samples were analyzed for VOCs, SVOCs, PCBs, and inorganic parameters. Phase II samples submitted to Ceimic Laboratories were analyzed using the CLP organic and inorganic SOWs (USEPA 1993a and 1994d) Phase III samples submitted to STL Savannah Laboratory were analyzed using the CLP Inorganic SOW (USEPA 1993a) and SW-846 methodology. Selected samples were also analyzed for TOC using SW-846 method 9060; grain size using ASTM method D422; and hardness using MCAWW method 130.1. Four fish-tissue samples were submitted to Savannah Laboratory and analyzed for SVOCs, pesticides/PCBs, and Appendix IX metals (aluminum, antimony, arsenic, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, thallium, vanadium, and zinc).

Organic and inorganic results were reported by the laboratory in 28 sample delivery groups (SDGs): 030301, 041M10, 5A0101, 63A401, 640801, EA0101, EAH030, EAH031, EAH032, EAH033, EM0040, EM005, EM0050, EM0060, EMD0060, EW0010, M00901, M06010, M06070, M52A10, Z30301, Z42101, Z53301, PEN11, PEN12, PEN13, PEN14, and PEN15. SDGs Z13601 and Z30201 are not included because these two SDGs were analyzed for metals using a modified hydrofluoric acid digestion. Although samples prepared by the modified method were not used to quantify specific analyte concentrations, the validation results are presented in this section. TOC results were not validated because the data were used for qualitative purposes only.

## 5.2 Organic Analysis

### 5.2.1 Holding Times

All technical and contractual holding times were within QC requirements for the VOC fraction. No SDGs were outside holding times for the VOC fraction. Several samples were analyzed outside holding times in the SVOC and pesticide/PCB fractions. When a sample was analyzed or extracted outside holding times, positive and undetected results were flagged as specified in CLP Organic SOW. Undetected values for samples that greatly exceeded holding times were rejected as "UR," based on professional judgment. Samples exceeding holding times and the corresponding flags are summarized below:

<b>Fraction/SDG</b>	<b>Sample IDs</b>	<b>Days Exceeded</b>	<b>Flag(s)</b>
SVOC / 041M10	041W130101	10	J, UJ
SVOC / M06070	041W250101, 041R250301, 041W270201	22	J, UR
PEST / EM0040	041M030101, 041N030101, 041M030101DL, 041N030101DL, 041M030201, 041W030201, 041M030201DL	1-4	J, UJ

Fraction/SDG	Sample IDs	Days Exceeded	Flag(s)
PEST / EM0050	041M150101, 041W150101, 041M150101DL, 041M150201, 041M150201DL, 041M150301, 041M150301DL, 041M150401	3-4	J
PEST / M06010	041M250201	14	J, UJ
PEST / M06070	041M060701	8	J, UJ
PEST / Z53301	041M10A101, 041M10A201, 041M120101, 041M120101DL	2-3	J, UJ

### 5.2.2 Matrix Spike/Matrix Spike Duplicates

A matrix spike (MS) is used to determine the accuracy of the analysis for a given matrix. A matrix spike duplicate (MSD) is used to determine the precision and accuracy of an analysis for a given matrix. The MS and MSD are used to detect matrix effects caused by contaminants that may interfere with the compounds of interest and may also be present within the sample. Both the MS and MSD consist of a known quantity of stock solution added to the sample before its preparation and analysis.

MS/MSD data evaluation involves two calculations to measure accuracy and precision. Accuracy is measured using an estimate of the percent recovery, which is calculated by comparing the amount of the compound recovered by analysis to the amount added to the sample. Precision is measured with an estimate of relative percent difference (RPD), which is calculated using the recoveries for both the MS and MSD. No specific requirements have been established for qualifying MS/MSD data. However, guidelines in applying professional judgment are discussed in Organic Functional Guidelines.

All reported MS/MSD results were satisfactory for the Site 41 investigation.

### 5.2.3 Calibrations

Initial and continuing calibrations with standard solutions are used to check an instrument's ability to produce acceptable quantitative data for the compounds.

**VOC and SVOC Initial Calibration** — A five-point initial calibration is done to check the instrument's performance at the beginning of the analytical run and to establish a linear calibration curve. The initial calibration is verified by calculating the relative response factor (RRF) and the percent relative standard deviation (%RSD) for each compound. An RRF less than 0.05 or a %RSD greater than 30% is outside the quality control limits for the initial calibration.

Instruments were calibrated initially and continually with standard solutions to verify their capability of producing acceptable quantitative data for the analyzed compounds. All compound quantitation was

analyzed against gas chromatograph/mass spectrometer (GC/MS) tunes within QC requirements for the VOC and SVOC fractions.

**VOC and SVOC Continuing Calibration** — Calibration standard solutions are run periodically to check the daily performance of the instrument and to establish the 12-hour RRF on which the sample quantitations are based. The initial calibration is verified by calculating the RRF and the percent difference (%D) for each compound. An RRF less than 0.05 or a %D greater than 25% is outside the quality control limits for the continuing calibration.

QC outliers were found for VOC continuing calibration RRFs for SDGs 030301, 5A0101, 63A401, 041M10, EM0040, EW0010, and Z53301. Details of the SDGs that had RRFs less than 0.050 are summarized below. For the following samples and noncompliant compounds, all positive results were estimated "J" and not-detected values were rejected and flagged "UR."

SDG	Sample	Analytes
030301	041W030401 041W030301	2-butanone, 2-hexanone acetone
041M10	041W130101, 041W5A0501, 041TM00401	acetone, 2-butanone
5A0101	041W5A0101, 041W5A0201, 041W5A0401, 041W5A0701, 041W061001	acetone, 2-butanone
63A401	041M63A401	acetone
EM0040	041R030101	acetone, 2-butanone
EW0010	041W160101, 041W160201	acetone, 2-butanone, 2-hexanone
Z53301	041W120101	acetone, 2-butanone

QC outliers were found for SVOC continuing calibration RRFs for SDG EM0050. No other RRF exceedances were identified. The target compound 4-chloroaniline for samples 041M150201 and 041M150401 in SDG EM0050 was qualified as estimated "J," for positive results. Values not detected were rejected and flagged "UR."

Both the VOC and SVOC fractions contained several compounds with %RSDs and %Ds outside the continuing calibration QC criteria. These QC deficiencies are within the normal fluctuations of laboratory function. All affected sample results were qualified for %RSD and %D outliers per the Organic Functional Guidelines.

**Pesticide/PCB Initial Calibration** — Using two separate standard mixes, three-point calibrations are analyzed for single-component pesticide compounds, and calibration factors (CF) are established. The

CF for single-component pesticides must be less than or equal to 20%. Multicomponent pesticide toxaphene and all PCBs (or Aroclors) are analyzed separately. Retention times and CFs are determined for three to five peaks. The only review criterion for multicomponent compounds is to verify that these steps were taken.

All initial calibration criteria were met for the pesticide/PCB analyses except for SDGs 030301, 640801, EM0040, EM005, EM0050, EMD060, M06010, and M06070. Details of the SDGs that were outside pesticide/PCB initial calibration QC criteria are summarized below. For the following samples and noncompliant compounds, all positive results were estimated "J," and not detected values were rejected and flagged "UR."

SDG	Sample	Analytes
030301	All samples	alpha-BHC and delta-BHC
640801	All samples	endosulfan II
EM0040	All samples	alpha-BHC and delta-BHC
EM005	All samples	alpha-BHC
EM0050	All samples	alpha-BHC
EM0060	041M18A201, 041M18B101, 041M18A101DL, 041M18A201DL, 041M18A101, 041M18B101DL	alpha-BHC
M06010	041M250101, 041M270101, 041M270201, 041M641501, 041M640501DL, 041M060101DL	alpha-BHC
M06070	041W060701, 041W320101, 041W320301, 041EM0010, 041FM00101, 041W330101, 041W330301, 041R250301, 041W060301, 041W250301, 041M060901, 041M320101, 041M320301, 041M330101,	alpha-BHC and delta-BHC
M06070	041W250101, 041W270201, 041M330201, 041M330301, 041M060801, 041M060801DL	alpha-BHC and delta-BHC
M06070	041M060701	alpha-BHC and 4,4'-DDT

**Pesticide/PCB Continuing Calibration** — To confirm the calibration and evaluate instrument performance, calibration is verified by analyzing instrument blanks, the performance evaluation mixture (PEM), and the midpoint concentration of the two standard mixes. The %D between the calculated amount and the true amount must not exceed 25%. Multicomponent compounds (e.g., PCBs) do not require continuing calibration verification.

No continuing calibration QC outliers were found for the SDGs analyzed for pesticides/PCBs.

#### 5.2.4 Blanks

*Laboratory method blanks* are used to assess the existence and magnitude of potential contamination introduced during analysis. Additionally, field-derived *field blanks* and *trip blanks* are submitted to the laboratories. The field blank is a sample of water used during decontamination activities. The trip blank is a 40-milliliter (ml) volatile organic analysis vial filled with certifiable water used to assess cross-contamination during VOC sample shipment. When compounds are found in both samples and laboratory blanks analyzed within the same 12-hour period *and/or* field-derived blanks, the usability of the data depends on the reviewer's judgment and the origin of the blank. According to the Organic Functional Guidelines, a sample result should not be considered positive unless the concentration of the compound in the sample exceeds 10 times the amount in *any* blank for common laboratory compounds (i.e., methylene chloride, acetone, and 2-butanone), or five times the amount for other compounds. These concentrations are referred to as *action levels* (ALs). Because blank samples may not be prepared using the same weight of the sample, volume of sample, or dilution, these variables should be considered when using blank criteria. The specific actions to be taken are as follows:

- If a compound is found in the blank but not in the sample, no action is taken.
- If the sample concentration is greater than the AL, the concentration may be used unqualified.
- If the sample concentration is less than the practical quantitation limit (PQL) and less than the AL, the sample is reported as not detected "U" at the PQL.

**Example (using "10x" rule):**

<b>Water Sample</b>		<b>Diluted Water Sample</b>	
Blank result	= 1	Blank Result	= 1
Blank AL	= 10	Dilution Factor	= 5
PQL	= 5	Blank AL	= 50
Sample result	= 4J	Diluted PQL	= 25
Final result	= 5U	Sample result	= 4J
		Final result	= 25U

In this example, note that data are not reported as 4U because it is less than the PQL. Also note that the dilution factor is used to calculate an AL of 50 ( $1 \times 5 \times 10$ ).

- If the sample concentration is greater than the PQL but less than the AL, the concentration is reported as not detected "U."

**Example (using "10x" rule):**

Water Sample		Soil Sample		Diluted Soil Sample	
Blank result	= 6	Blank result	= 6	Blank Result	= 6
Blank AL	= 60	% Solids	= 80	% Solids	= 80
PQL	= 5	Blank AL	= 75	Dilution Factor	= 5
Sample result	= 50	PQL	= 5	Blank AL	= 375
Final result	= 50U	Sample result	= 50	PQL	= 25
		Final result	= 50U	Sample result	= 250
				Final result	= 250U

In this example, water sample results less than 60 (or  $10 \times 6$ ) would be qualified as not detected. Soil results of less than 75 would be qualified as not detected because percent solids are used to calculate the AL:  $[(6 \div 0.8) \times 10]$ . Results less than 375 would be qualified as not detected in the diluted soil sample because dilution factors and percent solids are used to calculate the AL:  $[(6 \div 0.8) \times 10 \times 5]$ .

Several compounds were detected in the blanks associated with the investigation of Site 41. Most compounds were considered to be common laboratory compounds: acetone, methylene chloride, and phthalate esters. Target analytes detected in investigative samples were qualified as recommended by the Organic Functional Guidelines. ALs were based on the highest concentration of any laboratory compound found in associated method blank(s) or QC sample(s). No positive sample result for a common laboratory compound was reported unless that compound's concentration exceeded the ALs. All results believed to be attributed to blank contamination were flagged as undetected "U."

### 5.2.5 Surrogates

Accuracy is the degree to which a given result agrees with the true value. To check the accuracy in VOC, SVOC, and pesticide/PCB analyses, the methods require the addition of known amounts of surrogate compounds. If the surrogate percent recoveries are close to the known concentrations, as defined by the limits set by the method, the reported target compound concentrations are assumed to be accurate.

All volatile and semivolatile fraction surrogate recoveries were within QC limits for the Site 41 investigation.

Pesticide/PCB SDGs had surrogate recoveries within QC criteria except for 030301, 041M10, 5A0101, 63A401, 640801, EM0040, EM0050, EMD060, EW0010, M00901, M06010, M06070, M52A10, Z30301, Z42101, and Z53301. Pesticide/PCB surrogates outside QC criteria indicated that the sample results may have been influenced by matrix interference. Samples that had at least one surrogate recovery outside QC criteria are summarized below. When surrogate recoveries were above the QC limit, only positive results were estimated and qualified as estimated "J." When surrogate recoveries were less than the QC limit, all positive and undetected results were estimated and qualified "J" and "UJ," respectively.

### 5.2.6 Internal Standards

Internal standards (IS) are added to VOC and SVOC samples and used to calculate the concentrations of target compounds. Two IS QC criteria must be met when a sample is analyzed. The retention time of the IS must not vary by more than 30 seconds, and the IS area counts must not vary by more than a factor of two (-50% to +100%) from the associated calibration standard. For Site 41 samples, all VOC and SVOC internal standard retention times were within QC limits.

The following SDGs had internal standard area recoveries outside QC criteria: 63A401, 640801, EM0040, EM005, EM0050, EMD060, M06010, M06070, M52A10, and Z30301. Details of these SDGs are summarized below. All associated positive results were flagged "J" and all not-detected results as "UJ."

SDG	Sample	Noncompliant Internal Standard
<b>VOC Fraction</b>		
63A401	041M010201RE 041M010301, 041M010101RE	1, 4-difluorobenzene, chlorobenzene-d <sub>5</sub> chlorobenzene-d <sub>5</sub>
EM005	041M63A301	chlorobenzene-d <sub>5</sub>
EM0050	041M150101RE	1, 4-difluorobenzene, chlorobenzene-d <sub>5</sub>
EMD060	041M18A301, 041M18A101RE	chlorobenzene-d <sub>5</sub>
EMD060	041M18A301RE	ALL
M06010	041M250201, 041M640301	chlorobenzene-d <sub>5</sub>
M06010	041M250201RE, 041M270101RE, 041M270101, 041M640301	1, 4-difluorobenzene, chlorobenzene-d <sub>5</sub>
M06070	041M320201	1, 4-difluorobenzene, chlorobenzene-d <sub>5</sub>
M06070	041M320201RE	1, 4-difluorobenzene, chlorobenzene-d <sub>5</sub> , bromochloromethane
M52A10	041M52A101RE, 041M52A201	chlorobenzene-d <sub>5</sub>
640801	041M641901RE 041M641901	chlorobenzene 1,4-difluorobenzene, chlorobenzene-d <sub>5</sub>

SDG	Sample	Noncompliant Internal Standard
EM0040	041M030201	chlorobenzene-d <sub>5</sub>
<b>SVOC Fraction</b>		
EMD060	041M18A201	perylene-d <sub>12</sub>
PEN13	041M640501, 041M640401	perylene-d <sub>12</sub>
PEN15	041J750101	chrysene-d <sub>12</sub> , perylene-d <sub>12</sub>
PEN15	041J18B101, 041J330201, 041J640101	perylene-d <sub>12</sub>

### 5.2.7 Field Duplicates

The duplicate samples assist in indicating overall field and laboratory precision. A greater variance should be expected for soil sample duplicates than for water sample duplicates, due to the differences in matrix. All Site 41 samples demonstrated good field duplicate correlation except for the pesticide fraction of SDGs 041M10, EM0040, EM005, and M00901.

### 5.2.8 Compound Quantitation

For organic analyses, the data evaluator must assess the usability of values when multiple sample results are reported by the laboratory. The following paragraphs describe actions taken by the validator in these cases.

#### Reanalyzed Samples

Occasionally, organic samples may require reanalysis because of method requirements or QC results outside method criteria. Reasons for sample reanalysis include samples analyzed outside 12-hour tuning periods, extremely low surrogate %RSDs and IS retention times, and/or area counts outside QC limits. In these instances, the laboratory may report results for the original and reanalyzed samples. During validation, the reviewer evaluates QC associated with the original and reanalyzed samples and assesses which sample represents the preferable quality. The sample with the preferable QC should be used for interpretation. The preferred analysis is reported as a primary sample in the EnSafe database and analytical tables.

The following samples were reanalyzed. The laboratory reported two sample results, and the preferred analyses were used for interpretation.

SDG	Preferred Samples	Reason
<b>VOC Fraction</b>		
041M10	041M5A0501RE	IS areas improved with reanalyses.
63A401	041M010101RE, 041M010201RE, 041M010301	IS areas improved with reanalyses.
640801	041M64901RE	IS areas improved with reanalyses.
EM0040	041M030201	Surrogate recoveries did not improve with reanalysis.
EM005	041M63A301	IS areas did not improve with reanalysis.
EM0050	041M150101RE	Surrogate recoveries improved with reanalysis.
EMD060	041M18A301	IS areas improved with reanalysis.
EMD060	041M18A101RE	IS areas improved with reanalysis.
M06010	041M250201, 041M270101, 041M640301RE	IS areas did not improve with reanalysis.
M52A10	041M52A101RE 041M52E201	Surrogate recoveries improved with reanalysis. Surrogate recoveries did not improve with reanalysis.
PEN12	041M5A0601, 041M640601, 041N750101	IS areas did not improve with reanalysis.
<b>SVOC Fraction</b>		
EMD060	041M18A201	IS areas did not improve with reanalysis.
PEN13	041M640401, 041M640501	IS areas did not improve with reanalysis.

### Diluted Samples

When an analyte response exceeds the linear calibration range of the instrument or is off-scale, the laboratory dilutes the sample. If one or more compounds are outside the calibration range during an initial analysis, the laboratory flags the analyte "E." When diluted, the sample results are qualified "D." Generally, values from the initial analysis will be used except where they exceeded the calibration range. In this case, the initial analysis value will be substituted by the diluted value to ensure the most representative data. The "D" qualifier will remain on the value to alert the data user that the value from a secondary dilution was used.

The SDGs, samples, and compound used from the secondary dilution, and the corresponding samples are listed below.

SDG	Diluted Samples	Compounds Used from Secondary Dilution
5A0101	041M5A0101, 041M061101	acetone
EM005	041W170101, 041W04D401	methylene chloride
M00901	041WW10201	xylene
M06070	041M060901	acetone
	041R250301, 041W250301	methylene chloride
Z42101	041W5B0201	cis-1,2-dichloroethene

SDG	Diluted Samples	Compounds Used from Secondary Dilution
Z30301	041W570101	methylene chloride
030301	041M04D101	delta-BHC, 4,4'-DDE, 4,4'-DDD
	041M04D201	4,4'-DDE, 4,4'-DDD
041M10	041M5A0501	4,4'-DDE
5A0101	041M060601	4,4'-DDE, 4,4'-DDD
63A401	041M010301	4,4'-DDD, gamma-chlordane, Aroclor-1260
640801	041M010401	endrin, 4,4'-DDD, 4,4'-DDT
EM0040	041M030101, 041N030101	4,4'-DDE, 4,4'-DDD, 4,4'-DDT
	041M030201	4,4'-DDD, Aroclor-1260
EM005	041M19A101	heptachlor epoxide
	041C490101, 041M490101, 041M490201	4,4'-DDD
	041M63A301	4,4'-DDD, Aroclor-1260
EM0050	041M150101, 041M150201, 041M150301	4,4'-DDE, 4,4'-DDD
EM0060	041M790101	4,4'-DDD, alpha-chlordane
EMD060	041M18A101, 041M18A201	4,4'-DDE, 4,4'-DDD, 4,4'-DDT
	041M18B101	4,4'-DDE, 4,4'-DDT
M00901	041M480101, 041N480101	4,4'-DDE, 4,4'-DDD
M06010	041M060301	4,4'-DDE, 4,4'-DDD, 4,4'-DDT
	041M640201, 041M640501	4,4'-DDE, 4,4'-DDD
	041M060101	4,4'-DDE, 4,4'-DDT
M06070	041M060801	4,4'-DDE, 4,4'-DDD
M52A10	041M52E101, 041M56A101	4,4'-DDE, 4,4'-DDD
	041MW20101	4,4'-DDD
Z53301	041M120101	endrin ketone
PEN12	041M5A401	4,4'-DDE, 4,4'-DDD

### Pesticide/PCB Quantitation

Pesticide analysis employs an electron capture detector (ECD) for quantitation; however, ECD detection is not a definitive means of discerning between different components. Pesticides are routinely analyzed using two dissimilar columns with retention time windows as the qualitative indicator. If a peak falls within the retention time windows on both columns, then it is reported as a positive hit for the appropriate target analyte. Target analytes and surrogates are generally quantitated and reported on both columns; however, only the lower of the two concentrations is reported because, if present, co-eluting interferences are likely to increase the calculated concentration of any target analyte.

For detected analytes, the %D between the two columns is calculated. If the %D is greater than 25%, the laboratory flags the value with a "P" qualifier. This flag alerts the data user of the

potential problems in quantitating the analyte. If a significant difference exists in the quantitated values on the two columns, an interference likely exists, suggesting that the detected concentration may be a false positive. This is particularly true at lower concentrations where uncertainty may increase because of instrument noise.

During the validation process, the laboratory's "P" flags are assessed. General guidelines are used to assess result %Ds. For data in SDGs other than PEN11, PEN12, PEN13, PEN14, and PEN15, %Ds greater than 25% were qualified as estimated. For SDGs PEN11, PEN12, PEN13, PEN14, and PEN15, the guidelines below were used in conjunction with examination of the data provided to ascertain the validity of single-component pesticide results:

<b>Result %D</b>	<b>Validation Flag</b>
≤ 40%	Result is accepted unqualified.
40% > %D < 100%	Analyte is estimated and flagged "J."
> 100%	Analyte is flagged as undetected "U" if it is less than 10× the PQL and data review indicates the result may be a false positive.

OR

Analyte is flagged "NJ" if the result is greater than 10× the PQL. "NJ" flag indicates the presence of an analyte for which there is presumptive evidence to make a tentative identification at an estimated concentration.

### **5.3 Inorganic Analysis**

#### **5.3.1 Holding Times**

All samples were received by the laboratory in good condition with proper custody documentation. From the date of collection to the date of sample analysis, holding times were within method and contractual requirements. The only exceptions were SDGs Z13601 and Z30201, which were prepared using a modified acid digestion. Because the analytical data for SDGs Z13601 and Z30201 were not used to quantify specific analyte concentrations, the holding time exceedances do not affect data quality or usability.

### 5.3.2 Calibrations

Initial and continuing calibrations are conducted to ensure that the instrument can produce acceptable and quantitative data throughout each analytical run. For the analysis of Site 41 inorganics, no initial or continuing calibrations exceeded method QC limits for the inorganic parameters.

### 5.3.3 Blanks

As described previously, laboratory method blanks are used to assess the existence and magnitude of potential contamination introduced during analysis. Additionally, field blanks may be collected to assess the potential contamination introduced during sample collection. When chemicals are found in both samples and laboratory blanks, the usability of the data depends on the reviewer's judgment and the origin of the blank. According to Inorganic Functional Guidelines, a sample result should not be considered positive unless the concentration of the analyte in the sample exceeds five times the amount in *any* blank. These concentrations are referred to as ALs. Because blank samples may not be prepared using the same weight of sample, volume of sample, or dilution, these factors should be considered when using blank criteria. The specific actions to be taken are as follows:

- If an analyte is found in the blank but not in the sample, no action is taken.
- If the sample concentration is between the instrument detection limit (IDL) and the AL, the concentration is reported as "U."
- If the sample concentration is greater than the AL, the concentration may be used unqualified.

When the blank concentration is less than the IDL (negative value), but had an absolute value greater than the IDL, the AL is 10 times the absolute value of the blank concentration. The specific actions are as follows:

- If the sample concentration is greater than the AL, the concentration may be used unqualified.
- If the concentration of any detected analyte is less than the AL, it is qualified as estimated "J" for positive results.
- If the result is not detected, then it is qualified as estimated "UJ."

Contamination was identified in blanks of all SDGs. Action levels were set for each affected analyte based on the highest concentration in any associated blank. Analytes attributed to blank contamination

were flagged undetected "U." No positive sample result was reported for an analyte detected in any blank unless that artifact's concentration exceeded the action level of five times the amount found in any blank, per the Inorganic Functional Guidelines (USEPA, 1994b).

### 5.3.4 Inductive Coupled Plasma Interference Check Sample Analysis

The inductive coupled plasma (ICP) Interference Check Sample (ICS) analysis is performed to check the laboratory's instrument and background correction factors. All percent recovery criteria for the Site 41 samples were within the established criteria.

### 5.3.5 ICP Serial Dilutions

ICP serial dilutions assess matrix interference. One sample from each set of similar matrix types is diluted by a factor of five. For an analyte concentration that is at least 50 times above the IDL for CLP analyses and 10 times above the IDL for SW-846, the measured concentrations of the undiluted and diluted sample should agree within 10%. SDGs 030301, 5A0101, EM0040, M00901, Z30201, PEN13, and PEN14 had %Ds outside acceptable QC criteria. Elements that exceeded QC criteria are summarized below. When an element exceeded QC criteria, that analyte was qualified as estimated "J" for all positive sample values in the SDG, as specified in Inorganic Functional Guidelines. Nondetect results were accepted without qualification.

SDG	Affected Samples	Analyte(s)
030301	041M030301, 041M030401, 041M030501, 041M030601, 041M030701, 041M04D101, 041M04D201, 041M04D301, 041M04D401, 041M04D501	manganese
5A0101	041W061001, 041W5A0101, 041W5A0201, 041W5A0401, 041W5A0701	iron, magnesium
EM0040	041M030101, 041N030101, 041M030201	lead, calcium
M00901	041W480101, 041R480101, 041W490301, 041WW10101, 041WW10201, 041WW10301, 041W490101	calcium, magnesium
Z30201	041M10A101, 041M320301, 041M330201, 041M641401	iron, lead
PEN13	041M160301, 041M640401, 041M640501, 041M640601	aluminum
PEN14	041W640101, 041W640501, 041R640501	potassium
PEN15	041J400601, 041J18B101, 041J330201, 041J640101, 041J640601, 041J750101	copper, iron, manganese

### 5.3.6 Laboratory Control Samples

Laboratory control samples (LCS) are used to monitor the overall performance or accuracy of all steps in the analysis, including the sample preparation. All LCS criteria were met for all SDGs except for SDG Z30201. Samples in this SDG were prepared using a hydrofluoric acid digestion method. Because

the analytical data were not used to quantify specific analyte concentrations at Site 41, QC exceedances for this SDG do not affect data quality or usability.

### 5.3.7 Laboratory Matrix Spikes

Laboratory spiked samples are designed to provide information about the effects of the sample matrix on the digestion and measurement method. Many MS recoveries exceeded QC criteria for the Site 41 data. As specified by the CLP Inorganic SOW and SW-846 methods, the MS QC limits are 75% to 125%. When an element was outside MS QC limits, positive and undetected results for that analyte were qualified for all samples in the SDG, as specified in Inorganic Functional Guidelines. Spike results and the qualifiers applied to QC outliers are summarized below.

SDG	Affected Samples	Spike Results	Flag(s)
Antimony	EM0040, EMD060, 5A0101, 63A401 EM005, M52A10, Z53301, PEN12	>30% <75%	J, UJ
Antimony	030301, 041M10, Z30301, Z42101 (soils), 63A401, 640801, EM005 EM0050, EW0010, M06010, Z30301, Z42101, Z53301, PEN12	<30%	J, UR
Cadmium	EM0040	>30% <75%	J, UJ
Chromium	Z30301	>125%	J
Copper	M06010	>30% <75%	J, UJ
Cyanide	PEN12	>30% <75%	J, UJ
Lead	5A0101, Z42101	>125%	J
Lead	Z42101 (soils)	>30% <75%	J, UJ
Mercury	EMD060	>125%	J
Mercury	PEN14	>30% <75%	J, UJ
Selenium	041M10, EM0040 (soils), EM005 M52A10	>30% <75%	J, UJ
Selenium	Z42101 (soils), 030301, M06010	>125%	J
Silver	041M10, EM0040 (soils), 030301, Z53301, Z22401 (soils), M06010, Z42101, PEN14	>30% <75%	J, UJ
Thallium	041M10, EM0040 (soils), 640801, Z30301 (soils)	>30% <75%	J, UJ
Zinc	PEN14	>125%	J
Cyanide	PEN12	>30%, <75%	J, UJ

For SDGs Z13601 and Z30201, several elements exceeded the MS control limits. Because the data from these SDGs were not used to assess contamination at Site 41, the QC exceedances do not affect data quality and usability.

### 5.3.8 Laboratory Duplicates

Laboratory duplicate samples are used to determine the precision of analytical process for each parameter. The duplicate RPD analysis criteria were not met for SDGs 041M10, 63A401, M00901, EM0050, M06010, Z42101, and Z53301. A summary of the SDGs outside QC criteria and elements affected is provided below. When an element was outside QC criteria, that analyte was qualified as estimated "J" for all positive sample values in the SDG, as specified in Inorganic Functional Guidelines.

SDG	Analyte	Flag
041M10	calcium, lead	J
63A401	aluminum, calcium	J
M00901	aluminum	J
EM0050	calcium, chromium	J
M06010	calcium, lead, zinc	J
Z42101	antimony, lead, silver	J
Z53301	calcium	J

For SDGs Z13601 and Z30201, several elements exceeded the RPD control limits. Because the data from these SDGs were not used to assess contamination at Site 41, the QC exceedances do not affect data quality and usability.

### 5.3.9 Field Duplicates

Representativeness expresses the degree to which sample data represent the characteristic of a population, parameter variations at a sampling point, or an environmental condition. The duplicate samples assist in indicating overall field and laboratory precision. A greater variance should be expected for soil sample duplicates than for water duplicates due to matrix differences. RPDs for field duplicates were outside QC criteria for SDGs 041M10 (calcium), EM0040 (aluminum, iron, magnesium, manganese, vanadium, and zinc), EM0050 (calcium), M06010 (aluminum, calcium, iron, and sodium), and Z42101 (calcium).

### 5.3.10 Atomic Absorption Spike Recoveries

Antimony, arsenic, lead, silver, thallium, and selenium were analyzed by graphite furnace atomic absorption (GFAA). For elements analyzed by GFAA, every sample is spiked by the analyst to assess matrix interference. For the Site 41 samples, GFAA analytical spike recoveries met the control limits of 85 to 115% for all elements except antimony, silver, and thallium. QC criteria exceedances affected the following SDGs: 030301, 041M10, 5A0101, 63A401, 640801, EM0040, EM005, EM0050, EM0060, EMD060, EW0010, M00901, M06010, M06070, M52A10, Z30301, Z42101, Z53301, PEN11, and PEN14. Detections of antimony, silver, and thallium were flagged as estimated "J". Undetected

antimony, silver, and thallium results were estimated "UJ" unless they were previously rejected and flagged "UR" for poor MS results.

## **5.4 Site 41 Phase II and III Data Summary**

### **5.4.1 Completeness**

Completeness is defined as the percentage of acceptable data points. Except for the results flagged "UR", all of the samples analyzed for the investigation of Site 41 were determined to be valid with some qualification. Table 5-1 (tables are located at the end of each section) presents the analytical completeness for Site 41 data by parameter.

With the exception of Wetlands 13 and 25, all wetlands were within the analytical completeness criterion of 95% for each parameter. The low completeness percentages obtained for these two wetlands is due to the number of samples analyzed and the nature of the QC criteria that were not met. There were less than five samples collected at each wetland. Hence, if one sample was rejected because of noncompliant QC, the completeness was more impacted than if there were a larger number of samples. Pesticide/PCB sample 041W130101 was rejected because the surrogate recoveries were extremely low, indicating the possibility of matrix interference. SVOC sample 041W250101 was rejected because of missed holding times. In both instances, the rejected data indicate that any analytes detected may be biased low and the reported quantitation limits may not be representative.

### **5.4.2 Comparability**

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparability is assured through the use of established field sampling methods by experienced field personnel and performance of laboratory analyses as specified by USEPA protocols. All samples for Site 41 were collected in accordance with the USEPA Region IV Standard Operating Procedures and Quality Assurance Manual (SOP/QAM) and analyzed according to specified analytical protocols.

## **5.5 Conclusion**

With the exception of the unusable data identified in Section 5.3, the data are considered complete and satisfactory for the investigation of Site 41. Antimony completeness was 83.8% because of low matrix spike recovery, a result of the acid used during the digestion process. The acid digestion procedure prescribed by the CLP analytical method tends to precipitate antimony from the sample, and problems with antimony matrix recovery are inherent in the CLP sample preparation method. USEPA has acknowledged that this is a problem; in SW-846, it recommends a specific digestion process to reduce the amount of precipitation.

## 5.6 2001 Analytical Data

Site 41 data were validated by Heartland Environmental Services Inc. of St. Charles, Missouri. The analytical work was conducted by STL Savannah Inc., Savannah, Georgia. Sample analyses and data validation were performed in accordance with the guidance documents listed in Section 5.1.

Samples from Wetland 64 were collected in August 2001. All samples were received by the laboratory in good condition and with proper custody documentation. Samples were analyzed for SVOCs, pesticides, PCBs, and metals, SEM metals, acid volatile sulfide, mercury and total organic carbon. Seven fish-tissue samples were submitted to Savannah Laboratory and analyzed for SVOCs, pesticides/PCBs, and metals.

Organic and inorganic results were reported by the laboratory in two SDGs: NASP14 and NASP15. Data assessment narratives and summary reports are provided in Appendix I.

## 5.7 Confirmation Sampling 2004/Phase IV Analytical Data

Site 41 data from the 2004 sampling events were validated by EnSafe chemists. Laboratory analysis was performed by STL Savannah of Savannah, Georgia. Sample analyses and data validation were performed in accordance with the guidance documents listed in Section 5.1 except for PAHs, which were analyzed using a low concentration SOW.

Samples from selected wetlands were collected in April 2004. All samples were received by the laboratory in good condition and with proper custody documentation. Sediment samples were analyzed for VOCs, low PAHs, SVOCs, pesticides, PCBs, metals, and total organic carbon. Surface water samples were analyzed for VOCs, low PAHs, SVOCs, pesticides, PCBs, total metals, dissolved metals, and total organic carbon.

Organic and inorganic results were reported by the laboratory in two SDGs: PEN16 and PEN17. Data assessment narratives and summary reports are provided in Appendix I.

### Validation Qualifiers

- U Undetected** — The analyte was analyzed for but not detected or was also found in an associated blank at a concentration less than 10 times the blank concentration for common organic laboratory contaminants or five times the blank concentration for other target analytes or elements. The associated value shown is the quantitative limit.
- J Estimated Value** — At least one QC parameter was outside control limits.

- NJ Presumptive Identification** — NJ is used for pesticide/PCB analysis when the percent difference exceeds the QC limits by 100% or more. It indicates the presence of an analyte for which there is presumptive evidence to make a tentative identification at an estimated concentration. This qualifier is used for pesticide/PCB validation only.
- UJ Undetected and Estimated** — The analyte was analyzed for, but not detected above, the listed estimated quantitation limit; the quantitation limit is estimated because one or more QC parameters were outside control limits.
- D Diluted Result** — The compound was reanalyzed at a secondary dilution factor. If one or more compounds are outside the calibration range during an initial analysis, the laboratory flags the analyte "E." When diluted, the sample results are flagged "D." Generally, values from the initial analysis will be used except where the value exceeded the calibration range. In this case, the initial analysis value will be substituted by the diluted value to ensure the most representative data. The "D" flag will remain on the value to alert the data user that a secondary dilution value was used.
- R/UR Unusable Data** — One or more QC parameters grossly exceeded control limits.
- I** The reported value is between the laboratory minimum detection limit and the laboratory PQL. This qualifier applies to data collected in the 2004 investigations only.

**Table 5-1**  
**Phase II and III Analytical Completeness by Parameter**

<b>Fraction</b>	<b>Total Unusable Results</b>	<b>Total Results</b>	<b>Percent Completeness</b>
Metal	33	8,990	99.6
Pesticides/PCBs	128	10,541	98.8
SVOC	86	23,412	99.6
VOC	165	12,957	98.7
<b>TOTAL</b>	<b>412</b>	<b>56,176</b>	<b>99.2</b>

**Note:**

Analytical completeness was greater than 95% for each parameter analyzed for Site 41 sediment and surface water samples; therefore, the analytical completeness criterion of 95% was met for each fraction analyzed for this data set.

## **6.0 NATURE AND EXTENT EVALUATION METHODS**

This section presents the methods used to evaluate the nature and extent of contamination. Wetland specific evaluations are presented in Sections 10 through 15 of this report.

The nature and extent evaluation for each Site 41 wetland will include an overview of each wetland's data to examine the nature and extent of the sediment and surface water detections and where the detections occurred relative to the sample locations, onsite features, adjacent sites, and offsite features. The nature and extent discussion will also include a reference concentration comparison. Site 41 inorganic freshwater and estuarine reference concentrations for sediment and surface water is discussed in Section 6.1. Development of basewide DDT concentrations is described in Section 6.2.

### **6.1 Inorganic Sediment and Surface Water Reference Criteria**

Reference wetlands were identified from the wetlands list developed by Parsons and Pruitt (USEPA, 1991a) for comparison to the potentially impacted wetlands. These wetlands were selected because they had similar vegetation, topography, geology, and hydrology in contrast to the wetlands potentially impacted by an IR site. The reference wetlands were also distant from any IR site or other potential sources of contamination based on field observations and a historical study of adjacent areas. The four reference wetlands sampled were Wetlands 25, 27, 32, and 33. Wetlands 25 and 32 are freshwater reference wetlands, while Wetlands 27 and 33 are estuarine reference wetlands.

In determining reference criteria, the sediment and surface water results from Wetlands 25 and 32 were used to develop freshwater reference concentrations for the Site 41 freshwater wetlands. Likewise, sediment and surface water results from Wetlands 27 and 33 were used to develop estuarine reference concentrations for the Site 41 saltwater wetlands.

Reference criteria for both sediment and surface water were calculated by summing valid detections with one-half of each nondetect ("U" or "UJ" validation qualifier). The mean detection was calculated, then multiplied by two, with the resulting multiplier then used as the reference concentration. Tables 6-1 and 6-2 (tables are located at the end of each section) detail how the freshwater and estuarine inorganic sediment and surface water reference concentrations were developed, respectively.

### **6.2 Basewide Total-DDT Concentrations**

Although its use has been banned in the United States since 1972, 4,4'-DDT and its metabolites (4,4'-DDD, and 4,4'-dichlorodiphenyldichloroethylene 4,4'-DDE) are still detected in the Florida coastal sediments (Delfino, J.J. *et al.*, 1991). Although 4,4'-DDT is not naturally occurring, it appears to be

ubiquitous in the environment, i.e., in surface water, sediment, and biological tissues. 4,4'-DDT and its metabolites are generally highly lipophilic, resistant to biodegradation, and bioconcentrate in biota. 4,4'-DDT can be transferred to humans through the food chain. Atmospheric transport from Central America continues to contribute to the 4,4'-DDT concentrations in the Florida coastal sediment. Therefore, studies of the Pensacola Bay system (PBS) (National Status and Trends Program [NSTP]) and NAS Pensacola (Sites 40 and 41) were reviewed to establish a basewide concentration for 4,4'-DDT and its metabolites for NAS Pensacola coastal sediments. The NSTP results are detailed in *Magnitude and Extent of Sediment Toxicity in Four Bays of the Florida Panhandle: Pensacola, Choctawhatchee, St. Andrew, and Apalachicola* (Long, E.R. et al., 1997).

The NAS Pensacola results are detailed in this report for Site 41 and in the *Final Remedial Investigation Report, Site 40, Naval Air Station Pensacola* (EnSafe, 1999). The summary table from the NSTP study and a table presenting all the results from the Sites 40 and 41 investigations are presented in Appendix J.

The NSTP study analyzed 24 sediment samples from the Pensacola Bay system for pesticides/PCBs. During the field investigations for Sites 40 and 41, 265 sediment samples were analyzed for pesticides/PCBs. The Site 41 samples were further evaluated based on the color coding established for the wetlands earlier in the investigation. That data were evaluated for concentration populations indicative of widespread use versus elevated concentrations. The maximum concentration of widespread use population was established as the basewide level.

#### **4,4'-DDD**

4,4'-DDD was detected in 50% of the NSTP study locations at concentrations ranging from 2.58 µg/kg to 53.84 µg/kg. 4,4'-DDD was detected in 29.7% of the 265 sediment samples collected from Sites 40 and 41, with detections ranging from 0.2 µg/kg (Wetlands 64 and 72) to 2,600 µg/kg (Wetland 48). In non-IR-related wetlands and reference wetlands, the concentrations ranged from 0.2 µg/kg in Wetland 72 to 24 µg/kg in Wetland 32. Based on the concentrations in the NSTP study, and the PNAS wetlands, the basewide concentration for 4,4'-DDD is established at 50 µg/kg.

#### **4,4'-DDE**

4,4'-DDE was not analyzed for in the NSTP study. Of the 265 samples analyzed from the Sites 40 and 41 investigations, 4,4'-DDE concentrations ranged from 0.21 µg/kg (Site 40 Assessment Zone 3 sample) to 620 µg/kg (Wetland 48). The concentration of 4,4'-DDE in the non-IR-related wetlands and reference wetlands ranged from 0.24 µg/kg (Wetland 72) to 37 µg/kg (Wetland 32). Based on the

concentrations in the NSTP study and PNAS wetlands, the basewide concentration for 4,4'-DDE was established at 40 µg/kg.

#### **4,4'-DDT**

4,4'-DDT was detected in 41.7% of the NSTP study samples. The concentrations ranged from 2.02 µg/kg to 37.06 µg/kg in that study. 4,4'-DDT was detected in 23.6% of the 265 Sites 40 and 41 sediment samples, with detections ranging from 0.21 µg/kg (Site 40 Assessment Zone 2 sample) to 1,800 µg/kg (Wetland 18B).

The reference wetland concentrations ranged from 0.26 µg/kg (Wetland 72) to 13 µg/kg (Wetland 32). Based on the results of the NSTP study and the PNAS wetlands, a basewide concentration of 20 µg/kg was established for 4,4'-DDT.

#### **Total DDT**

The basewide level for total DDT is 110 µg/kg, and was derived from adding the basewide levels of 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT.

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Aluminum (mg/kg)</b>						<b>Aluminum (µg/L)</b>					
041M250101	4,180	J	4,180	6,805	<b>13,610</b>	041W250101	1,820		1,820	545.13	<b>1,090.25</b>
041M250201	8,780	J	8,780			041W250301	221		221		
041M250301	12,500	J	12,500			041W320101	141	U	70.5		
041M320101	3,670		3,670			041W320301	138	U	69		
041M320201	3,920		3,920								
041M320301	7,780		7,780								
<b>Antimony (mg/kg)</b>						<b>Antimony (µg/L)</b>					
041M320101	1.6	UJ	0.8	2.217	<b>4.43</b>	041W250101	2	UJ	1	2	<b>4</b>
041M320201	6.7	UJ	3.35			041W250301	2	U	1		
041M320301	5	U	2.5			041W320101	2	UJ	1		
						041W320301	10	U	5		
<b>Arsenic (mg/kg)</b>						<b>Arsenic (µg/L)</b>					
041M250101	1.1	J	1.1	3.31	<b>6.62</b>	041W250101	2.4	J	2.4	1.35	<b>2.7</b>
041M250201	8		8			041W250301	2	U	1		
041M250301	8.8		8.8			041W320101	2	U	1		
041M320101	1.6	U	0.8			041W320301	2	U	1		
041M320201	1.3	U	0.65								
041M320301	1	U	0.5								
<b>Barium (mg/kg)</b>						<b>Barium (µg/L)</b>					
041M250101	2.3	J	2.3	7	<b>14</b>	041W250101	2.2	U	1.1	1.84	<b>3.68</b>
041M250201	5.6	J	5.6			041W250301	1.9	U	0.95		
041M250301	8.6	J	8.6			041W320101	5.4	U	2.7		
041M320101	9.1	J	9.1			041W320301	5.2	U	2.6		
041M320201	6.7	J	6.7								
041M320301	9.7	J	9.7								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Beryllium (mg/kg)</b>						<b>Beryllium (µg/L)</b>					
041M250101	0.46	U	0.23	0.42	<b>0.84</b>	041W250101	1	U	0.5	0.5	<b>1</b>
041M250201	0.47	J	0.47			041W250301	1	U	0.5		
041M250301	0.59	J	0.59			041W320101	1	U	0.5		
041M320101	0.78	U	0.39			041W320301	1	U	0.5		
041M320201	0.67	U	0.335								
041M320301	0.51	J	0.51								
<b>Cadmium (mg/kg)</b>						<b>Cadmium (µg/L)</b>					
041M250101	1.4	U	0.7	0.9	<b>1.8</b>	041W250101	3	U	1.5	1.5	<b>3</b>
041M250201	1	U	0.5			041W250301	3	U	1.5		
041M250301	1.3	J	1.3			041W320101	3	U	1.5		
041M320101	2.3	U	1.15			041W320301	3	U	1.5		
041M320201	2	U	1								
041M320301	1.5	U	0.75								
<b>Calcium (mg/kg)</b>						<b>Calcium (µg/L)</b>					
041M250101	1,770	J	1,770	5,378.33	<b>10,756.67</b>	041W250101	4,620	J	4,620	3,837.5	<b>7,675</b>
041M250201	3,700	J	3,700			041W250301	6,720		6,720		
041M250301	17,900	J	17,900			041W320101	1,750	J	1,750		
041M320101	2,150	J	2,150			041W320301	2,260	J	2,260		
041M320201	2,430	J	2,430								
041M320301	4,320		4,320								
<b>Chromium (mg/kg)</b>						<b>Chromium (µg/L)</b>					
041M250101	7.1		7.1	19.68	<b>39.37</b>	041W250101	8	U	4	4	<b>8</b>
041M250201	33		33			041W250301	8	U	4		
041M250301	59.1		59.1			041W320101	8	U	4		
041M320101	7.2	J	7.2			041W320301	8	U	4		
041M320201	5.7	J	5.7								
041M320301	6		6								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Cobalt (mg/kg)</b>						<b>Cobalt (µg/L)</b>					
041M250101	1.6	J	1.6	1.4	<b>2.8</b>	041W250101	3	U	1.5	1.5	<b>3</b>
041M250201	1.9	J	1.9			041W250301	3	U	1.5		
041M250301	2	J	2			041W320101	3	U	1.5		
041M320101	2.3	U	1.15			041W320301	3	U	1.5		
041M320201	2	U	1								
041M320301	1.5	U	0.75								
<b>Copper (mg/kg)</b>						<b>Copper (µg/L)</b>					
041M250101	6.1	J	6.1	9.75	<b>19.5</b>	041W250101	4	U	2	2	<b>4</b>
041M250201	12.2	J	12.2			041W250301	4	U	2		
041M250301	19.6	J	19.6			041W320101	4	U	2		
041M320101	5.7	J	5.7			041W320301	4	U	2		
041M320201	5.7	J	5.7								
041M320301	9.2	J	9.2								
<b>Cyanide (CN) (mg/kg)</b>						<b>Cyanide (CN) (µg/L)</b>					
041M250101	4.8	U	2.4	2.61	<b>5.22</b>	041W250101	5	U	2.5	2.5	<b>5</b>
041M250201	3.5	U	1.75			041W250301	5	U	2.5		
041M250301	3.8	U	1.9			041W320101	5	U	2.5		
041M320101	7.5	U	3.75			041W320301	5	U	2.5		
041M320201	6.4	U	3.2								
041M320301	5.3	U	2.65								
<b>Iron (mg/kg)</b>						<b>Iron (µg/L)</b>					
041M250101	1,780	J	1,780	5,955.83	<b>11,911.67</b>	041W250101	4,030		4,030	1,180	<b>2,360</b>
041M250201	13,500	J	13,500			041W250301	317		317		
041M250301	18,500	J	18,500			041W320101	182		182		
041M320101	652		652			041W320301	191		191		
041M320201	471		471								
041M320301	832		832								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Lead (mg/kg)</b>						<b>Lead (µg/L)</b>					
041M250101	21.4	J	21.4	41.23	<b>82.47</b>	041W250101	4.9		4.9	1.6	<b>3.2</b>
041M250201	32.1	J	32.1			041W250301	1	U	0.5		
041M250301	58.7	J	58.7			041W320101	1	U	0.5		
041M320101	41.3		41.3			041W320301	1	U	0.5		
041M320201	41.6		41.6								
041M320301	52.3		52.3								
<b>Magnesium (mg/kg)</b>						<b>Magnesium (µg/L)</b>					
041M250101	1,420	J	1,420	3,756.67	<b>7,513.33</b>	041W250101	12,500		12,500	10,130	<b>20,260</b>
041M250201	5,490		5,490			041W250301	20,400		20,400		
041M250301	6,660		6,660			041W320101	3,050	J	3,050		
041M320101	2,230	J	2,230			041W320301	4,570	J	4,570		
041M320201	2,460	J	2,460								
041M320301	4,280		4,280								
<b>Manganese (mg/kg)</b>						<b>Manganese (µg/L)</b>					
041M250101	2.6	J	2.6	18.98	<b>37.97</b>	041W250101	4.2	J	4.2	6.6	<b>13.2</b>
041M250201	30.7		30.7			041W250301	2.9	J	2.9		
041M250301	66		66			041W320101	10	J	10		
041M320101	5.5	J	5.5			041W320301	9.3	J	9.3		
041M320201	3.5	J	3.5								
041M320301	5.6	J	5.6								
<b>Mercury (mg/kg)</b>						<b>Mercury (µg/L)</b>					
041M250101	0.44	U	0.22	0.27	<b>0.55</b>	041W250101	0.13	U	0.065	0.07	<b>0.13</b>
041M250201	0.31	U	0.155			041W250301	0.13	U	0.065		
041M250301	0.4	U	0.2			041W320101	0.13	U	0.065		
041M320101	0.61	U	0.305			041W320301	0.13	U	0.065		
041M320201	0.49	U	0.245								
041M320301	0.51	J	0.51								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Nickel (mg/kg)</b>						<b>Nickel (µg/L)</b>					
041M250101	5.5	U	2.75	4.64	<b>9.28</b>	041W250101	12	U	6	6	<b>12</b>
041M250201	6.9	J	6.9			041W250301	12	U	6		
041M250301	6.5	J	6.5			041W320101	12	U	6		
041M320101	9.3	U	4.65			041W320301	12	U	6		
041M320201	8.1	U	4.05								
041M320301	6	U	3								
<b>Potassium (mg/kg)</b>						<b>Potassium (µg/L)</b>					
041M250101	172	J	172	814.33	<b>1,628.67</b>	041W250101	3,980	J	3,980	3,497.5	<b>6,995</b>
041M250201	1,430	J	1,430			041W250301	7,060		7,060		
041M250301	2,060		2,060			041W320101	1,170	J	1,170		
041M320101	433	J	433			041W320301	1,780	J	1,780		
041M320201	306	J	306								
041M320301	485	J	485								
<b>Selenium (mg/kg)</b>						<b>Selenium (µg/L)</b>					
041M250101	1.4	U	0.7	1.73	<b>3.45</b>	041W250101	3	U	1.5	1.5	<b>3</b>
041M250201	1.9	J	1.9			041W250301	3	U	1.5		
041M250301	1.2	U	0.6			041W320101	3	U	1.5		
041M320101	2.3	U	1.15			041W320301	3	U	1.5		
041M320201	2.4	J	2.4								
041M320301	3.6		3.6								
<b>Silver (mg/kg)</b>						<b>Silver (µg/L)</b>					
041M250101	1.8	UJ	0.9	1.05	<b>2.1</b>	041W250101	4	U	2	2	<b>4</b>
041M250201	1.4	UJ	0.7			041W250301	4	U	2		
041M250301	1.6	UJ	0.8			041W320101	4	U	2		
041M320101	3.1	U	1.55			041W320301	4	U	2		
041M320201	2.7	U	1.35								
041M320301	2	U	1								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Sodium (mg/kg)</b>						<b>Sodium (µg/L)</b>					
041M250101	640	J	640	9,496.67	<b>18,993.33</b>	041W250101	105,000		105,000	91,100	<b>182,200</b>
041M250201	22,400	J	22,400			041W250301	185,000		185,000		
041M250301	24,700	J	24,700			041W320101	30,000		30,000		
041M320101	3,680	J	3,680			041W320301	44,400		44,400		
041M320201	2,980	J	2,980								
041M320301	2,580		2,580								
<b>Thallium (mg/kg)</b>						<b>Thallium (µg/L)</b>					
041M250101	1.4	U	0.7	0.78	<b>1.57</b>	041W250101	3.9	J	3.9	2.1	<b>4.2</b>
041M250201	1	U	0.5			041W250301	3	U	1.5		
041M250301	1.2	U	0.6			041W320101	3	U	1.5		
041M320101	2.3	U	1.15			041W320301	3	U	1.5		
041M320201	2	U	1								
041M320301	1.5	U	0.75								
<b>Vanadium (mg/kg)</b>						<b>Vanadium (µg/L)</b>					
041M250101	10.1	J	10.1	14.33	<b>28.67</b>	041W250101	6.4	J	6.4	2.35	<b>4.7</b>
041M250201	22.8		22.8			041W250301	2	U	1		
041M250301	33.7		33.7			041W320101	2	U	1		
041M320101	6.6	J	6.6			041W320301	2	U	1		
041M320201	5.2	J	5.2								
041M320301	7.6	J	7.6								

**Table 6-1**  
**Development of Freshwater Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=6)						Surface Water Reference Concentrations (n=4)					
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Zinc (mg/kg)</b>						<b>Zinc (µg/L)</b>					
041M250101	7.3	J	7.3	18.365	<b>36.73</b>	041W250101	7.4	U	3.7	2.76	<b>5.53</b>
041M250201	21.7	J	21.7			041W250301	5.4	U	2.7		
041M250301	57.1	J	57.1			041W320101	3.9	U	1.95		
041M320101	6.8	J	6.8			041W320301	5.4	U	2.7		
041M320201	7.9	J	7.9								
041M320301	9.4	J	9.4								

**Notes:**

- µg/kg = Micrograms per kilogram
  - mg/kg = Milligrams per kilogram
  - µg/l = Micrograms per liter
  - U = Not Detected
  - J = Estimated value: concentration is below limit of quantitation
- Sample frequency adjusted for rejected data.

**Table 6-2**  
**Development of Estuarine Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sample ID	Sediment Reference Concentrations (n=5)					Sample ID	Surface Water Reference Concentrations (n=4)				
	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)		Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value	Mean Value	Reference Concentration (2 X Mean)
<b>Aluminum (mg/kg)</b>						<b>Aluminum (µg/L)</b>					
041M270101	2,900	J	2,900	2,137	<b>4,274</b>	041W270201	5,550		5,550	1,463.75	<b>2,927.5</b>
041M270201	3,670	J	3,670			041W330101	151	U	75.5		
041M330101	2,460		2,460			041W330201	162		162		
041M330201	1,520		1,520			041W330301	135	U	67.5		
041M330301	135		135								
<b>Antimony (mg/kg)</b>						<b>Antimony (µg/L)</b>					
041M330101	0.36	UJ	0.18	0.13	<b>0.26</b>	041W270201	2	UJ	1	2.08	<b>4.15</b>
041M330201	0.28	UJ	0.14			041W330101	10	UJ	5		
041M330301	0.13	UJ	0.065			041W330201	2.6	U	1.3		
<b>Arsenic (mg/kg)</b>						<b>Arsenic (µg/L)</b>					
041M270101	1.1		1.1	1.07	<b>2.14</b>	041W270201	4.1	J	4.1	1.8	<b>3.6</b>
041M270201	0.98	J	0.98			041W330101	2	U	1		
041M330101	1.8		1.8			041W330201	2.2	UJ	1.1		
041M330201	1.4	J	1.4			041W330301	2	U	1		
041M330301	0.13	U	0.065								
<b>Barium (mg/kg)</b>						<b>Barium (µg/L)</b>					
041M270101	2.3	J	2.3	1.92	<b>3.84</b>	041W270201	11.6	U	5.8	4.71	<b>9.43</b>
041M270201	3.1	J	3.1			041W330101	6.7	U	3.35		
041M330101	2.6	J	2.6			041W330201	7.2	J	7.2		
041M330201	1.3	J	1.3			041W330301	5	U	2.5		
041M330301	0.3	J	0.3								
<b>Beryllium (mg/kg)</b>						<b>Beryllium (µg/L)</b>					
041M270101	0.11	U	0.055	0.07	<b>0.13</b>	041W270201	1	U	0.5	0.41	<b>0.82</b>
041M270201	0.16	U	0.08			041W330101	1	U	0.5		
041M330101	0.18	U	0.09			041W330201	0.28	U	0.14		
041M330201	0.14	U	0.07			041W330301	1	U	0.5		
041M330301	0.06	U	0.03								

**Table 6-2**  
**Development of Estuarine Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=5)					Surface Water Reference Concentrations (n=4)						
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)
			"U" or "UJ" Value	Mean Value					"U" or "UJ" Value	Mean Value	
<b>Cadmium (mg/kg)</b>					<b>Cadmium (µg/L)</b>						
041M270101	0.33	U	0.165	0.2	<b>0.39</b>	041W270201	3	U	1.5	1.2	<b>2.4</b>
041M270201	0.47	U	0.235			041W330101	3	U	1.5		
041M330101	0.54	U	0.27			041W330201	0.58	U	0.29		
041M330201	0.42	U	0.21			041W330301	3	U	1.5		
041M330301	0.19	U	0.095								
<b>Calcium (mg/kg)</b>					<b>Calcium (µg/L)</b>						
041M270101	941	J	941	989.4	<b>1,978.8</b>	041W270201	99,000		99,000	38,400	<b>76,800</b>
041M270201	1,260	J	1,260			041W330101	14,100		14,100		
041M330101	1,470		1,470			041W330201	18,800		18,800		
041M330201	1,160		1,160			041W330301	21,700		21,700		
041M330301	116	J	116								
<b>Chromium (mg/kg)</b>					<b>Chromium (µg/L)</b>						
041M270101	11.1		11.1	6.55	<b>13.1</b>	041W270201	13.3		13.3	5.44	<b>10.87</b>
041M270201	12.4		12.4			041W330101	8	U	4		
041M330101	5.5		5.5			041W330201	0.88	UJ	0.44		
041M330201	3.5		3.5			041W330301	8	U	4		
041M330301	0.51	U	0.255								
<b>Cobalt (mg/kg)</b>					<b>Cobalt (µg/L)</b>						
041M270101	0.46	J	0.46	0.45	<b>0.91</b>	041W270201	3	U	1.5	1.19	<b>2.38</b>
041M270201	0.51	J	0.51			041W330101	3	U	1.5		
041M330101	0.99	J	0.99			041W330201	0.53	UJ	0.265		
041M330201	0.42	U	0.21			041W330301	3	U	1.5		
041M330301	0.19	U	0.095								
<b>Copper (mg/kg)</b>					<b>Copper (µg/L)</b>						
041M270101	4.2	J	4.2	4.22	<b>8.44</b>	041W270201	9.2	J	9.2	3.51	<b>7.03</b>
041M270201	3.4	J	3.4			041W330101	4	U	2		
041M330101	8.1		8.1			041W330201	1.7	U	0.85		
041M330201	4.9		4.9			041W330301	4	U	2		
041M330301	0.49	J	0.49								

**Table 6-2**  
**Development of Estuarine Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=5)					Surface Water Reference Concentrations (n=4)						
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)
			"U" or "UJ" Value	Mean Value					"U" or "UJ" Value	Mean Value	
<b>Cyanide (CN) (mg/kg)</b>					<b>Cyanide (CN) (µg/L)</b>						
041M270101	1.1	U	0.55	0.64	<b>1.29</b>	041W270201	5	U	2.5	2.05	<b>4.1</b>
041M270201	1.6	U	0.8			041W330101	5	U	2.5		
041M330101	1.7	U	0.85			041W330201	1.4	UJ	0.7		
041M330201	1.4	U	0.7			041W330301	5	U	2.5		
041M330301	0.63	U	0.315								
<b>Iron (mg/kg)</b>					<b>Iron (µg/L)</b>						
041M270101	1,440	J	1,440	1,342.2	<b>2,684.4</b>	041W270201	2,230		2,230	676	<b>1,352</b>
041M270201	1,380	J	1,380			041W330101	189		189		
041M330101	2,120		2,120			041W330201	102	J	102		
041M330201	1,620		1,620			041W330301	183		183		
041M330301	151		151								
<b>Lead (mg/kg)</b>					<b>Lead (µg/L)</b>						
041M270101	13.5	J	13.5	10.52	<b>21.04</b>	041W270201	25.9		25.9	6.88	<b>13.75</b>
041M270201	13.2	J	13.2			041W330101	1	U	0.5		
041M330101	13.3		13.3			041W330201	1.2	U	0.6		
041M330201	11.9		11.9			041W330301	1	U	0.5		
041M330301	0.69		0.69								
<b>Magnesium (mg/kg)</b>					<b>Magnesium (µg/L)</b>						
041M270101	1,200		1,200	1,471.8	<b>2,943.60</b>	041W270201	327,000		327,000	121,825	<b>243,650</b>
041M270201	2,070		2,070			041W330101	40,100		40,100		
041M330101	2,420		2,420			041W330201	55,600		55,600		
041M330201	1,480		1,480			041W330301	64,600		64,600		
041M330301	189	J	189								
<b>Manganese (mg/kg)</b>					<b>Manganese (µg/L)</b>						
041M270101	5.1		5.1	4.9	<b>9.81</b>	041W270201	1	U	0.5	6.08	<b>12.15</b>
041M270201	5.1		5.1			041W330101	8.2	J	8.2		
041M330101	8.2		8.2			041W330201	9.3	J	9.3		
041M330201	5.5		5.5			041W330301	6.3	J	6.3		
041M330301	0.62	J	0.62								

**Table 6-2**  
**Development of Estuarine Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=5)					Surface Water Reference Concentrations (n=4)						
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X		Reference Concentration (2 X Mean)
			"U" or "UJ" Value	Mean Value					"U" or "UJ" Value	Mean Value	
<b>Mercury (mg/kg)</b>					<b>Mercury (µg/L)</b>						
041M270101	0.09	U	0.045	0.05	<b>0.11</b>	041W270201	0.17	J	0.17	0.11	<b>0.21</b>
041M270201	0.12	U	0.06			041W330101	0.13	U	0.065		
041M330101	0.14	U	0.07			041W330201	0.05	U	0.025		
041M330201	0.12	U	0.06			041W330301	0.16	J	0.16		
041M330301	0.06	U	0.03								
<b>Nickel (mg/kg)</b>					<b>Nickel (µg/L)</b>						
041M270101	2	J	2	1.85	<b>3.69</b>	041W270201	12	U	6	4.65	<b>9.3</b>
041M270201	3	J	3			041W330101	12	U	6		
041M330101	3	J	3			041W330201	1.2	U	0.6		
041M330201	1.7	U	0.85			041W330301	12	U	6		
041M330301	0.76	U	0.38								
<b>Potassium (mg/kg)</b>					<b>Potassium (µg/L)</b>						
041M270101	406	J	406	449.86	<b>899.72</b>	041W270201	106,000		106,000	40,625	<b>81,250</b>
041M270201	689	J	689			041W330101	12,300		12,300		
041M330101	698	J	698			041W330201	23,300		23,300		
041M330201	386	J	386			041W330301	20,900		20,900		
041M330301	70.3	J	70.3								
<b>Selenium (mg/kg)</b>					<b>Selenium (µg/L)</b>						
041M270101	0.39	J	0.39	0.33	<b>0.66</b>	041W270201	3	U	1.5	1.45	<b>2.9</b>
041M270201	0.47	U	0.235			041W330101	3	U	1.5		
041M330101	0.54	U	0.27			041W330201	2.6	U	1.3		
041M330201	0.66	J	0.66			041W330301	3	U	1.5		
041M330301	0.19	U	0.095								
<b>Silver (mg/kg)</b>					<b>Silver (µg/L)</b>						
041M270101	0.43	UJ	0.215	0.26	<b>0.52</b>	041W270201	4	U	2	1.5	<b>3.01</b>
041M270201	0.63	UJ	0.315			041W330101	4	U	2		
041M330101	0.72	U	0.36			041W330201	0.03	U	0.015		
041M330201	0.56	U	0.28			041W330301	4	U	2		
041M330301	0.25	U	0.125								

**Table 6-2**  
**Development of Estuarine Sediment and Surface Water Inorganic Reference Concentrations**  
**Site 41**

Sediment Reference Concentrations (n=5)					Surface Water Reference Concentrations (n=4)						
Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value		Reference Concentration (2 X Mean)	Sample ID	Sample Result	Valid. Qual.	Adjusted 0.5 X "U" or "UJ" Value		Reference Concentration (2 X Mean)
			Mean Value	Mean Value					Mean Value	Mean Value	
<b>Sodium (mg/kg)</b>					<b>Sodium (µg/L)</b>						
041M270101	3,170	J	3,170	5,719.8	<b>11,439.60</b>	041W270201	2,580,000		2,580,000	976,000	<b>1,952,000</b>
041M270201	8,610	J	8,610			041W330101	315,000		315,000		
041M330101	10,100		10,100			041W330201	462,000		462,000		
041M330201	5,740		5,740			041W330301	547,000		547,000		
041M330301	979		979								
<b>Thallium (mg/kg)</b>					<b>Thallium (µg/L)</b>						
041M270101	0.33	U	0.165	0.2	<b>0.39</b>	041W270201	3	U	1.5	1.28	<b>2.55</b>
041M270201	0.47	U	0.235			041W330101	3	U	1.5		
041M330101	0.54	U	0.27			041W330201	1.2	U	0.6		
					<i>Note:</i> *= Sample frequency adjusted for rejected data.						
041M330201	0.42	U	0.21			041W330301	3	U	1.5		
041M330301	0.19	U	0.095								
<b>Vanadium (mg/kg)</b>					<b>Vanadium (µg/L)</b>						
041M270101	5.2	J	5.2	4.3	<b>8.59</b>	041W270201	11	J	11	3.35	<b>6.69</b>
041M270201	6.9	J	6.9			041W330101	2	U	1		
041M330101	4.7	J	4.7			041W330201	0.77	UJ	0.385		
041M330201	4.3	J	4.3			041W330301	2	U	1		
041M330301	0.38	J	0.38								
<b>Zinc (mg/kg)</b>					<b>Zinc (µg/L)</b>						
041M270101	8.2	J	8.2	7.18	<b>14.36</b>	041W270201	19.6	J	19.6	6.44	<b>12.88</b>
041M270201	4.7	J	4.7			041W330101	4.2	U	2.1		
041M330101	14		14			041W330201	3.7	U	1.85		
041M330201	8.3		8.3			041W330301	4.4	U	2.2		
041M330301	1.4	U	0.7								

**Notes:**

µg/kg = Micrograms per kilogram  
 mg/kg = Milligrams per kilogram  
 µg/l = Micrograms per liter  
 U = Not Detected  
 J = Estimated value: concentration is below limit of quantitation  
 Sample frequency adjusted for rejected data.

## **7.0 FATE AND TRANSPORT ANALYSIS METHODS**

This section presents the methods used to evaluate fate and transport of contaminants. Wetland-specific evaluations are presented in Sections 10 through 15.

The fate and transport assessment evaluates the ability of chemical constituents to become mobile or change in the environment, based on their chemical and physical properties, and also evaluates processes that govern their interaction with environmental media. This evaluation helps identify receptors that may be impacted by constituent movement in the environment.

This section describes media and contaminant properties that affect fate and transport, and concludes with a discussion of the potential pathways and sources presumed to affect the NAS Pensacola wetlands. Sections 10 through 15 present the wetland-specific evaluations and validation of migration pathways.

### **7.1 Contamination Summary**

Chemical and physical analyses were performed on Site 41 sediment and surface water samples. A wide range of metals, pesticides/PCBs, and SVOCs were detected. Sections 10 through 15 evaluate the nature and extent of sediment and surface water contamination.

### **7.2 Contaminant Migration**

#### **7.2.1 Properties Affecting Fate and Transport**

Numerous chemical and physical properties of both the chemical constituents and the surrounding media are used to evaluate fate-transport mechanisms. The primary mechanisms in estuarine and freshwater environments are sediment transport and aqueous solubility of an analyte. Chemical and physical properties of constituents used to evaluate fate and transport are vapor pressure, density, solubility, Henry's law constant, half-life, organic carbon-water partitioning coefficient ( $K_{oc}$ ), and molecular weight (see Table 7-1). Compounds with similar chemical and physical properties display similar fate-transport behavior. These characteristics facilitate the general grouping of contaminants into the following categories: VOCs, SVOCs, pesticides/PCBs, and metals.

#### **7.2.2 Media Properties Affecting Fate and Transport**

The properties of environmental media used to evaluate fate and transport are TOC, normalized partition coefficient ( $K_d$ ), cation-exchange capacity (CEC), redox conditions, pH, and sediment type. The following paragraphs briefly discuss these properties.

### **Total Organic Carbon**

TOC indicates the sediment's adsorption capabilities. With an elevated TOC, there is a greater potential for a chemical to adsorb sediment particles and become less bio-available, particularly an organic compound. For example, it is possible for a sediment sample to have a very high concentration of a particular organic constituent, but show no observable toxic effect typically associated with that constituent. If the TOC for that sample was elevated, then the contaminant would likely be bound to the sediment and not be bio-available, reducing the net toxic effect.

### **Normalized Partition Coefficient**

$K_d$  is used to predict the capacity for a constituent to partition between sediment and water; it is a function of both the constituent and the sediment. To estimate  $K_d$ , the constituent's constant  $K_{oc}$  is adjusted by the sediment's TOC:  $K_d = K_{oc} \times \text{fraction of organic carbon } (f_{oc})$ , where  $f_{oc}$  is a function of the organic carbon content fraction of the sediment. Sediments with a higher  $K_d$  have a higher potential to adsorb organic compounds.

Most wetlands at NAS Pensacola have depositional areas of high TOC, and these areas tended to have the highest detected contaminant concentrations. These areas were purposely targeted for sampling during Phase IIA to locate areas of maximum contaminant concentrations.

### **Cation-Exchange Capacity**

CEC reflects the sediment's capacity to adsorb ions, neutralizing ionic deficiencies on the surfaces of its particles. Generally, trivalent ions are preferentially adsorbed to sediment over divalent ions, and divalent ions are preferentially adsorbed over monovalent ions. Although this relationship generally holds true, the process also depends on sediment pH.

Sediments with high CEC values have the potential to adsorb inorganic ions, although dipolar organic compounds also have an affinity for adsorption.

However, in estuarine environments, the presence of brackish water can result in an excess of alkali metals, which in turn can out-compete other metals for these cationic binding sites. Therefore, the estuarine wetlands at NAS Pensacola may have lower concentrations of some metals due to alkali metals competing for binding sites within the sediment. Other factors such as TOC can improve the effects of CEC in sediment in estuarine wetlands.

### **Oxidation/Reduction Conditions**

Redox is the process that includes oxidation (the loss of electrons) and reduction (the gain of electrons). The resultant change in valence generates products that are different from the parent

reactants in solubility, toxicity, reactivity, and mobility. Extreme redox conditions tend to mobilize chemicals, especially transition metals. However, in an estuarine environment, the excess of alkali metals in seawater can reduce the effect of redox conditions on nonalkaline metals.

## **pH**

pH is a measure of the negative logarithm of the hydrogen ion concentration in water, indicating the medium's acidity or alkalinity. Chemicals react differently as pH changes. Low pH conditions tend to mobilize most metals and facilitate substitution in organic compounds. High pH conditions may cause metals to precipitate and organic molecules to degrade. In general, pH conditions are uniform in the estuarine environment. Within the freshwater environment, pH conditions generally appeared in the 7.0 to 7.5 range, reflecting relatively neutral conditions.

## **Sediment Type**

Sediment mineral composition, particle-size distribution, and organic content affect chemical fate and transport. Sediment characteristics influence or determine hydraulic conductivity, effective porosity, and hydraulic gradient, which in turn dictate groundwater flow. In wetland environments, smaller particle sizes (i.e., clays) are observed in areas of deposition where currents are low-energy. Because clays and silts have larger surface areas than sands relative to total particle size, they tend to absorb more contaminants than larger sediment types. Each wetland at NAS Pensacola had a wide range of sediment particle sizes, but sampling was biased toward areas of lowest particle size, as these areas were likely to have the highest concentrations of contaminants.

## **7.3 Contaminant Properties**

This section describes the properties of the major contaminant classes (VOCs, SVOCs, pesticides/PCBs, and metals) and how these properties relate to interactions in the environment.

### **7.3.1 VOCs**

The chemical and physical properties that most influence fate and transport of VOCs are solubility, Henry's law constant, and vapor pressure. The mechanisms for transportation of VOCs include the following:

- sorption to sediment from groundwater or surface water
- escape via volatilization from both sediment and water
- dissipation via diffusion

VOCs have low molecular weights, high solubilities, and high vapor pressures. Because of these properties, VOCs are expected to be highly mobile in the environment and, therefore, quick to migrate from sediment and groundwater.

### **7.3.2 Metals**

The adsorption potential for metals in sediment is related to grain size, the presence of various metallic hydroxides, and organic carbon. Fine-grained particles, particularly aluminosilicate clays and amorphous hydroxides of iron, provide a greater surface area relative to total particle size (ferrous hydroxide can contain as much as 600 square meters of surface area per gram of mass), and the crystalline microstructure is conducive to the adsorption of inorganic contaminants.

The primary transport mechanism for metals bound to sediment is through physical movement of the sediment itself. When metals are tightly bound within the mineral structure, currents are the predominant transport mechanism. Over time, sediments will be transported into natural depositional locations.

The fate of metals in sediments involves both chemical and biological transformation. Chemical transformation may involve formation of organo-metallics and sulfide complexes, or methylation from microbial processes. Transfer of metals through biological uptake by benthic infauna is also a possibility. Biomagnification of metals is not considered a critical pathway in estuarine wetlands, but may occur in acidic freshwater wetlands. Bioaccumulation and biomagnification of contaminants are discussed in the ecological risk assessments, Sections 10 through 15.

### **7.3.3 Organics**

Organic contaminants, particularly hydrophobic compounds (those less-inclined to enter a dissolved state in natural waters), tend to sorb to water-borne particulates (clays, colloids, and humic substances) that eventually end up as bottom deposits. From there, they may be transformed into more or less toxic forms, migrate from the sediment into benthic organisms via ingestion/respiration, or reach overlying waters as physicochemical conditions change. Sediment organic carbon, in the form of humic substances (measured by TOC), is the primary storage site for organic chemicals in sediments. Also, particle size and chemical hydrophobicity are important environmental influences affecting adsorption rates. As particle size decreases and hydrophobicity increases, there is increased binding of organic contaminants to sediment organic carbon. Increased surface area, resulting from decreased particle size, provides more adsorption sites for neutral and/or hydrophobic organic chemicals.

For PAHs in sediments, photolytic degradation rates are a function of the available penetrating sunlight and oxygen. PAHs may persist indefinitely in the low light/low oxygen environments common in many wetlands on base. PAHs may also persist when they are tightly bound to organic substances.

Fate of organic constituents in sediments is also influenced by biotransformation and biodegradation by benthic organisms. Neutral organics that are more hydrophobic tend to be more persistent in the food chain due to their accessibility when they bind with organic substances. Some organic compounds, particularly pesticides (such as 4,4'-DDT), are inherently stable due to their chemical structure and are very slow to undergo any type of degradation. For example, their persistence of 4,4'-DDT is demonstrated by its detection throughout the base and the country long after its use was banned in the United States.

As with metals, organics have been detected throughout the NAS Pensacola wetlands in many forms. The highest concentrations of organics detected tended to be in depositional areas with high TOC values.

#### **7.4 Water Transport Characteristics**

In water, the likelihood that a dissolved contaminant will be retained within the medium is dependent on that chemical's fugacity, or escaping tendency. The fugacity potential is based on both the chemical-specific traits and medium thermodynamic influences. The partitioning coefficient of a chemical indicates its affinity for water or another medium (sediment, tissue, or suspended particles). Under ideal conditions the partitioning coefficient for a chemical is constant, but the environmental parameters that can influence partitioning vary with site conditions.

Environmental variables include suspended and dissolved materials, light attenuation, pH, and redox. Redox and pH have a strong influence on metals but little effect on neutral organic chemicals. In freshwater wetlands, acidic water will result in a greater abundance of free metal ions which, under oxidizing conditions, are more bioavailable. Under reducing conditions, these metals tend to form insoluble sulfides and are less bioavailable. Generally, higher pH environments have more particulate matter and metals can be precipitated out. In saltwater, the presence of divalent cations of magnesium ( $Mg^{++}$ ) and calcium ( $Ca^{++}$ ) can cause suspended fine-grained sediments, colloids, and dissolved organic matter to flocculate and settle from the water column. Organic contaminants may co-precipitate with metal complexes on these flocculated materials. Dissolved organic carbon (DOC) in water, composed primarily of humic substances produced by the degradation of dead plant material, can also provide binding sites for metal ions and neutral organics. DOC concentrations also affect bioavailability and bio-concentration of chemicals by aquatic organisms like that of suspended sediment (Carlberg, G.E. *et al.*, 1986).

## **7.5 Pathways and Sources**

The factors influencing fate and transport of contaminants into, within, and out of wetlands at NAS Pensacola are complex. This section describes the pathways and sources other than chemical factors that influence contaminant distribution. Sections 10 through 15 present the validation of these pathways with respect to the individual wetlands.

### **7.5.1 Pathways**

Three primary migratory routes for transport are immediately evident for the NAS Pensacola wetlands:

- *Surface water:* surface water runoff from adjacent terrestrial areas, natural surface water drainage into and out of wetlands
  
- *Sediment:* physical sediment movement via entrainment in surface water flow into, within, and out of wetlands
  
- *Groundwater:* discharge to wetlands from adjacent upgradient areas and wetland surface water to groundwater recharge to downgradient areas where no surface water outlet is observed

### **Surface Water Migration**

Surface water migration into the wetlands can be evaluated by considering the physical properties of the area. Many wetlands receive surface water discharge from storm water outfalls or nearby paved areas. Heavy rainfall will cause surface runoff (or rejected recharge) to enter the wetlands. For wetlands that are not adjacent to impervious surfaces or outfalls, the high permeability of the surficial sand deposits precludes direct runoff. Precipitation will evaporate or enter the surficial aquifer as recharge, and may eventually discharge to the wetlands as groundwater. Figure 7-1 illustrates the surface topography at NAS Pensacola; with the wetland areas occupying the lowest elevations, the general patterns of surface drainage is toward them; surface water flow then moves toward the larger water bodies of Pensacola Bay and Bayou Grande.

In addition to surface runoff, some wetlands at NAS Pensacola receive surface water influx directly as a result of natural drainage patterns. In these cases, upgradient wetlands receive discharge from nearby groundwater, and this discharge then follows in the natural direction to the receiving wetland. A special circumstance involves those wetlands that are connected directly to Bayou Grande or Pensacola Bay through tidal channels. In these cases, tidal flux will allow a backflow of brackish bay water to enter the wetland. Flow into and out of the wetlands is considered to be consistent with the direction of base flow or topography. None of the wetlands is sufficiently large to expect a complex flow configuration.

In cases where no surface water outlet is observed for a wetland, surface water is assumed to infiltrate into the aquifer on the downgradient side of the wetland (in essence, the wetland is a "window" into the aquifer). The surface water transport pathway is evaluated in Sections 10 through 15 for each wetland with respect to its location and hydrologic and topographic configuration.

### **Sediment Transport**

Sediment transport is expected to be coincident with and as a consequence of surface water transport. Sediment will become entrained in the surface water runoff stream and enter the wetland. Sediment entrainment is expected to be a mechanism for contaminant transport into, within, and out of the wetlands as natural drainage moves through the system. With natural drainage, sediment movement is expected to be governed more through bottom transport, whereby sediment load is redistributed en masse by current movement along the bottom and sides of the drainage watercourses and wetlands. Data regarding the rate and mass of sediment movement into and through the wetland systems are not available. Therefore, this mechanism of transport is treated qualitatively in Sections 10 through 15 by considering the physical configuration of the wetland system, and any trends in sediment concentrations.

Leaching of constituents from sediment to surface water is a distinct possibility when environmental conditions are highly variable. Otherwise, these two media tend to reach a metastable balance between chemical supply and demand. Given the relatively unchanging conditions of groundwater and surface water contributing to the conditions within NAS Pensacola wetlands (source activities have ceased except for storm water runoff from currently active areas such as Sherman Field), it is expected that water quality will not exhibit remarkable variation. However, storm water runoff containing entrained sediment could alter the metastable balance, and cause a partitioning from sediment to surface water. Without significantly detailed chemical data, it is virtually impossible to define the direction of imbalance between sediment and its paired surface water — whether the sediment is partitioning to surface water, or whether the surface water is partitioning to the sediment.

Therefore, for the purpose of this fate and transport analysis, the presence of a COPC in both will be cited simply as a matter of evidence that a metastable balance exists.

If there is a marked difference in the concentrations of a COPC between sediment and surface water, it is likely that the direction of partitioning is to the media with the lower concentration, but this is not a given, as the balance is dependent on particular chemical constraints (for example, high CEC in the sediment can alter the sorptive capacity of the sediment, or a change in pH can alter the dissolution capacity of the surface water).

## **Groundwater Discharge**

Throughout the investigative phases for terrestrial sites at NAS Pensacola, groundwater heads have consistently been higher than those of the adjoining wetlands. Therefore, the predominant flow cycle is expected to be from the groundwater regime to the NAS Pensacola wetlands. Therefore, this pathway has been evaluated extensively as a matter of course during this analysis. Under these conditions, the flow of wetland water to shallow groundwater is expected to be a relatively minor process and is not specifically evaluated as part of the wetlands evaluation. Instead, groundwater is being extensively assessed as part of numerous other NAS Pensacola site investigations.

### **7.5.2 Sources**

There are many sources of influx to the NAS Pensacola wetlands, including adjacent sites of environmental concern and adjacent areas of the base contributing runoff. Table 7-1 provides a compilation of known or suspected sources for each wetland, accompanied by the presumed pathways for transport and pertinent remarks. Figure 2-1 shows the locations of wetlands and environmental sites.

## **7.6 Wetland-Specific Fate and Transport**

The wetland-specific fate and transport evaluations will deal solely with the physical and chemical aspects of contaminant transport, and will be integrated with the data presented in Section 10. Figure 7-2 presents a conceptual model of the pathways that will be evaluated for each wetland. The major pathways for contaminants to reach the receptor wetlands include:

- Surface water/sediment transport into the receptor wetland from both upgradient IR sites and upgradient nonpoint sources; prime mechanism is natural drainage and storm water runoff.
- Groundwater discharge into the receptor wetland from upgradient IR sites.

Again, in general, the above pathways have some degree of empirical data available to validate the pathway. Sediment to surface water partitioning (and vice versa) can be an important pathway as well, but without more detailed chemical data, it can only be treated conceptually in this evaluation.

For this fate and transport analysis, sediment and surface water within the wetland are viewed as the ultimate receptors. Enrichment of a given parameter over time can occur in either of these media if the physical/chemical conditions have reached a metastable balance, and if the source to the receptors remains active.

### **7.7 Pathway Evaluation (Validation and Significance)**

The ecological assessment process conducted a thorough screening to evaluate all parameters detected in soil and sediment. Because of the exhaustive nature of the ERA screening process, which incorporates a number of procedures and benchmark comparisons, only those detected parameters retained for the ERA are evaluated as part of the fate and transport analysis.

The fate and transport analysis is qualitative in nature, and relies on “matched” comparisons. For example, this type of analysis requires tracing the detections of a parameter through the various sampled media to link the noted detections of interest. The data to be used include sediment and surface water samples from within the evaluated wetland and from those wetlands upstream from it; and soil and groundwater samples in proximity to the evaluated wetland.

The fate and transport analysis will be conducted for each of the pathways noted in the introduction to Section 7.6 above, namely:

- Surface water/sediment transport into the receptor wetland from both upgradient IR sites and upgradient nonpoint sources; prime mechanism is natural drainage and storm water runoff.
- Groundwater discharge into the receptor wetland from upgradient IR sites.

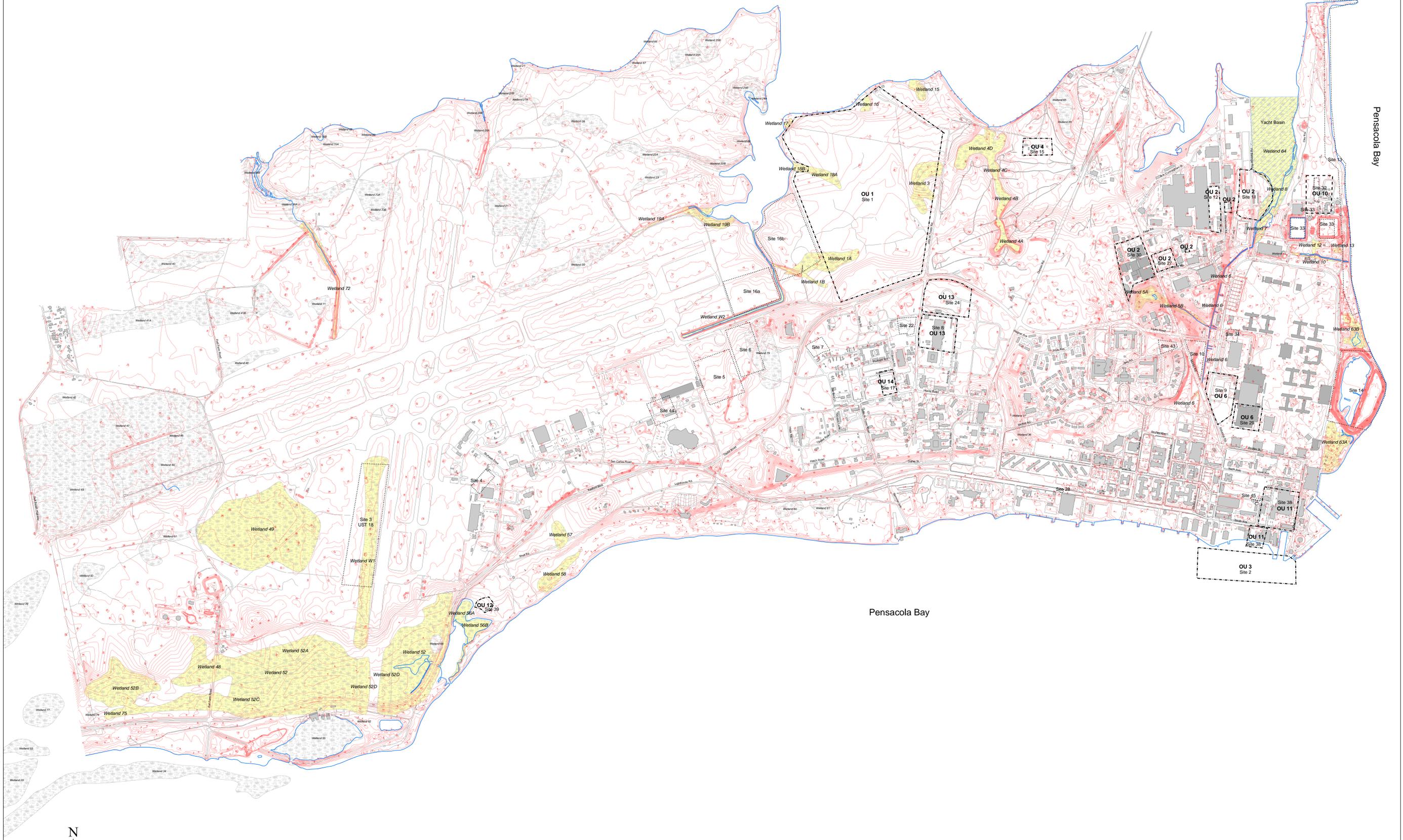
Where sufficient data are available, the following pathways will also be addressed:

- Surface water/sediment transport within the wetland.

For the qualitative analysis, two levels of evaluation are of note. First, a pathway is deemed to be “valid” if COPC is detected in both the source and receptor media. Secondly, a pathway is deemed “significant” only if that parameter has been validated, and if the receptor media concentration is at concentrations above appropriate screening levels (the screening levels will be those used to retain parameters for refinement as part of the ERA).

Bayou Grande

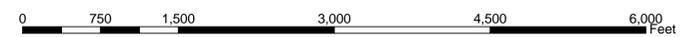
Pensacola Bay



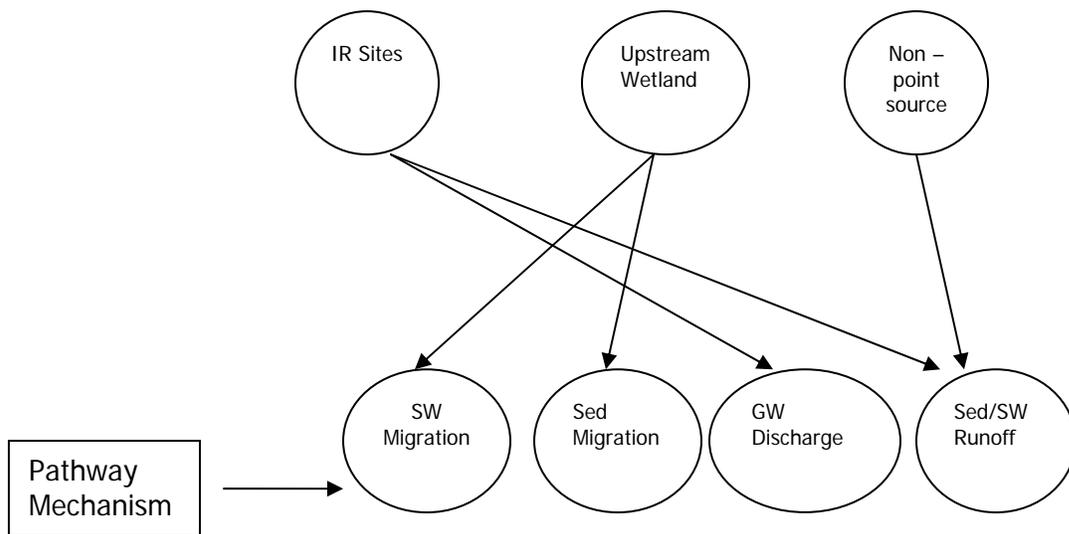
Pensacola Bay

**FIGURE 7-1**  
**Siteside Study Area Topography**  
 Final Remedial Investigation Report  
 Site 41  
 NAS Pensacola, FL

Legend	
	Site
	Operable Unit (OU)
	Building
	Site 41 RI Wetland- Approximate
	Wetland- Approximate
	Consolidated Wetland 64
	Road
	Shoreline
	Topographic Contour(ft)



**FIGURE 7-2**  
**CONCEPTUAL MODEL OF FATE AND TRANSPORT SOURCES AND PATHWAYS TO**  
**RECEPTOR WETLAND SEDIMENT AND SURFACE WATER — SITE 41.**



**Table 7-1  
 Known or Suspected Sources for Each Wetland's Transport Pathways**

<b>Wetland</b>	<b>Associated Site(s) and/or Concerns</b>	<b>Transport Pathways</b>	<b>Remarks</b>
64	OU 2, OU 6, OU 10, Yacht Basin activities	SW, ST, GW, SL	Drainage from OU 2; storm water runoff from OU 2, OU 6 and Yacht Basin; groundwater discharge from OU 2, OU 6, and OU 10; sediment leaching from Yacht Basin; tidal flux from Site 40.
5	OU 2	SW, ST, GW	Storm water runoff and groundwater discharge from OU 2.
3	Site 1	SW, ST, GW	Intermittent drainage from Site 1; GW discharge from Site 1.
4D	Site 15, Site 1, Site 40, Wetland 3	SW, ST, GW, SL	Runoff from Site 1 and Wetland 3; sediment leaching and tidal flux from Site 40; groundwater discharge from Sites 1 and 15.
16 and 18	Site 1, Site 40	SW, ST, GW, SL	Runoff and groundwater discharge from Site 1; sediment leaching and tidal flux from Site 40.
10 and 12	OU 10, OU 6	SW, ST	Runoff from southern portion of former IWTP, Bilge water Plant, and former Chevalier Field area.
W1	Site 3 (UST 18), Sherman Field	SW, ST, GW	Runoff from site and airfield; groundwater discharge from Site 3 (UST 18).
1	Site 16, Site 1, Site 40, Site 7, Site 5, Site 22 (UST 26), OU 13	SW, ST, GW	Runoff and drainage from Site 16 and airfield; groundwater discharge from Sites 1, 7, 5, 22, OU 13.
15	Site 1, Site 40, Golf Course	SW, ST, GW	Runoff from Golf Course; groundwater discharge from Site 1 and tidal flux from Site 40.
6	OU 2, OU 6, Site 10, Chevalier Field	SW, ST, GW	Runoff from OU 2, OU 6, Site 10, and former Chevalier Field area; groundwater discharge from OU 2 and OU 6.
63A and 63B	Site 13, Site 14, Site 42, Chevalier Field	SW, ST, GW	Runoff from former Chevalier Field area, Site 13, and Site 14; groundwater discharge from Site 14; tidal flux from Site 42.
48, 49, 52	USTs S, O, X, Sherman Field	SW, ST, GW	Runoff from Sherman Field; groundwater discharge from UST sites.
13	OU 10, Chevalier Field	SW, ST	Runoff from southern portion of former IWTP and former Chevalier Field area.
17	Site 1, Site 40	GW	Groundwater discharge from Site 1; tidal flux from Site 40.
19	Sherman Field	SW, ST	Runoff from Sherman Field; tidal flux from Site 40.
56	Site 39, Site 42	GW	Groundwater discharge from Site 39; tidal flux from Site 42.
57 and 58	Site 4	GW	Groundwater discharge from Site 4.
72	Sherman Field	SW	Runoff from Sherman Field.

**Table 7-1**  
**Known or Suspected Sources for Each Wetland's Transport Pathways**

Wetland	Associated Site(s) and/or Concerns	Transport Pathways	Remarks
W2	Site 5, Site 6, Site 16, Sherman Field	SW, ST, GW	Runoff from Sherman Field; groundwater discharge from Sites 5, 6, and 16.

**Notes:**

- SW = Surface Water
- ST = Sediment Transport
- GW = Groundwater Discharge
- SL = Sediment Leaching

## **8.0 ECOLOGICAL RISK ASSESSMENT METHODS**

This section presents the methods and steps used during the ERA process for Site 41. Wetland-specific risk evaluations are presented in Section 10 (Site-Specific Evaluations).

### **8.1 Introduction**

The ERA evaluates potential ecological risks from hazardous substances at the Site 41 wetlands under current and future conditions. The ERA examines wetland chemical contamination and exposure pathways that could result in unacceptable levels of exposure to flora and fauna. For Site 41, the remedial investigation has been ongoing since 1994, and has been conducted in several phases. The ERA for each wetland included in Site 41 uses all data that has been collected during each phase to attempt to accurately portray the potential for risk at each wetland. The ERAs presented in this RI will summarize the data collected to date and provide the necessary analysis to determine if remedial actions are necessary to address risk to ecological receptors at Site 41. For clarity, the wetlands have been grouped by operable units identified during the investigations conducted at NAS Pensacola, or by area. Grouping wetlands in this way allows clearer conclusions to be drawn on potential contaminant migration pathways from known sources at NAS Pensacola. The Site 41 ERAs have followed the process for conducting risk assessments at Superfund sites as laid out by USEPA in 1997 and the methods provided in the Site 41 work plans as approved by USEPA and FDEP with input from natural resource trustees.

### **8.2 Wetland-Specific ERAs**

The general outline for each wetland will be as follows:

- General physical description of wetland
- Description of nearby sites that may impact wetlands
- Conceptual Site Model
- Evaluation of contaminant migration pathways
- Evaluation of exposure pathways
- Screening HQ tables
- Listing of screening COPCs
- Problem formulation
- Refinement of COPCs
- Re-evaluation of conceptual site model
- Characterization of potential ecological effects

- List of final COPCs
- Presentation of site-specific biotic data (where available)
- Uncertainties
- Conclusions/Recommendations

### **8.2.1 Data Preparation**

Section 5 explains the data validation process for the Site 41 sediment and surface water sample results. The validated sample data for each wetland were prepared in the following ways:

- Detected constituents for both sediment and surface water with the appropriate validation qualifier (no qualifier, J, D, B, E, etc.), were compared to screening and refinement criteria.
- Sediment and surface water constituents that were not detected (U or UJ validation qualifier) were compared to screening and refinement criteria using one-half the detection limit.
- Sediment constituent totals were calculated for total BHCs, total chlordanes, total endrins, total PCBs, total dichlorodiphenyltrichloroethane (DDT), and total PAHs. Constituent totals were derived by summing valid detections with one-half the detection limit for not detected parameters. Total PAHs for sediment were calculated by combining the values for the 13 low and high molecular weight PAHs outlined in *Approach to the Assessment of Sediment Quality in Florida Coastal Waters; Volume 1 — Development and Evaluation of Sediment Quality Assessment Guidelines* (MacDonald, D.D., 1994).
- Surface water constituent totals were calculated for total chlordanes, total endosulfans, total endrins, total PCBs, total 1,3-dichloropropene, and total PAHs. The same logic used for sediment, summing valid detections with one-half the detection limit for not detected parameters, was used for surface water. Surface water total PAHs were calculated using the 10 PAHs outlined in *Contaminant Target Cleanup Levels, Groundwater and Surface Water Cleanup Target Levels (CTLs)*, Table 1, Chapter 62-777, Florida Administrative Code (FAC) (2003b), and *Criteria for Surface Water Quality Classifications*, Rule 62-302.503, (FAC, 2003a).

### **8.3 Screening and COPC Refinement Criteria for Sediment**

The sediment samples will initially be screened by comparing sediment results to applicable regulatory criteria, as follows:

- USEPA Region IV Sediment Screening Values (SSVs) (USEPA Region 4, 2001b)
- Sediment Quality Assessment Guidelines (SQAGs), Threshold Effects Levels (TELs) (MacDonald, D.D., 1994)

The lower of the SSV or TEL is used to derive a screening value (SV) for sediment, which is then used to screen detected values, one-half the not detected concentrations, or constituent totals as appropriate.

After screening constituents using the sediment SVs described above, constituents retained for further refinement are then compared to refinement values (RVs). The refinement values used are the Probable Effects Levels (PELs) from MacDonald, D.D. (1994), or if no PEL is available, surrogates were used as outlined below. The Site 41 SVs, RVs, and the freshwater and estuarine sediment reference concentrations are presented in Table 8-1 (tables are located at the end of each section).

Additionally, during the July 15-16, 2002, Eco Subgroup Meeting, it was decided to use surrogates for the following constituents (also detailed in the footnotes for Table 8-1):

- Phthalate Esters (diethylphthalate, dimethylphthalate, di-n-butylphthalate, and di-n-octylphthalate) — The 182 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ) SV and the 2,647  $\mu\text{g}/\text{kg}$  RV (FDEP TEL and PEL, respectively) for bis(2-ethylhexyl)phthalate (BEHP) will be used as surrogates for all phthalate esters.
- Alpha, beta, delta, and total-BHC — The 0.32  $\mu\text{g}/\text{kg}$  SV and the 0.99  $\mu\text{g}/\text{kg}$  RV (FDEP TEL and PEL, respectively) for gamma-BHC (Lindane) are used as surrogates for all BHCs.
- Alpha, gamma, and total-Chlordane — The 1.7  $\mu\text{g}/\text{kg}$  SV and 4.79  $\mu\text{g}/\text{kg}$  RV (USEPA SSV and FDEP PEL, respectively) for chlordane will be used as surrogates for all chlordanes.
- PCBs — The 21.6  $\mu\text{g}/\text{kg}$  SV and 189  $\mu\text{g}/\text{kg}$  RV (FDEP TEL and PEL, respectively) for total-PCBs are used as surrogates for all PCBs except for aroclor-1221, which uses the USEPA SSV (67  $\mu\text{g}/\text{kg}$ ) for a SV.

- Phenol — The 50 µg/kg no-effects surrogate value is used as the SV for phenol.
  
- TOC-normalized total PAHs — The Threshold Effects Concentration (TEC) of 290 milligrams per kilogram of organic carbon (mg/kg-oc), and the Median Effects Concentration (MEC) of 1,800 mg/kg oc found in *Consensus Sediment Quality Guidelines for Polycyclic Aromatic Hydrocarbon Mixtures* (Swartz, R.C., 1999) are used as the SV and RV, respectively, for TOC-normalized total PAHs.

### **8.3.1 Development of Sediment-Screening-Level COPCs**

Screening-level COPCs for sediment are determined by one or more of the following ways:

- Comparison of maximum detections to the appropriate SVs
  
- Comparison of one-half the detection limit of “U” or “UJ” flagged constituents (not detected parameters) to their appropriate SVs
  
- Comparison of constituent totals to their appropriate SVs

Sediment constituents are summarized in tables showing their frequency of detection, the maximum detection and its validation qualifier (if any), the location of the maximum detection, the SV and its source, the maximum SV HQ, the number of detections exceeding the SV, and whether or not the constituent is retained for refinement, along with the rationale driving the decision.

During the screening process, any detected sediment constituent with an HQ > 1 is retained for later refinement using the appropriate RV. Constituents detected for which no SV is available are conservatively included as screening COPCs and are retained for further refinement.

For constituent totals, if the total concentration is found to have an HQ < 1, then all of the parameters making up the total concentration are removed from further refinement in the ERA process.

Many sediment constituents are not detected above detection limits at any sediment sample location. Since no conclusive statement can be made about the potential for adverse effects from exposure below the identified limits, sample quantitation limits for the not detected parameters are taken through the same process as real detections. This is done by conservatively appraising one-half the detection limit to the SVs and calculating HQs. Parameters quantitation limit HQs > 1 are retained as screening

COPCs, since the potential for risk from those constituents can not be ruled out. Not detected parameters, for which no SVs are available, are also retained for further comparison to the RVs.

### **8.3.2 Refinement of Sediment Screening Level COPCs**

Sediment detections, not detected parameters, and constituent totals that were retained in the screening process are carried through the refinement process. The refinement process uses several lines of evidence to address these constituents that were retained through the screening process, including:

- Comparison of maximum detections and average concentrations, not detected concentrations, and constituent totals to the appropriate RVs
- Comparison of average concentration to appropriate SVs
- Comparison of maximum inorganic detections and not detected concentrations to the appropriate reference concentrations
- Comparison of maximum 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and total DDT detections and not detected parameters to the appropriate basewide levels
- Further comparison of inorganic constituents using the appropriate freshwater or estuarine interpretive method for Florida sediments

#### **8.3.2.1 Comparison of Concentrations in Refinement**

During refinement, a series of HQs is generated to help clarify the potential for risk posed by each of the screening COPCs. This is presented in the tables by comparing the average concentration to the SV, the maximum concentration to the RV, and the average concentration to the RV. The tables for each wetland indicate how many of the sample collected in each wetland exceeds the SV and the RV. This evaluation helps evaluate the magnitude of potential risk as well as distribution of risk at each wetland.

#### **8.3.2.2 Inorganic Sediment and Surface Water Reference Criteria**

Reference wetlands are identified from the wetlands list developed by Parsons and Pruitt (USEPA, 1991a) for comparison to the potentially impacted wetlands. These wetlands are selected because they had similar vegetation, topography, geology, and hydrology in contrast to the wetlands potentially impacted by an IR site. The reference wetlands are also distant from any IR site or

other potential sources of contamination based on field observations and a historical study of adjacent areas. The four reference wetlands sampled are Wetlands 25, 27, 32, and 33. Based on field auxiliary data, Wetlands 25 and 32 are selected as freshwater reference wetlands, while Wetlands 27 and 33 are used as estuarine reference wetlands. In determining reference criteria, the sediment and surface water results from the two freshwater and two estuarine reference wetlands are used to develop freshwater and estuarine sediment and surface water reference concentrations.

Reference criteria for both sediment and surface water are calculated by summing valid detections with one-half of the quantitation limit for each not detected parameter ("U" or "UJ" validation qualifier). The mean detection is calculated, then multiplied by two, with the resulting product then used as the reference concentration. Tables 6-1 and 6-2 show how the freshwater and estuarine inorganic sediment and surface water reference concentrations are developed, respectively.

### **8.3.2.3 Basewide Total DDT Concentrations**

A summary for the basewide total DDT concentrations for NAS Pensacola are listed below:

- 4,4'-DDD — 50 µg/kg
- 4,4'-DDE — 40 µg/kg
- 4,4'-DDT — 20 µg/kg
- Total DDT — 110 µg/kg

The approach used in their development is explained in Section 6.1.2.

### **8.3.2.4 Regression Analysis for Metals**

The FDEP developed an interpretive tool for identifying metals outside of background range for both freshwater and estuarine sediments. This interpretive tool can determine whether metals in freshwater or estuarine sediments in Florida exceed expected natural concentrations, providing a way to determine whether sediments at a specific location are metal enriched. The freshwater interpretive tool (Carvalho, A., *et al.*, 2002) uses iron and aluminum as normalizers for plotting regressions for arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc.

A statistical process similar to FDEP's interpretive tool was used to assess metals concentrations in estuarine sediments. The methods used and the results of the analysis are presented in Appendix L.

### 8.3.2.5 DiToro Sediment VOCs Compared to SQGs

Since VOCs have no SVs or RVs, these are carried forward in the ERA as a class of contaminants. This conservative approach was taken because many of the IR sites adjacent or nearby the Site 41 wetlands are known to have VOC contamination in soil and/or groundwater. However, the likelihood of risk to the wetlands from VOCs is limited, since VOCs are known to have a short half-life, are not persistent, and readily volatilize.

The article *Technical Basis for Narcotic Chemicals and Polycyclic Aromatic Hydrocarbon Criteria. II. Mixtures and Sediments* (Di Toro, J. M. and J. A. McGrath, 2000b) explains how TOC-normalized VOC concentrations in sediment can be compared to EqP SQGs to develop HQs for evaluation of potential sediment toxicity. Since wetland-specific TOC is available for this site, each Di Toro SQG is normalized based on the amount of organic carbon present at each location (rather than 1% as in the original methodology). At wetlands where TOC is not available for each sample location, the lowest TOC measured in that wetland is used as a conservative surrogate. The data evaluation using the Di Toro SQG is provided in Appendix K.

### 8.3.2.6 Mean ERM Quotients

Mean ERL and ERM analyses is used in the refinement process for the Site 41 sediments. These methods are characterized in *Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments* (Long, E.R. et al., 1995). ERL and ERM delineate three concentration ranges for a particular chemical. The concentrations below ERL values represent a minimal-effects range, which is intended to estimate conditions where biological effects would be rarely observed. Concentrations equal to or greater than ERL, but below ERM, represent a range within which biological effects occur occasionally. Concentrations at or above ERM values represent a probable-effects range, within which adverse biological effects frequently occur. To estimate the adverse effects of mixtures of chemicals, mean ERM quotients are determined by normalizing the concentration of each substance to its ERM value, summing the quotient for each substance, and dividing the resultant sum by the total number of contaminants for which guidelines are available.

This study developed mean ERM quotients as a useful way to evaluate mixtures of the following 25 constituents include (nine metals, three pesticides/PCBs, and 13 PAHs), as shown below:

- |            |                       |                          |
|------------|-----------------------|--------------------------|
| • Arsenic  | • Silver              | • Napthalene             |
| • Cadmium  | • Zinc                | • Phenanthrene           |
| • Chromium | • Acenaphthene        | • Benzo(a)anthracene     |
| • Copper   | • Acenaphthalene      | • Benzo(a)pyrene         |
| • Lead     | • Anthracene          | • Chrysene               |
| • Mercury  | • Fluorine            | • Dibenzo(a,h)anthracene |
| • Nickel   | • 2-Methylnaphthalene | • Fluoranthene           |
| • Pyrene   | • Total DDT           |                          |
| • 4,4'-DDE | • Total PCBs          |                          |

The results of the study yielded indices which were derived by dividing the individual chemical constituents by their respective ERM values, yielding quotients for each of the 25 constituents listed above. The mean ERM quotient is the average of the 25 quotients obtained. The ERM quotients represent the likelihood of adverse effects due to direct toxicity and are sorted according to the following categories:

- **Category 1:** Sediments have no ERL exceedances or a mean ERM quotient of less than 0.1. These sediments are considered least likely to be toxic.
- **Category 2:** Sediments with the greatest uncertainty due to the average survival approximates the critical threshold of 80%; whereas other categories are clearly greater or less than 80%. Mean ERM quotients are 0.11 — 0.5, with 1-5 ERLs exceeded.
- **Category 3:** Sediment is likely to cause adverse effects. Mean ERM quotients are 0.5 — 1.5, with 6-10 ERLs exceeded.
- **Category 4:** Sediments have high probability to cause adverse effects. Mean ERM quotients are >1.5, with >10 ERLs exceeded.

To assist in evaluating the Site 41 sediment data, mean ERM quotients for the 25 ERM constituents will be developed for each Site 41 sample location. For not detected parameters, one-half the detection limit is used in the ERM calculations. Mean ERM quotients derived from the data are then graphed to show one of three conditions for each of the 25 ERM constituents, including: (1) the constituent exceeds the mean ERL; (2) the constituent exceeds the mean ERM; (3) the mean ERM quotient is driven by one-half the detection limit for the not detected parameters.

## **8.4 Evaluating Surface Water Constituents**

### **8.4.1 Development of Surface Water Screening — Level COPCs**

Screening level COPCs for surface water conditions are developed similarly to the sediment method and includes:

- Comparison of maximum detections to SVs
- Comparison of detection limits for not detected parameters to SVs
- Comparison of constituent totals to SVs

The surface water screening values and reference concentrations are summarized in Table 8-2. As with sediment, surface water constituents are summarized in tables showing their frequency of detection, the maximum detection and its validation qualifier (if any), the location of the maximum detection, the SV (including its source), the maximum SV HQ, the number of detections exceeding the SV, and whether or not the constituent is retained for further refinement.

Constituents with HQs  $\geq 1$  are retained for refinement, along with constituents detected for which no SV is available. As with sediment, if a total constituent concentration is found to have an HQ  $< 1$ , then all of the parameters making up the total concentration are removed from further refinement (regardless of HQs for individual constituents). Not detected parameters with HQs  $\geq 1$  are also retained as screening COPCs, as are not detected parameters for which no SV was available.

### **8.4.2 Refinement of Surface Water Screening Level COPCs**

Retained surface water detections, not detected parameters, and constituent totals were further evaluated in the refinement process by performing the following comparisons:

- Comparison of average concentration HQs to SVs
- Comparison of surface water inorganic concentrations to their reference concentrations

Surface water constituents that were retained after the refinement process are listed as COPCs for their specific wetland.

## **8.5 Baseline Problem Formulation and Sampling Plan**

Based on the results of the screening and COPC refinement conducted on the Phase II sampling, all the wetlands are grouped based on the HQs generated and the potential receptor species from each wetland. Once they are grouped, representative wetlands were selected from each group to be resampled during Phase III. The grouping of the wetlands is summarized in the paragraphs below.

### **8.5.1 Wetlands Selected for Study in Phase III**

Based on HQs and potential receptor species, Wetland 64 from Group A, Wetlands 3 and 5A from Group B, and Wetlands 16 and 18 from Group C were selected for the highest sampling priority in Phase III. If contamination in Wetlands 16 and 18 was determined to be at levels producing adverse ecological effects, then the potential for effects in the remaining Group C wetlands (4D, 15, 63A) can also be determined by back-calculation or regression analysis.

Wetlands in Groups D and E were not considered for Phase III sampling. Both groups contain elevated levels of contaminants, mostly pesticides. The primary reason the Group D wetlands were not considered for further sampling is that these are channelized drainage ditches that are a part of the NAS Pensacola storm water drainage system. They receive continual impacts from storm water and are actively maintained by base maintenance personnel; however, in 2004 Wetland 5B is included in Phase III evaluations to fill data gaps identified for cadmium in sediment detected during the Phase II investigation for this wetland. The Group E Wetlands 48 and 49 were not sampled because both are heavily influenced by seasonal fluctuations in rainfall, appear dry for much of the year, and do not appear to be impacted by any IR sites.

In 1997, the Phase III assessment was conducted at Wetlands 3, 5A, 16, 18B, 33, and 64. Wetland 75 was also sampled during Phase III as a reference wetland but was later dropped from consideration. Phase III was conducted to further characterize risk at the Site 41 wetlands. In 2001 and 2004, further Phase III sampling was conducted at Wetlands 64 and 5B, respectively, to fill data gaps at these wetlands. Select sediment sample locations from wetlands that exhibited Phase II contamination above the SVs were resampled. At each Phase III location, a sediment sample was collected for full-scan analyses, TOC, and grain-size analysis to better correlate the sediment contaminants with the toxicity results. In collecting Phase III samples from the Phase II locations, deviations in sediment chemistry were expected due to changes in site conditions during the time between the sampling events. Toxicity testing, biota sampling, and modeling were conducted to determine the extent of ecological risk at these wetlands.

The Phase II data analysis indicated contamination may pose a risk to receptors in Wetland Groups A, B, and C. The objective of the problem formulation phase was to help establish a link between contamination and effects. The conceptual model developed for each of these wetlands identifies exposure pathways and uses assessment and measurement endpoints to evaluate potential impacts through those pathways.

The *Final RI/FS SAP Addendum* (E/A&H, 1997d) describes the technical basis for the following factors selected for further study: (1) the specific functional uses and conceptual models for each wetland; (2) the selected assessment endpoints; (3) the measurement endpoints (including site-specific benthic community studies, toxicity tests, and food chain models); and (4) the scientific/management decision points.

### **8.5.2 Phase III Wetland-Specific Functional Uses and Conceptual Models**

The conceptual models represent all possible exposure routes to particular receptor species from each wetland of concern. However, several assessment endpoints were selected based on their sensitivity to the contaminants and likelihood of exposure. For example, due to the prevalence of the wading birds throughout the area, health of piscivorous bird populations was selected as an assessment endpoint to represent impacts on wading bird species.

The conceptual models were developed according to site contaminants, the receptors identified within the NAS Pensacola estuarine system, and the complete predicted contaminant exposure pathways. Specific conceptual models were based on a functional use assessment of the red- and orange-coded wetlands and their prevalent contaminants. The functional uses of the red- and orange-coded wetlands selected for further study are summarized in Table 8-3. Conceptual models are provided in the site-specific evaluations in Sections 10 through 15.

### **8.5.3 Phase III Sample Locations**

The Phase III sample locations were selected in wetland areas where Phase II data showed relatively high, medium, and low levels of contamination. Contaminant-level gradient sampling was selected to show the risk gradients in wetlands selected for further sampling. In wetlands where only one Phase III sediment sample was collected, the most contaminated Phase II location that corresponded to the conceptual model was sampled.

Sediment samples were collected in Wetlands 3, 5A, 16, 18B, 33, and 64. Surface water samples were collected (concurrent with sediment samples) in Wetlands 3, 5A, 33, and 64. Wetland 75 was also sampled for sediment and surface water during Phase III but was later dropped from consideration. GPS coordinates of the Phase II sample locations were used to locate the Phase III sample locations. As expected, the sediment and surface water chemistry results varied between Phases II and III due to changes in conditions between the respective phases. These variations meant that the contaminant gradients detected in Phase II sediments were not evident in Phase III.

## 8.6 Assessment Endpoint and Measurement Endpoints

For Phase III, several assessment and measurement endpoints were identified and presented in the *Final RI/FS SAP*, Site 41(E/A&H, 1995g) for Phase III. Those endpoints are summarized in Table 8-4.

### 8.6.1 Assessment Endpoint: Piscivorous Bird Health

The green heron was selected for several factors relevant to assessing risk in Site 41 wetlands. The green heron is common throughout NAS Pensacola, and data are readily available on its habitat use and feeding characteristics. The heron is considered an ideal assessment endpoint species for assessment of aquatic food-chain contaminant transfer based on diet, feeding characteristics, and limited home range.

For example, the heron feeds on some of the measurement endpoint species selected for the study. Any effects to these measurement endpoint species, either through toxicity or body burden effects, may help establish a correlation between: (1) effects to the measurement endpoint and (2) potential effects in the heron.

Specific factors making the heron an attractive assessment endpoint species include:

- *Diet* — The green heron feeds primarily on fish, but it also eats amphibians, reptiles, and other organisms. Fish consumed by the heron are generally less than 20 centimeters in length with small home ranges. The limited home range of the fish prey species simplifies the prediction of sediment impacts from these fish species. The limited migration increases the certainty in predicting impacts to species consuming fish in their diet from specific portions of the bayou and the adjacent wetlands. Food, body weight, and water ingestion rates for the heron are also readily available.
- *Limited Home Range* — The green heron is widely distributed in both saltwater and freshwater environments, making the bayou and adjacent wetlands a suitable, attractive habitat. Herons have a limited home range and do not venture far from their nesting sites; thus, it is assumed that they spend a significant amount of time in portions of the bayou and the adjacent wetlands where they have been observed. Also, herons do not appear to be sensitive to human presence, feeding in portions of the bayou and wetlands near the more developed parts of the base.

- *Correlation with Accepted Measurement Endpoints* — Based on their diet, feeding habits, and feeding range, effects to the heron may be correlated with impacts caused by contaminants present in Site 41 wetlands. For example, body burdens in particular prey fish species may be used to predict reproductive impacts to herons.

#### **8.6.2 Assessment Endpoint: Piscivorous Mammal Health**

The mammalian piscivore community health assessment endpoint was added after the work plan was approved as a result of meetings with regulators and trustees. This assessment endpoint is aimed at ecologically viable mammalian piscivore community or organism sustainability. The piscivorous mammal to be used as a surrogate for this assessment endpoint is the mink (*Mustella vison*). Piscivorous mammals are selected as an important endpoint for Site 41 based on the prey preferences, their known sensitivity to environmental contaminants, and their position as a predator in the food chain. All these factors collectively make piscivorous mammals a good sentinel endpoint for community health. Risk to this community is evaluated using a food-chain model described in Section 8.7.1.

#### **8.6.3 Assessment Endpoint: Survival, Growth, and Reproduction of Macroinvertebrates Associated with the Benthic Environment**

Benthic macroinvertebrate communities are selected as an assessment endpoint because this endpoint is relatively sessile and may significantly affect higher trophic level organisms. Benthic macroinvertebrates are an important biomonitoring tool because they are relatively sessile, generally have short life cycles, and represent a range of ecological niches. In addition to showing acute and chronic toxicological effects, benthic organisms also have the potential to accumulate metals and other contaminants at several orders of magnitude above ambient concentrations in the sediment or surface water. Benthic macroinvertebrates are localized in their habitat, meaning effects to benthic organisms can often be directly related to conditions in the immediate vicinity. The ability to focus on effects in particular areas may help focus remedial decisions.

#### **8.6.4 Assessment Endpoint: Protection of Fish Viability**

Predatory and prey fish communities are selected as an assessment endpoint based on their potential for exposure through diet and/or absorption. Fish occupy a significant niche in an estuarine community, and effects to populations can alter the overall community structure.

Body burden and toxicity data from fish species will be important for the following reasons:

- *Higher Food-Chain Impacts* — Fish are prey for a variety of other species, emphasizing the importance of the piscivorous assessment endpoints.
- *Biotransfer* — Fish may ingest sediment during feeding, becoming a direct transfer pathway to higher trophic level species for contaminants present in the sediment.
- *Toxicity from Direct Exposure* — Toxicity to fish species may be correlated with contaminant concentrations in sediment.

## **8.7 Measurement Endpoints**

Ecological risk in each wetland is evaluated through impacts on its assessment endpoints. The methods used to quantify risk to each of these assessment endpoints are described below. The data evaluation is provided in Section 10 through 15.

Decision points are toxicological or bioaccumulative effects that indicate ecological risk meaning a decision is required concerning whether risk is assumed or additional analysis is needed. A decision point is selected for each Phase III measurement endpoint test. For all toxicity tests, the decision point is defined as statistically significant differences in mortality, growth, or fecundity when compared to a control. After these differences are established, they are also compared to effects seen in the reference wetlands. For the bioaccumulation analysis, the decision point is whole-body contaminant levels associated with an adverse effect. These are defined as tissue concentrations that exceed a defined threshold effects level in the assessment endpoint species.

### **8.7.1 Food-Chain Model**

Some constituents are known to bioaccumulate or biomagnify within the food web. The potential for constituent movement from the environmental media into upper trophic level predators requires additional analysis for these constituents. To evaluate this exposure route, a food web model is developed using Site 41 sediment, surface water, and fish tissue concentrations to develop a dietary exposure estimate. The dietary exposure estimate is then compared to literature-based values related to no observed effects levels and lowest observed effects levels to determine the potential for unacceptable risk based on this exposure route.

While numerous receptors may be exposed to constituents in sediments and prey items within Site 41, three assessment endpoints have been selected to represent a conservative estimate for all potential exposures. The three assessment endpoints identified are:

- Health and survival of the piscivorous bird community
- Health and survival of the piscivorous mammal community
- Health and survival of the predatory fish community

The general list of constituents to be evaluated includes the following bioaccumulative constituents:

- Mercury
- Total PCBs
- Pesticides

#### 8.7.1.1 Food-Chain Model Methodology

Two separate uptake models were used to estimate uptake of sediment COPCs at the Site 41 wetlands. For exposure to piscivorous birds and carnivorous mammals, a simple exposure model was used based on the site specific data gathered during the RI. A model developed by Evans and Engel (Evans and Engel, 1994) was used to estimate the exposure of predatory fish to mercury at Site 41. Each of these food-chain models is described below.

#### 8.7.1.2 General Food-Chain Model Equation

The simple food web model estimated dietary exposure as a body-weight normalized total daily dose for each receptor species. The general structure of the food web exposure model is described by the following calculation:

$$\text{Estimated exposure} = \frac{\sum_i (C_i \times M_i \times A_i \times F_i)}{W}$$

**where:**

- Estimated exposure = total ingestion rate of chemical from all dietary components (mg/kg body weight/day)
- C = concentration of the chemical in a given dietary component and medium (mg/kg dry weight)
- M<sub>i</sub> = rate of ingestion of an abiotic medium (kg/day dry weight)

- $A_i$  = relative gastrointestinal absorption efficiency for the chemical in a given dietary component or medium (fraction, assumed 1 for this risk assessment)
- $F$  = fraction of the daily intake of a given dietary component or medium derived from the study area (unitless, assumed to be 1 for this risk assessment)
- $W$  = body weight of receptor species (kg)

For this assessment,  $A$  has been set to 1.0 (100 percent absorption) and  $F$ , has been set to 1.0 (dietary component is assumed to be 100% fish) scenarios evaluated.

The estimated exposure term can be expanded to specify each ingestion medium, which includes one or more primary food items, drinking water, and incidentally ingested sediment (or soil):

$$IR_{\text{chemical}} = \frac{[(\sum (C_{\text{food}} \cdot M_{\text{food}} \cdot F_{\text{food}}) + (C_{\text{water}} \cdot M_{\text{water}} \cdot F_{\text{water}}) + (C_{\text{sediment}} \cdot M_{\text{sediment}} \cdot F_{\text{sediment}})]}{W}$$

### 8.7.1.3 Red Drum Mercury Model

A model was performed that predicts mercury tissue concentration in the red drum based on concentrations of mercury in the sediment of Site 41. This model is based on the red drum mercury bioaccumulation model developed by Evans and Engel. The model assumes that mercury uptake into the red drum occurs via prey ingestion exclusively. The three prey sources are forage fish, crustaceans, and infaunal invertebrates. The *Final RI Report, Site 40* (EnSafe, 1999) and Evans and Engel (1994) explain this model in detail.

The equation used in the model is briefly explained below:

$$= \left( \frac{a * R}{g + K} \right) * [(Cf)(\% Cf) + (Ccr)(\% Ccr) + (Cinv)(\% Cinv)]$$

**where:**

- $a$  = Assimilation efficiency of mercury from food, or 0.8
- $R$  = Feeding rate of the red drum, or 0.02/day
- $g$  = growth rate coefficient, or 0.003/day

<i>K</i>	=	Methyl mercury excretion rate from the red drum, or 0.00035/day
<i>Cf</i>	=	Methyl mercury tissue concentration in forage fish
<i>%Cf</i>	=	Percent of red drum diet composed of forage fish, or 0.3
<i>Ccr</i>	=	Methyl mercury tissue concentration in crustaceans
<i>%Ccr</i>	=	Percent of red drum diet composed of crustaceans, or 0.6
<i>Cinv</i>	=	Methyl mercury tissue concentrations in infaunal benthic invertebrates
<i>%Cinv</i>	=	Percent of red drum diet composed of benthic invertebrates, or 0.1

The first part of the mercury model equation calculates the bioaccumulation factor for methyl mercury, adjusting for input and excretion of this metal (which are assumed to be in balance at steady state).

The second portion of the equation estimates the accumulation of methyl mercury from the prey pathway, based on the assumption of a diet composed of 30% forage fish, 60% crustaceans, and 10% infaunal invertebrates. For the purposes of this risk assessment, the submodel results for fish will be replaced by the fish tissue results from each of the Operable Units included in this RI. The details of how *Ccr* and *Cinv* are calculated are presented in the Evans and Engel model.

#### **8.7.1.4 Food-Chain Model Evaluation of Risk**

Both of these models output an estimate of the exposure to each assessment endpoint. This exposure estimate is then compared to toxicity reference values (TRVs) from the scientific literature using the HQ approach. Where possible, both a “no observed adverse effects” level (NOAEL) and a “lowest observed adverse effects” level (LOAEL) are obtained from the literature, so a protective range can be evaluated.

#### **8.7.1.5 Input Parameters for Food-Chain Models**

The literature-based input parameters for the food web models are summarized in Table 8-5. These input parameters include life history data taken from scientific literature for each of the proposed model species and site-specific media concentrations from the previous investigations. The ingestion rates and body weights used are reported on a dry weight basis. Only dry weight values were used for consistency with the laboratory data.

#### **8.7.1.6 Site-Specific Food-Chain Model Inputs**

Each of the food chain models described above will be applied to the following list of wetland groupings:

- **OU 1 Wetlands:** Those wetlands, located within the general area of OU 1, are potentially impacted by the Site 1 landfill. Wetlands in this group include: Wetland 1, Wetland 3, Wetland 4D, Wetland 15, Wetland 16, Wetland 17, Wetland 18A, and Wetland 18B.
- **OU 2 Wetlands:** Wetlands in this group include: Wetland 5A and 5B, Wetland 6, and Wetland 64.
  
- **OU 10 Wetlands:** Wetlands in this group include: Wetland 10, Wetland 11, and Wetland 13.
  
- **Chevalier Field Wetlands:** Wetlands in this group include: 63A and 63B.
  
- **Forrest Sherman Field Wetlands:** Wetlands in this group include: Wetland 19, Wetland 52, Wetland 56, Wetland 57, Wetland 58, Wetland 72, Wetland 79, Wetland W2, Wetland W1, Wetland 48, and Wetland 49.

### **Exposure Scenarios**

Since work has been completed in several phases at Site 41, two general exposure scenarios will be evaluated for each wetland grouping listed above. For each OU listed above, a food-chain model will be completed showing the concentrations present during the Phase II sampling event and the Phase III sampling event. The data used are presented in Appendix M. It should be noted that the tissue concentrations used in the food-chain models were collected during the Phase III sampling event. Therefore, the site-specific biota data will only be utilized in the food-chain models summarizing conditions during the Phase III sampling event. Biota concentrations for the Phase II sampling event will be derived using literature-based bioaccumulation factors presented in Table 8-6.

For each wetland grouping, the site-specific media concentrations (sediment and biota tissue, where available) to be utilized in the food web models will include the maximum concentration detected in an OU (using one-half the sample quantitation limit for all NDs) and the average concentration. Fish tissue was collected during the Phase III sampling event at targeted wetlands, based on Phase II results of previous investigation concentrations. Since fish were the biota selected for collection during this field event, the food-chain models will assume all predators feed exclusively on fish tissue. The red drum model will use the prey assumptions discussed in that model (Evans and Engel, 1994).

### **8.7.2 Benthic Community Analysis**

Benthic community data can reveal what effects are actually occurring from site contamination in the area sampled. Species diversity results by themselves are not considered a reliable indicator of ecological risk. This is because many factors influence diversity, including: (1) sediment type;

(2) deposition rates; (3) water temperature; (4) salinity; (5) waterborne nitrates and phosphates; (6) dissolved oxygen; or (7) many other factors which may or may not be directly related to IR site contamination. Therefore, it is important to view species diversity in context with contaminant concentrations and toxicity test results.

This approach is referred to as the Sediment Quality Triad. The three indices used to categorize species diversity for Phase III (Shannon Weiner, Pielou's Evenness, and Margalef's Richness Diversity) are described below. The Shannon Weiner Diversity Index refers to the diversity of a community taking into account the evenness and richness of individuals and species collected. The Shannon Weiner Diversity Index ranges from 1.3 (low diversity) to 6.5 (high diversity) and is always presented with the other two indices, which also influence diversity. A low value would indicate a higher chance that one or two species dominate a particular site.

Pielou's Evenness Index measures the abundance of species. In an ideal setting, a community of 100 individuals would be composed of 100 species. The Pielou Evenness Index ranges from zero to 1.0, with 1.0 indicating perfect evenness.

Margalef's Species Richness Index refers to species abundance and distribution over a given area. An example of this would be a community of 100 individuals composed of 10 species, of which 90% of those individuals belong to a single species. The remaining 10% of the community are distributed among the nine species, which would indicate low evenness. Margalef's Species Richness Index ranges from 1.0 to 10, with 10 being the best range.

The Shannon Weiner Diversity Index should be evaluated by itself and not averaged with Pielou's Evenness Index or Margalef's Species Richness Index, as they are components in the diversity index. From this type of data, it is possible to assess whether a particular habitat is healthy, in a recovery state, or impacted.

### **8.7.3 Toxicity Tests**

Toxicity tests were performed on sediment and surface water samples collected at selected locations from Phase III wetlands. The test species used include the freshwater species, the fathead minnow (*Pimephales promelas*) and larval midge (*Chironomus tentans*); and the estuarine species, the marine amphipod (*Leptocheirus plumulosus*) and marine polychaete (*Neanthes arenaceodentata*).

These are considered surrogate species for naturally occurring fish, benthic macroinvertebrates, and polychaetes. Acute (survival endpoint) and chronic (survival and sublethal endpoints) exposures were

performed on the freshwater and estuarine sediments collected from the Phase III wetlands. Statistical analyses were then performed on the results to determine differences between the subject samples and the control samples.

To assist in the evaluation of these processes, a triad matrix is developed that gives equal weight to the sediment chemistry, toxicity tests, and benthic assessments. Interpretation of the matrix and the logical steps to be followed are shown in the decision flow-charts discussed later in this section.

Decision making for sediment assessment will proceed based on the triad assessment results presented in the matrices below. Sediment chemistry is evaluated by comparing the detected concentrations to the SVs and RVs. Benthic diversity is assessed by measures in: (1) abundance; (2) diversity; or (3) the presence of pollution indicator species. Biological decision making triads are used to assess biological test results. These results will be processed through the Project Decision Making Triad to establish decisions at the project level.

“Unacceptable” and “adverse effects” (terms used below) mean “statistically different” using methods accompanying each test protocol. “Acceptable” means results were not statistically significant. For weighting purposes, “unacceptable” on survival is considered twice as important as “unacceptables” on reproduction or growth. This is because survival (i.e., mortality) is irreversible, whereas reproduction and growth endpoints are potentially reversible; therefore, two sublethal unacceptables equal one lethal unacceptable. After the bioassays are considered individually, their results will be combined for input to the triad matrix assuming the compounding of cumulative adverse effects.

Within the triad matrix, +’s and —’s are used to reflect the continuum of chemistry, toxicity, and benthic community response one normally encounters. In the interpretation, multiple +’s reflect a higher score for a particular interpretation. These scores consider the strength or weakness one should associate with a particular interpretation.

### **Sediment Toxicity Test**

The boxes below chart the possible outcomes for the *Leptocheirus plumulosus* amphipod test, the *Neanthes* polychaete test, and the *Chironomous tentans* midge test, conducted to analyze the sediments of a particular wetland.

Possible outcomes from the *Leptocheirus plumulosus* amphipod test:

Survival	Scoring
Acceptable (>80%)	—
Not Acceptable (<80%)	+

Possible outcomes from the *Neanthes* Polychaete test:

Survival	Weight	Scoring
Acceptable	Acceptable	—
Acceptable	Unacceptable	+
Not Acceptable	Acceptable	++
Not Acceptable	Unacceptable	+++

Possible outcomes from the *Chironomous tentans* midge test:

Survival	Weight	Emergence	Scoring
Acceptable	Acceptable	Acceptable	—
Acceptable	Acceptable	Unacceptable	+
Acceptable	Unacceptable	Unacceptable	++
Acceptable	Unacceptable	Unacceptable	++
Acceptable	Unacceptable	Acceptable	++
Unacceptable	Acceptable	Acceptable	++
Unacceptable	Acceptable	Unacceptable	+++
Unacceptable	Unacceptable	Acceptable	+++
Unacceptable	Unacceptable	Unacceptable	++++

At locations with more than one toxicity test result for sediment, the results are integrated as shown in the box below:

Combined Score	Biological Interpretation Considering both Bioassays	Input to Triad Matrix		
—	No adverse effects	—	=	—
+	Acceptable survival in both species 1 sublethal significant difference result in one species	—	=	—
++	1 unacceptable survival in one species or two sublethal significant difference results	+	=	+
+++	1 unacceptable survival result in one species and/or adverse sublethal effects	+	=	+
++++	Unacceptable survival results in 1-2 species and/or adverse sublethal effects	++	=	+
+++++	Unacceptable survival results in both test species and significantly different sublethal effects	+++	=	+

### **Sediment Decision Making Triad**

The decision making triad is composed of the combined scores for sediment chemistry, benthic assessment, and toxicity tests. Using the triad, the condition of a wetland’s surface water can be interpreted, along with any degradation impacting sediment. The conditions and their interpretations are explained in the box below.

Surface water conditions and their interpretations are also presented below but will be explained in the assessment of fish viability endpoint.

<b>Condition</b>	<b>Chemistry</b>	<b>Toxicity Tests</b>	<b>Benthic Assessment</b>	<b>Interpretation</b>
1	+	+	+	Strong evidence for pollution-induced degradation.
2	—	—	—	Strong evidence for the absence of pollution-induced degradation.
3	+	—	—	Contaminants are not bioavailable.
4	—	+	—	Unmeasured contaminants or conditions exist that have the potential to cause degradation.
5	—	—	+	Alteration of benthic community is probably not due to toxic chemical contamination.
6	+	+	—	Toxic chemicals are probably stressing the system.
7	—	+	+	Unmeasured toxic chemicals are causing degradation.
8	+	—	+	Benthic community degraded by toxic chemicals but toxicity test not sensitive to toxic chemicals present or chemicals are not bioavailable or alteration is not due to toxic chemicals.

**Notes:**

- + = Measured difference between test and control or reference conditions
  - = No measurable difference between test and control or reference conditions
- The shaded area relates to surface water acute tests and is described in Figure 7-5

#### **8.7.4 Assessment Endpoint: Protection of Fish Viability**

Determining potential impact to the fish community involves a more complex analysis of different lines of evidence depending on the wetland. The first line of evidence is the comparison of surface water concentrations to surface water quality criteria to estimate the effect of contaminant concentrations.

Surface water data are presented in the wetland-specific ERAs in Section 10 through 15. The second line of evidence is the comparison of body burden values in foraging fish species to ERED values, then calculating HQ values and determining whether these whole-body residue concentrations are associated with any adverse effects.

The second line of evidence is similar to the first but incorporates the TTC, which predicts effects on predatory fish species based on the whole-body residue concentrations in foraging fish tissue. In the third line of evidence, toxicity are evaluated for the fathead minnow. For Wetlands 18B and 64, all four lines of evidence were applied. For Wetland 3, only toxicity and chemistry data were analyzed, because the shallow depth of the surface water does not support upper trophic level fish.

**Surface Water Toxicity Test**

The box below charts the possible outcomes for the *Pimephales promelas* fathead minnow test conducted to analyze surface water conditions:

Survival	Growth	Scoring
Acceptable (>80%)	No Significant Difference	—
Acceptable (>80%)	Significant Difference	+
Not Acceptable (<80%)	No Significant Difference	++
Not Acceptable (<80%)	Significant Difference	+++

Because only one surface water toxicity test is performed at each location, the above scores will be put directly into the Triad Matrix. Multiple +'s will be input as a single +.

**Surface Water Decision Making Triad**

The surface water decision making triad is comprised of the combined scores for surface water chemistry, benthic assessment, and toxicity tests. Using the triad, the condition of a wetland's surface water can be interpreted, along with degradation which may have an impact on the wetland.

**8.8 ERA Uncertainties**

All sampling programs may produce unavoidable design variations. Uncertainties in field conditions, laboratory procedures, or other circumstances may have resulted in overestimation or underestimation of risk in the Site 41 ERAs.

These include:

- Analytical matrix interferences, due to excess organic material in sediment, may over- or underestimate risk. Some wetland samples included roots and other benthic organisms.
- Many constituents lack criteria or benchmark values, which can over- or underestimate risk and increase the uncertainty for screening level assessments.

- The HQ approach does not consider natural background metals concentrations, synergistic or antagonistic effects, and the effects of TOC as they relate to bioavailability. These factors could lead to over- or underestimating risk.
  
- Three exposure point scenarios will be developed for each constituent: (1) The maximum exposure point scenario will assume that each receptor spends all its time feeding in the area with maximum concentration (using half detection limits for any non-detected parameters in total PCBs, endrins, chlordanes, total DDT, and BHCs) for each constituent; (2) A maximum exposure calculated using only detected parameters; and (3) An average exposure scenario was calculated using one-half the detection limits for any location where a constituent may have been reported as not detected.
  
- For simplicity, it is assumed that all piscivorous predators evaluated with the simple food-chain models consume a diet of 100 percent fish (with the exception of the red drum mercury model).
  
- Fish tissue data are available from a small number of wetlands. The rationale for sampling these wetlands was they were deemed to be a reasonable representative of constituent levels throughout NAS Pensacola. While many things can affect bioaccumulation of constituents into prey tissue, it is assumed that the concentrations measured during the Phase III sampling are representative of exposure throughout each OU grouping.

Since the fish sampled during the Phase III sampling event were not analyzed for mercury, fish samples collected at nearby sampling stations from the Site 40 RI were used. While this introduces some uncertainty, since the fish tissue samples were not collocated with the sediment samples, it should present a reasonable substitute for the Site 41 data due to the sample locations close proximity to Wetland 18B.

The ERA process is applied to surface water data, but the main focus of the ERA is on sediment data. This is because sediment contaminants are more persistent than surface water contaminants, correlate better with long-term effects, and can drive the development of remedial options. This is particularly important when the surface water data are reviewed in comparison to SVs. In some cases, contaminant HQ values are elevated for surface water, even though similar constituents are not detected in the associated sediment samples, and the contaminants do not appear to be associated with impacts from an IR site. It is suspected that these elevated HQs are due to high turbidity (an uncertainty previously discussed) during collection of the surface water samples or other possible non-site-related factors.

**Table 8-1**  
**Site 41**  
**Sediment Screening/Refinement Values and Reference Concentrations**

Parameter	Screening Value (SV)		Refinement Value (RV)		Freshwater Reference Concentration	Saltwater Reference Concentration	Units
	Value	Source	Value	Source			
<b>Metals (mg/kg)</b>							
Aluminum	N/S	N/A	N/R	N/A	13,610	4,274	mg/kg
Antimony	12	1	N/R	N/A	4.43	0.26	mg/kg
Arsenic	7.24	1, 2	41.6	PEL	6.62	2.14	mg/kg
Barium	N/S	N/A	N/R	N/A	14	3.84	mg/kg
Beryllium	N/S	N/A	N/R	N/A	0.84	0.13	mg/kg
Cadmium	0.68	2	4.21	PEL	1.8	0.39	mg/kg
Calcium	N/S	N/A	N/R	N/A	10,756.67	1,978.80	mg/kg
Chromium	52.3	1, 2	160	PEL	39.37	13.1	mg/kg
Cobalt	N/S	N/A	N/R	N/A	2.8	0.91	mg/kg
Copper	18.7	1, 2	108	PEL	19.5	8.44	mg/kg
Cyanide (CN)	N/S	N/A	N/R	N/A	5.22	1.29	mg/kg
Iron	N/S	N/A	N/R	N/A	11,911.67	2,684.40	mg/kg
Lead	30.2	1, 2	112	PEL	82.47	21.04	mg/kg
Magnesium	N/S	N/A	N/R	N/A	7,513.33	2,943.60	mg/kg
Manganese	N/S	N/A	N/R	N/A	37.97	9.81	mg/kg
Mercury	0.13	1, 2	0.696	PEL	0.55	0.11	mg/kg
Nickel	15.9	1, 2	42.8	PEL	9.28	3.69	mg/kg
Potassium	N/S	N/A	N/R	N/A	1,628.67	899.72	mg/kg
Selenium	N/S	N/A	N/R	N/A	3.45	0.66	mg/kg
Silver	0.73	2	1.77	PEL	2.1	0.52	mg/kg
Sodium	N/S	N/A	N/R	N/A	18,993.33	11,439.60	mg/kg
Thallium	N/S	N/A	N/R	N/A	1.57	0.39	mg/kg
Vanadium	N/S	N/A	N/R	N/A	28.67	8.59	mg/kg
Zinc	124	1, 2	271	PEL	36.73	14.36	mg/kg
<b>Pesticides and PCBs (µg/kg)</b>							
Aldrin	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Dieldrin	0.715	2	4.3	PEL	N/A	N/A	µg/kg
Endosulfan I	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Endosulfan II	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Endosulfan sulfate	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Heptachlor	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Heptachlor epoxide	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Methoxychlor	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Toxaphene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
<i>alpha</i> -BHC	0.32	2	0.99	PEL	N/A	N/A	µg/kg
<i>beta</i> -BHC	0.32	2	0.99	PEL	N/A	N/A	µg/kg
<i>delta</i> -BHC	0.32	2	0.99	PEL	N/A	N/A	µg/kg
<i>gamma</i> -BHC (Lindane)	0.32	2	0.99	PEL	N/A	N/A	µg/kg
<b>Total BHCs</b>	0.32	2	0.99	PEL	N/A	N/A	µg/kg
<i>alpha</i> -Chlordane	1.7	1	4.79	PEL	N/A	N/A	µg/kg
<i>gamma</i> -Chlordane	1.7	1	4.79	PEL	N/A	N/A	µg/kg
<b>Total Chlordanes</b>	1.7	1	4.79	PEL	N/A	N/A	µg/kg
<i>4,4'</i> -DDD	1.22	2	7.81	PEL	50	50	µg/kg
<i>4,4'</i> -DDE	2.07	2	374	PEL	40	40	µg/kg
<i>4,4'</i> -DDT	1.19	2	4.77	PEL	20	20	µg/kg
<b>Total 4,4'-DDx</b>	3.3	1	51.7	PEL	110	110	µg/kg
<i>Endrin</i>	3.3	1	N/R	N/A	N/A	N/A	µg/kg
<i>Endrin aldehyde</i>	3.3	1	N/R	N/A	N/A	N/A	µg/kg
<i>Endrin ketone</i>	3.3	1	N/R	N/A	N/A	N/A	µg/kg
<b>Total Endrins</b>	3.3	1	N/R	N/A	N/A	N/A	µg/kg
<i>Aroclor-1016</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1221</i>	67	1	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1232</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1242</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1248</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1254</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<i>Aroclor-1260</i>	21.6	2	189	PEL	N/A	N/A	µg/kg
<b>Total PCBs</b>	21.6	2	189	PEL	N/A	N/A	µg/kg

**Table 8-1**  
**Site 41**  
**Sediment Screening/Refinement Values and Reference Concentrations**

Parameter	Screening Value (SV)		Refinement Value (RV)		Freshwater Reference Concentration	Saltwater Reference Concentration	Units
	Value	Source	Value	Source			
<b>SVOCs (µg/kg)</b>							
1,2,4-Trichlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,2-Dichlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,3-Dichlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,4-Dichlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,2'-oxybis(1-Chloropropane)/bis(2-chlor)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4,5-Trichlorophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4,6-Trichlorophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4-Dichlorophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4-Dimethylphenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4-Dinitrophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,4-Dinitrotoluene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2,6-Dinitrotoluene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Chloronaphthalene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Chlorophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Methyl-4,6-Dinitrophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Methylphenol (o-Cresol)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Nitroaniline	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Nitrophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
3,3'-Dichlorobenzidine	N/S	N/A	N/R	N/A	N/A	N/A	N/A
3-Nitroaniline	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Bromophenyl-phenylether	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Chloro-3-methylphenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Chloroaniline	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Chlorophenylphenyl ether	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Methylphenol (p-Cresol)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Nitroaniline	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Nitrophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Benzo(g,h,i)perylene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
bis(2-Chloroethoxy)methane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
bis(2-Chloroethyl)ether	N/S	N/A	N/R	N/A	N/A	N/A	N/A
bis(2-Ethylhexyl)phthalate (BEHP)	182	1, 2	2,647	PEL	N/A	N/A	µg/kg
Butylbenzylphthalate	182	3	2,647	PEL	N/A	N/A	µg/kg
Carbazole	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Dibenzofuran	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Diethylphthalate	182	3	2,647	PEL	N/A	N/A	µg/kg
Dimethylphthalate	182	3	2,647	PEL	N/A	N/A	µg/kg
Di-n-butylphthalate	182	3	2,647	PEL	N/A	N/A	µg/kg
Di-n-octylphthalate	182	3	2,647	PEL	N/A	N/A	µg/kg
Hexachlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Hexachlorobutadiene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Hexachlorocyclopentadiene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Hexachloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Indeno(1,2,3-cd)pyrene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Isophorone	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Nitrobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
N-Nitroso-di-n-propylamine	N/S	N/A	N/R	N/A	N/A	N/A	N/A
N-Nitrosodiphenylamine	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Pentachlorophenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Phenol	N/S	N/A	N/R	N/A	N/A	N/A	N/A
<i>2-Methylnaphthalene</i>	20.2	2	201	PEL	N/A	N/A	µg/kg
<i>Acenaphthene</i>	6.71	2	88.9	PEL	N/A	N/A	µg/kg
<i>Acenaphthylene</i>	5.87	2	128	PEL	N/A	N/A	µg/kg
<i>Anthracene</i>	46.9	2	245	PEL	N/A	N/A	µg/kg
<i>Benzo(a)anthracene</i>	74.8	2	693	PEL	N/A	N/A	µg/kg
<i>Benzo(a)pyrene</i>	88.8	2	763	PEL	N/A	N/A	µg/kg
<i>Chrysene</i>	108	2	846	PEL	N/A	N/A	µg/kg
<i>Dibenz(a,h)anthracene</i>	6.22	2	135	PEL	N/A	N/A	µg/kg
<i>Fluoranthene</i>	113	2	1,494	PEL	N/A	N/A	µg/kg
<i>Fluorene</i>	21.2	2	144	PEL	N/A	N/A	µg/kg
<i>Naphthalene</i>	34.6	2	391	PEL	N/A	N/A	µg/kg
<i>Phenanthrene</i>	86.7	2	544	PEL	N/A	N/A	µg/kg
<i>Pyrene</i>	153	2	1,398	PEL	N/A	N/A	µg/kg
<b>Total PAHs</b>	1684	2	16,770	PEL	N/A	N/A	µg/kg
<b>TOC Normalized PAHs</b>	290	5	1,800	MEC	N/A	N/A	mg/kg-oc

**Table 8-1**  
**Site 41**  
**Sediment Screening/Refinement Values and Reference Concentrations**

Parameter	Screening Value (SV)		Refinement Value (RV)		Freshwater Reference Concentration	Saltwater Reference Concentration	Units
	Value	Source	Value	Source			
<b>VOCs (µg/kg)</b>							
1,1,1-Trichloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,1,2,2-Tetrachloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,1,2-Trichloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,1-Dichloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,1-Dichloroethene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,2-Dichloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,2-Dichloroethene (total)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
1,2-Dichloropropane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Butanone (MEK)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
2-Hexanone	N/S	N/A	N/R	N/A	N/A	N/A	N/A
4-Methyl-2-Pentanone (MIBK)	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Acetone	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Benzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Bromodichloromethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Bromoform	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Bromomethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Carbon disulfide	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Carbon tetrachloride	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Chlorobenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Chloroethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Chloroform	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Chloromethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
cis-1,3-Dichloropropene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Dibromochloromethane	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Ethylbenzene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Methylene chloride	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Styrene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Tetrachloroethene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Toluene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
trans-1,3-Dichloropropene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Trichloroethene	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Vinyl chloride	N/S	N/A	N/R	N/A	N/A	N/A	N/A
Xylene (Total)	N/S	N/A	N/R	N/A	N/A	N/A	N/A

**Notes:**

- 1 = USEPA value.
- 2 = FDEP value.
- 1,2 = USEPA/FDEP values.
- 3 = 182 µg/kg EPA/FDEP value for BEHP used as a surrogate, per decision from the July 15-16, 2002 Eco Subgroup meeting.
- 4 = Swartz Threshold effects concentration (TEC).

**Table 8-2**  
**Site 41**  
**Surface Water Screening/Refinement Values and Reference Concentrations**

Fresh	Parameter	SV	Source	Ref. Conc.	Salt	Parameter	SV_SW	Source	Ref Conc.
<b>Metals</b>									
F	Aluminum	13	FDEP	1,090.25	S	Aluminum	1,500	FDEP	2927.5
F	Antimony	160	USEPA	4	S	Antimony	4,300	FDEP	4.15
F	Arsenic	50	FDEP	2.7	S	Arsenic	36	USEPA	3.6
F	Barium		N/A	3,675	S	Barium		N/A	9.425
F	Beryllium	0.13	FDEP	1	S	Beryllium	0.13	FDEP	0.82
F	Cadmium	0.66	USEPA	3	S	Cadmium	9.3	FDEP	2.395
F	Calcium		N/A	7,675	S	Calcium		N/A	76800
F	Chromium	11	FDEP	8	S	Chromium	50	FDEP	10.87
F	Cobalt		N/A	3	S	Cobalt		N/A	2.3825
F	Copper	6.54	USEPA	4	S	Copper	2.9	FDEP	7.025
F	Cyanide (CN)	5.2	FDEP	5	S	Cyanide (CN)	1	FDEP	4.1
F	Iron	1,000	FDEP	2,360	S	Iron	300	FDEP	1352
F	Lead	1.32	USEPA	3.2	S	Lead	8.5	FDEP	13.75
F	Magnesium		N/A	20,260	S	Magnesium		N/A	243650
F	Manganese		N/A	13.2	S	Manganese		N/A	12.15
F	Mercury	0.012	FDEP	0.13	S	Mercury	0.025	FDEP	0.21
F	Nickel	87.71	USEPA	12	S	Nickel	8.3	FDEP	9.3
F	Potassium		N/A	6,995	S	Potassium		N/A	81250
F	Selenium	5	FDEP	3	S	Selenium	71	FDEP	2.9
F	Silver	0.012	USEPA	4	S	Silver	0.23	USEPA	3.0075
F	Sodium		N/A	182,200	S	Sodium		N/A	1952000
F	Thallium	4	USEPA	4.2	S	Thallium	6.3	FDEP	2.55
F	Vanadium		N/A	4.7	S	Vanadium		N/A	6.6925
F	Zinc	58.91	USEPA	5.525	S	Zinc	86	FDEP	12.875
<b>Pesticides/PCBs</b>									
F	4,4'-DDD	0.0003	FDEP	N/A	S	4,4'-DDD	0.0003	FDEP	N/A
F	4,4'-DDE	0.0002	FDEP	N/A	S	4,4'-DDE	0.0002	FDEP	N/A
F	4,4'-DDT	0.00059	FDEP	N/A	S	4,4'-DDT	0.00059	FDEP	N/A
F	Aldrin	0.00014	FDEP	N/A	S	Aldrin	0.00014	FDEP	N/A
F	alpha-BHC	0.005	FDEP	N/A	S	alpha-BHC	0.005	FDEP	N/A
F	alpha-Chlordane	0.00059	FDEP	N/A	S	alpha-Chlordane	0.00059	FDEP	N/A
F	Aroclor-1016	0.000045	FDEP	N/A	S	Aroclor-1016	0.000045	FDEP	N/A
F	Aroclor-1221	0.000045	FDEP	N/A	S	Aroclor-1221	0.000045	FDEP	N/A
F	Aroclor-1232	0.000045	FDEP	N/A	S	Aroclor-1232	0.000045	FDEP	N/A
F	Aroclor-1242	0.000045	FDEP	N/A	S	Aroclor-1242	0.000045	FDEP	N/A
F	Aroclor-1248	0.000045	FDEP	N/A	S	Aroclor-1248	0.000045	FDEP	N/A
F	Aroclor-1254	0.000045	FDEP	N/A	S	Aroclor-1254	0.000045	FDEP	N/A
F	Aroclor-1260	0.014	FDEP	N/A	S	Aroclor-1260	0.014	FDEP	N/A
F	beta-BHC	0.046	FDEP	N/A	S	beta-BHC	0.046	FDEP	N/A
F	delta-BHC		N/A	N/A	S	delta-BHC		N/A	N/A
F	Dieldrin	0.00014	FDEP	N/A	S	Dieldrin	0.00014	FDEP	N/A
F	Endosulfan I	0.056	FDEP	N/A	S	Endosulfan I	0.0087	FDEP	N/A
F	Endosulfan II	0.056	FDEP	N/A	S	Endosulfan II	0.0087	FDEP	N/A
F	Endosulfan sulfate	0.056	FDEP	N/A	S	Endosulfan sulfate	0.0087	FDEP	N/A
F	Endrin	0.0023	FDEP	N/A	S	Endrin	0.0023	FDEP	N/A
F	Endrin aldehyde	0.0023	FDEP	N/A	S	Endrin aldehyde	0.0023	FDEP	N/A
F	Endrin ketone	0.0023	FDEP	N/A	S	Endrin ketone	0.0023	FDEP	N/A
F	gamma-BHC (Lindane)	0.08	FDEP	N/A	S	gamma-BHC (Lindane)	0.016	USEPA	N/A
F	gamma-Chlordane	0.00059	FDEP	N/A	S	gamma-Chlordane	0.00059	FDEP	N/A
F	Heptachlor	0.0038	FDEP	N/A	S	Heptachlor	0.0036	USEPA	N/A
F	Heptachlor epoxide	0.00004	FDEP	N/A	S	Heptachlor epoxide	0.00004	FDEP	N/A
F	Methoxychlor	0.03	FDEP	N/A	S	Methoxychlor	0.03	FDEP	N/A
F	Total BHC		N/A	N/A	S	Total BHC		N/A	N/A
F	Total Chlordane	0.0043	FDEP	N/A	S	Total Chlordane	0.004	USEPA	N/A
F	Total DDT		N/A	N/A	S	Total DDT	0.00059	FDEP	N/A
F	Total Endrin		N/A	N/A	S	Total Endrin	0.0023	FDEP	N/A
F	Total PCB		N/A	N/A	S	Total PCB		N/A	N/A
F	Toxaphene	0.0002	FDEP	N/A	S	Toxaphene	0.0002	FDEP	N/A
<b>SVOCs</b>									
F	1,2,4-Trichlorobenzene	23	FDEP	N/A	S	1,2,4-Trichlorobenzene	4.5	USEPA	N/A
F	1,2-Dichlorobenzene	15.8	USEPA	N/A	S	1,2-Dichlorobenzene	19.7	USEPA	N/A
F	1,3-Dichlorobenzene	50.2	USEPA	N/A	S	1,3-Dichlorobenzene	28.5	USEPA	N/A
F	1,4-Dichlorobenzene	3	FDEP	N/A	S	1,4-Dichlorobenzene	3	FDEP	N/A
F	2,2'-oxybis(1-Chloropropane)/bis(2-chlor)		N/A	N/A	S	2,2'-oxybis(1-Chloropropane)/bis(2-chlor)		N/A	N/A
F	2,4,5-Trichlorophenol	23	FDEP	N/A	S	2,4,5-Trichlorophenol	23	FDEP	N/A
F	2,4,6-Trichlorophenol	3.2	USEPA	N/A	S	2,4,6-Trichlorophenol	6.5	FDEP	N/A
F	2,4-Dichlorophenol	36.5	FDEP	N/A	S	2,4-Dichlorophenol	13	FDEP	N/A
F	2,4-Dimethylphenol	21.2	USEPA	N/A	S	2,4-Dimethylphenol	160	FDEP	N/A
F	2,4-Dinitrophenol	3	FDEP	N/A	S	2,4-Dinitrophenol	3	FDEP	N/A
F	2,4-Dinitrotoluene	9.1	FDEP	N/A	S	2,4-Dinitrotoluene	9.1	FDEP	N/A
F	2,6-Dinitrotoluene	0.7	FDEP	N/A	S	2,6-Dinitrotoluene	0.7	FDEP	N/A
F	2-Chloronaphthalene	1,600	FDEP	N/A	S	2-Chloronaphthalene	1,600	FDEP	N/A
F	2-Chlorophenol	43.8	USEPA	N/A	S	2-Chlorophenol	130	FDEP	N/A
F	2-Methyl-4,6-Dinitrophenol	2.3	USEPA	N/A	S	2-Methyl-4,6-Dinitrophenol		N/A	N/A
F	2-Methylnaphthalene	30	FDEP	N/A	S	2-Methylnaphthalene	30	FDEP	N/A
F	2-Methylphenol (o-Cresol)	250	FDEP	N/A	S	2-Methylphenol (o-Cresol)	250	FDEP	N/A
F	2-Nitroaniline		N/A	N/A	S	2-Nitroaniline		N/A	N/A
F	2-Nitrophenol	3,500	USEPA	N/A	S	2-Nitrophenol		N/A	N/A
F	3,3'-Dichlorobenzidine	0.03	FDEP	N/A	S	3,3'-Dichlorobenzidine	0.03	FDEP	N/A
F	3-Methylphenol/4-Methylphenol		N/A	N/A	S	3-Methylphenol/4-Methylphenol		N/A	N/A
F	3-Nitroaniline		N/A	N/A	S	3-Nitroaniline		N/A	N/A
F	4-Bromophenyl-phenylether		N/A	N/A	S	4-Bromophenyl-phenylether		N/A	N/A
F	4-Chloro-3-methylphenol	100	FDEP	N/A	S	4-Chloro-3-methylphenol	100	FDEP	N/A
F	4-Chloroaniline	2.5	FDEP	N/A	S	4-Chloroaniline		N/A	N/A
F	4-Chlorophenylphenyl ether		N/A	N/A	S	4-Chlorophenylphenyl ether		N/A	N/A
F	4-Methylphenol (p-Cresol)	70	FDEP	N/A	S	4-Methylphenol (p-Cresol)	70	FDEP	N/A
F	4-Nitroaniline	1,200	FDEP	N/A	S	4-Nitroaniline	1,200	FDEP	N/A
F	4-Nitrophenol	55	FDEP	N/A	S	4-Nitrophenol	55	FDEP	N/A
F	Acenaphthene	3	FDEP	N/A	S	Acenaphthene	3	FDEP	N/A
F	Acenaphthylene		N/A	N/A	S	Acenaphthylene		N/A	N/A
F	Anthracene	0.3	FDEP	N/A	S	Anthracene	0.3	FDEP	N/A
F	Benzo(a)anthracene		N/A	N/A	S	Benzo(a)anthracene		N/A	N/A
F	Benzo(a)pyrene		N/A	N/A	S	Benzo(a)pyrene		N/A	N/A
F	Benzo(b)fluoranthene		N/A	N/A	S	Benzo(b)fluoranthene		N/A	N/A
F	Benzo(g,h,i)perylene		N/A	N/A	S	Benzo(g,h,i)perylene		N/A	N/A
F	Benzo(k)fluoranthene		N/A	N/A	S	Benzo(k)fluoranthene		N/A	N/A
F	bis(2-Chloroethoxy)methane		N/A	N/A	S	bis(2-Chloroethoxy)methane		N/A	N/A
F	bis(2-Chloroethyl)ether	0.5	FDEP	N/A	S	bis(2-Chloroethyl)ether	0.5	FDEP	N/A
F	bis(2-Ethylhexyl)phthalate (BEHP)	0.3	USEPA	N/A	S	bis(2-Ethylhexyl)phthalate (BEHP)	2.2	FDEP	N/A
F	Butylbenzylphthalate	22	USEPA	N/A	S	Butylbenzylphthalate	26	FDEP	N/A
F	Carbazole	47	FDEP	N/A	S	Carbazole		N/A	N/A
F	Chrysene		N/A	N/A	S	Chrysene		N/A	N/A
F	Dibenz(a,h)anthracene		N/A	N/A	S	Dibenz(a,h)anthracene		N/A	N/A
F	Dibenzofuran	67	FDEP	N/A	S	Dibenzofuran	67	FDEP	N/A
F	Diethylphthalate	380	FDEP	N/A	S	Diethylphthalate	75.9	USEPA	N/A
F	Dimethylphthalate	330	USEPA	N/A	S	Dimethylphthalate	580	USEPA	N/A
F	Di-n-butylphthalate	9.4	USEPA	N/A	S	Di-n-butylphthalate	3.4	USEPA	N/A

**Table 8-2**  
**Site 41**  
**Surface Water Screening/Refinement Values and Reference Concentrations**

Fresh	Parameter	SV	Source	Ref. Conc.	Salt	Parameter	SV_SW	Source	Ref Conc.
<b>SVOCS</b>									
F	Di-n-octylphthalate		N/A	N/A	S	Di-n-octylphthalate		N/A	N/A
F	Fluoranthene	0.3	FDEP	N/A	S	Fluoranthene	0.3	FDEP	N/A
F	Fluorene	30	FDEP	N/A	S	Fluorene	30	FDEP	N/A
F	Hexachlorobenzene	0.0003	FDEP	N/A	S	Hexachlorobenzene	0.0003	FDEP	N/A
F	Hexachlorobutadiene	0.93	USEPA	N/A	S	Hexachlorobutadiene	0.32	USEPA	N/A
F	Hexachlorocyclopentadiene	0.07	USEPA	N/A	S	Hexachlorocyclopentadiene	0.07	USEPA	N/A
F	Hexachloroethane	3.3	FDEP	N/A	S	Hexachloroethane	3.3	FDEP	N/A
F	Indeno(1,2,3-cd)pyrene		N/A	N/A	S	Indeno(1,2,3-cd)pyrene		N/A	N/A
F	Isophorone	650	FDEP	N/A	S	Isophorone	129	USEPA	N/A
F	Naphthalene	26	FDEP	N/A	S	Naphthalene	23.5	USEPA	N/A
F	Nitrobenzene	90	FDEP	N/A	S	Nitrobenzene	66.8	USEPA	N/A
F	N-Nitroso-di-n-propylamine	0.5	FDEP	N/A	S	N-Nitroso-di-n-propylamine	0.5	FDEP	N/A
F	N-Nitrosodiphenylamine	6	FDEP	N/A	S	N-Nitrosodiphenylamine	6	FDEP	N/A
F	Pentachlorophenol	8.2	FDEP	N/A	S	Pentachlorophenol	7.9	FDEP	N/A
F	Phenanthrene		N/A	N/A	S	Phenanthrene		N/A	N/A
F	Phenol	6.5	FDEP	N/A	S	Phenol	6.5	FDEP	N/A
F	Pyrene	0.3	FDEP	N/A	S	Pyrene	0.3	FDEP	N/A
F	Total PAH	0.031	FDEP	N/A	S	Total PAH	0.031	FDEP	N/A
F	Petroleum Hydrocarbons, TPH	5,000	FDEP	N/A	S	Petroleum Hydrocarbons, TPH		N/A	N/A
<b>VOCs</b>									
F	1,1,1-Trichloroethane	270	FDEP	N/A	S	1,1,1-Trichloroethane	270	FDEP	N/A
F	1,1,2,2-Tetrachloroethane	10.8	FDEP	N/A	S	1,1,2,2-Tetrachloroethane	90.2	FDEP	N/A
F	1,1,2-Trichloroethane	16	FDEP	N/A	S	1,1,2-Trichloroethane	16	FDEP	N/A
F	1,1-Dichloroethane		N/A	N/A	S	1,1-Dichloroethane		N/A	N/A
F	1,1-Dichloroethene	3.2	N/A	N/A	S	1,1-Dichloroethene	3.2	FDEP	N/A
F	1,2-Dibromo-3-Chloropropane		N/A	N/A	S	1,2-Dibromo-3-Chloropropane		N/A	N/A
F	1,2-Dibromoethane	13	FDEP	N/A	S	1,2-Dibromoethane	13	FDEP	N/A
F	1,2-Dichlorobenzene	15.8	USEPA	N/A	S	1,2-Dichlorobenzene	19.7	USEPA	N/A
F	1,2-Dichloroethane	37	FDEP	N/A	S	1,2-Dichloroethane	37	FDEP	N/A
F	1,2-Dichloroethene (total)	7,000	FDEP	N/A	S	1,2-Dichloroethene (total)	7,000	FDEP	N/A
F	1,2-Dichloropropane	14	FDEP	N/A	S	1,2-Dichloropropane	14	FDEP	N/A
F	1,3-Dichlorobenzene	50.2	USEPA	N/A	S	1,3-Dichlorobenzene	85	USEPA	N/A
F	1,4-Dichlorobenzene	3	FDEP	N/A	S	1,4-Dichlorobenzene	3	FDEP	N/A
F	2-Butanone (MEK)	120,000	FDEP	N/A	S	2-Butanone (MEK)	120,000	FDEP	N/A
F	2-Hexanone		N/A	N/A	S	2-Hexanone		N/A	N/A
F	4-Methyl-2-Pentanone (MIBK)	23,000	FDEP	N/A	S	4-Methyl-2-Pentanone (MIBK)	23,000	FDEP	N/A
F	Acetone	1,700	FDEP	N/A	S	Acetone	1,700	FDEP	N/A
F	Benzene	53	USEPA	N/A	S	Benzene	71.28	FDEP	N/A
F	Bromochloromethane		N/A	N/A	S	Bromochloromethane		N/A	N/A
F	Bromodichloromethane	22	FDEP	N/A	S	Bromodichloromethane	22	FDEP	N/A
F	Bromoform	293	USEPA	N/A	S	Bromoform	360	FDEP	N/A
F	Bromomethane	35	FDEP	N/A	S	Bromomethane	35	FDEP	N/A
F	Carbon disulfide	110	FDEP	N/A	S	Carbon disulfide	110	FDEP	N/A
F	Carbon tetrachloride	4.42	FDEP	N/A	S	Carbon tetrachloride	4.42	FDEP	N/A
F	Chlorobenzene	17	FDEP	N/A	S	Chlorobenzene	17	FDEP	N/A
F	Chloroethane		N/A	N/A	S	Chloroethane		N/A	N/A
F	Chloroform	289	USEPA	N/A	S	Chloroform	470.8	FDEP	N/A
F	Chloromethane	470.8	FDEP	N/A	S	Chloromethane	470.8	FDEP	N/A
F	cis-1,2-Dichloroethene		N/A	N/A	S	cis-1,2-Dichloroethene	7.9	USEPA	N/A
F	cis-1,3-Dichloropropene		N/A	N/A	S	cis-1,3-Dichloropropene		N/A	N/A
F	Dibromochloromethane	34	FDEP	N/A	S	Dibromochloromethane	34	FDEP	N/A
F	Ethylbenzene	453	USEPA	N/A	S	Ethylbenzene	4.3	USEPA	N/A
F	Methylene chloride	1,580	FDEP	N/A	S	Methylene chloride	1,580	FDEP	N/A
F	Styrene	460	FDEP	N/A	S	Styrene	460	FDEP	N/A
F	Tetrachloroethene	84	FDEP	N/A	S	Tetrachloroethene	45	USEPA	N/A
F	Toluene	175	USEPA	N/A	S	Toluene	37	USEPA	N/A
F	trans-1,2-Dichloroethene		FDEP	N/A	S	trans-1,2-Dichloroethene	11,000	FDEP	N/A
F	trans-1,3-Dichloropropene		N/A	N/A	S	trans-1,3-Dichloropropene		USEPA	N/A
F	Trichloroethene	80.7	FDEP	N/A	S	Trichloroethene	80.7	FDEP	N/A
F	Vinyl chloride	2.4	FDEP	N/A	S	Vinyl chloride	2.4	FDEP	N/A
F	Xylene (Total)	370	FDEP	N/A	S	Xylene (Total)	370	FDEP	N/A

**Notes:**  
All values are in micrograms per liter or parts per billion  
N/A = Not Applicable

**Table 8-3**  
**Wetland Functional Use Assessment Phase III**  
**NAS Pensacola Site 41**  
**Wetland (Group)**

<b>Condition</b>	<b>64(A)</b>	<b>5(B)</b>	<b>3(B)</b>	<b>16(C)</b>	<b>18(C)</b>
Fishery Habitat	Consistent	Consistent	Consistent	Consistent	Consistent
Wading Bird Habitat	Consistent	Variable	Variable	Consistent	Variable
Diving Bird Habitat	Consistent			Consistent	
Benthic Macro. Habitat	Consistent	Consistent	Consistent	Consistent	Consistent
Mammal Usage	Consistent	Consistent	Consistent	Consistent	Consistent

**Table 8-4**  
**Phase III Wetlands and Assessment and Measurement Endpoints**  
**NAS Pensacola Site 41**

Wetland Groups and Representative Wetland(s)	Assessment Endpoints	Measurement Endpoints
<b>Group A</b> <b>(Wetland 64)</b>	A) Piscivorous bird and mammal health and reproduction	A) Whole-body contaminant levels in a foraging fish species used in a food chain model and residue effects analysis
	B) Survival and growth of macroinvertebrates associated with the benthic environment (general benthic community)	B1) 10-day marine amphipod <i>Leptocheirus plumulosus</i> acute toxicity sediment test B2) 20-day marine polychaete <i>Neanthes arenacoedentata</i> chronic toxicity test B3) Benthic community indices
	C) Protection of fish viability (foraging and predatory fish species)	C1) Correlation of fish body burden values with effects values in literature C2) Comparison of surface water data with state and federal water quality standards C3) Fish trophic transfer model and residue effects analysis
<b>Group B</b> <b>(Wetlands 5A and 3)</b>	A) Survival, growth and emergence of macroinvertebrates associated with the benthic environment (general benthic community)	A1) 28-day midge larvae <i>Chironomus tentans</i> survival, growth and emergence A2) Benthic community indices
	B) Protection of fish viability using fathead minnow ( <i>Pimephales promelas</i> )	B) 7-day fathead minnow <i>Pimephales promelas</i> survival and growth
<b>Group C</b> <b>(Wetlands 16 and 18)</b>	A) Survival and growth of macroinvertebrates associated with the benthic environment (general benthic community)	A1) 10-day marine amphipod <i>Leptocheirus plumulosus</i> acute toxicity sediment test A2) 20-day marine polychaete <i>Neanthes arenacoedentata</i> chronic toxicity test 3) Benthic community indices
	B) Health of piscivorous birds (great blue heron in Wetland 18 only)	B) Whole body contaminant levels in foraging fish species (Wetland 18 only) used in a food chain model and residue effects analysis
	C) Protection of fish viability (foraging and predatory fish species in Wetland 18 only)	C1) Correlation of fish body burden values with effects values in literature C2) Fish trophic transfer model and residue effects analysis

**Table 8-5  
Input Parameters  
Food Chain Models**

Exposure Scenario	Body Weight (kg)	Dietary Composition	Area Use Factor/ Alternate AUF	PCB Concentration in Media (biotic/abiotic)	Food Ingestion Rate (kg/day dry weight)	Surface Water Ingestion Rate (L/day)	Sediment/Soil Ingestion Rate (kg/day dry weight)
<b>ASSESSMENT ENDPOINT 1 - Piscivorous Bird</b>							
<b>Representative Species - Green Heron (<i>Butorides virescens</i>)</b>							
Maximum	0.241 <sup>a</sup>	100 percent fish	1/1	Max./Max.	0.0115 <sup>b</sup>	0.0227 <sup>c</sup>	0.00023 <sup>d</sup>
RME	0.241 <sup>a</sup>	100 percent fish	1/1	95%UCL/95% UCL	0.0115 <sup>b</sup>	0.0227 <sup>c</sup>	0.00023 <sup>d</sup>
Average	0.241 <sup>a</sup>	100 percent fish	1/1	Mean/Mean	0.0115 <sup>b</sup>	0.0227 <sup>c</sup>	0.00023 <sup>d</sup>
<b>ASSESSMENT ENDPOINT 2 - Piscivorous Mammal</b>							
<b>Representative Species - Mink (<i>Mustela vison</i>)</b>							
Maximum	0.55 <sup>l</sup>	100 percent fish	1/0.9	Max./Max.	0.0290 <sup>m</sup>	0.0578 <sup>c</sup>	0.003 <sup>d</sup>
RME	0.55 <sup>l</sup>	100 percent fish	1/0.9	95%UCL/95%UCL	0.0290 <sup>m</sup>	0.0578 <sup>c</sup>	0.003 <sup>d</sup>
Average	0.55 <sup>l</sup>	100 percent fish	1/0.9	Mean/Mean	0.0290 <sup>m</sup>	0.0578 <sup>c</sup>	0.003 <sup>d</sup>

**Notes:**

<sup>a</sup> Niethammer and Kaiser (1983).

<sup>b</sup> Kushlan (1978).

<sup>c</sup> Calder and Braun (1983).

<sup>d</sup> Estimated based on the results of Beyer et al. (1994).

<sup>e</sup> Derived from McLane and Hughes (1980).

<sup>f</sup> Derived from Peakall and Peakall (1973).

<sup>g</sup> Henny and Van Camp (1979).

<sup>h</sup> Nagy et al. (1999).

<sup>i</sup> Owen and Krohn (1973).

<sup>j</sup> Sheldon (1967).

<sup>k</sup> Beyer et al. (1994).

<sup>l</sup> Mitchell (1961).

<sup>m</sup> Bleavins and Aulerich (1981).

<sup>n</sup> Derived from Aulerich and Ringer (1977).

<sup>o</sup> Fagerstone (1987).

<sup>p</sup> Guilday (1957).

<sup>q</sup> Based on Morrison (1957)

<sup>r</sup> Chew (1951).

**Table 8-6**  
**Literature Based BSAFs**

Parameter	Species	BSAF Reported	Reference
Chlordane	Salmonids	2.22	A
		2	C
	Carp	4.77	C
		0.498	B
		0.762	B
		1.439	B
		1.3878	B
		1.4825	B
		2.9939	B
	White Sucker	0.301	B
		1.307	B
		2.379	B
		0.9073	B
		4.0389	B
	Slimy sculpin	6.1861	B
2.47		A	
4.821		A	
Average Chlordane BSAF		2.350794118	
DDT	Eel	6.78	D
		16.88	D
		8.44	D
	Salmonids	7.39	D
		1.09	A
		1.67	C
	Mountain Whitefish	1.706	E
		0.12	E
	mixed suckers	0.135	E
		2.385	E
	slimy sculpin	0.544	A
	Average DDT BSAF		4.285454545
Total PCBs	Salmonids	1.85	A
		4.3	F, G
	Lake Trout	10.7	F, G
		3.8	F, G
	Golden shiner	1.8	F, G
		7.3	F, G
		3	F, G
		0.9	F, G
		2.9	F, G
		0.13	F, G
		0.13	F, G
	Bluntnose minnow	3.1	F, G
		2.8	F, G
		4.3	F, G
		1.6	F, G
13.2		F, G	
13.8	F, G		
Average Total PCBs BSAF		4.7175	
Dieldrin		4.83	C

**References:**

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## **9.0 HUMAN HEALTH RISK ASSESSMENT METHODS**

This section presents the methods used in the human health risk assessment (HHRA).

Wetland-specific risk evaluations are presented in Sections 10 through 15.

### **9.1 Introduction**

A baseline risk assessment (BRA) estimates current and future risk assuming no remedial actions are undertaken to facilitate risk management and remedial decisions. "Risk" is the estimated potential for toxic effects on actual or hypothetical human or ecological receptors, while "baseline risk" refers to risk arising from exposure to chemicals, assuming overall site conditions remain unchanged. Baseline risk can vary with time according to changing fate and transport conditions or changing source amounts and properties. Risk may be reduced to acceptable levels by remediation or removal; engineered barriers and/or institutional controls to prevent or limit exposure; or natural attenuation over time.

Generally, a BRA contains two parts; one assessing human health risk and a second one addressing ecological risk. Because ecological risk is expected to be the risk driver at Site 41, the HHRA is limited in scope. The HHRA for Site 41 examines human health risk posed by exposure to contaminants in sediment, fish tissue, and surface water based on current and future land-use scenarios. Screening calculations are performed on fish tissue data to address these scenarios and assist risk managers in identifying potential data gaps.

Acceptable risk and hazard levels and remedial actions are determined by FDEP, USEPA, and the Navy, who are the managers that use risk assessments in their decision-making process. USEPA's acceptable incremental cancer risk range is  $1E-6$  to  $1E-4$ , which reflects one in 1 million to one in 10,000 chances of contracting cancer. FDEP's threshold is  $1E-6$ . Both agencies' hazard index (HI) threshold is 1. A HI greater than 1 could indicate the potential for toxic effects other than cancer. The Site 41 HHRA presents risk and hazard estimates for land-use scenarios and exposure pathways relative to the wetlands at NAS Pensacola. Risk managers will decide which thresholds are acceptable for those scenarios and if remedial or other actions will be necessary to reduce or further characterize risk.

#### **9.1.1 Site Background**

Various releases from industrial activities at NAS Pensacola may have impacted wetlands, such as spills from tanks or broken or leaking pipelines, releases from waste dumping, landfill operations,

pesticide use, and other activities. Many of the IR sites are adjacent to or nearby the Site 41 wetlands.

Site 41 wetlands were sampled in four events to correlate chemical concentrations with toxicity, diversity, and bioaccumulation samples. Sediment and surface water sampling were conducted during most phases, and whole preyfish body tissue samples were collected and analyzed to support the ERA. This HHRA summarizes the conceptual site model, methods, and uncertainties. In following sections of this report, human health risk is screened and characterized for each wetland.

### **9.1.2 Objectives of the HHRA**

The objectives of this section are to:

- Characterize the source media and data sources.
- Identify potential receptors and quantify their likely exposure under current and future conditions to all affected environmental media.
- Determine the COPCs for affected environmental media.
- Qualitatively and quantitatively evaluate adverse effects associated with the site-specific COPCs in each medium.
- Characterize the baseline carcinogenic and noncarcinogenic risks associated with exposure to environmental media at the sites under current and future land-use conditions.
- Evaluate the uncertainties related to exposure predictions, toxicological data, and resulting carcinogenic risk and noncarcinogenic hazard estimations.
- Establish chemicals of concern (COCs) in each environmental medium, based on risk/hazard, to facilitate risk management decision-making.

## **9.2 Site Characterization**

When performing a risk assessment, environmental data are compiled to determine potential site-related chemicals and exposures as outlined in Risk Assessment Guidance for Superfund

(RAGS), Volume I- Human Health Evaluation Manual, Part A (USEPA, 1989a). The data sources used in this risk assessment are summarized in the following sections.

### **9.2.1 Data Sources**

Surface water, sediment, and tissue data were collected from selected Site 41 wetlands and were used in this assessment. Data collection methods are described in Section 4 of this RI report.

### **9.2.2 Data Validation**

Data validation is an independent, systematic process of evaluating data and comparing them with established criteria to confirm they are of the technical quality necessary to support the decisions made in the RI process. Parameters specific to the data are reviewed to determine whether they meet the stipulated data quality objectives (DQOs). These quality objectives address five principal parameters: precision, accuracy, completeness, comparability, and representativeness. To verify that these objectives are met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and nonconformances and discrepancies in the data are examined to determine compliance with appropriate and applicable procedures.

Data validation methods and results are described in Section 5 of this RI report. Data are summarized in Sections 10 through 15 for individual wetlands.

### **9.2.3 Management of Site-Related Data**

All environmental sampling data are evaluated for suitability for use in the quantitative BRA. Data obtained by the following methods are considered inappropriate:

- Analytical methods not specific to a particular chemical, such as total organic carbon, total organic halogen, or total petroleum hydrocarbons.
- Field screening instruments, including total organic vapor monitoring units and organic vapor analyzers.

#### **9.2.3.1 Not Detects and Assumed Concentrations**

Chemicals are often reported in few samples relative to the number collected. These “not detected” chemicals indicate they are not present at or above the sample quantitation limit, although the chemicals could be present at concentrations between zero and the sample quantitation limit. In accordance with RAGS Part A (USEPA, 1989a), one-half the sample quantitation limit is assumed to be the concentration of “not detected” chemicals when

estimating exposure in a given area or when calculating benzo(a)pyrene equivalent (BEQ) concentrations. This assumption is applicable only to chemicals detected in at least one sample in a wetland. If a chemical is not detected in any samples within a wetland, exposure is not estimated for that chemical.

Some data are qualified by the reporting laboratory or during data validation. Data qualified as estimated concentrations, or "J" values, are assumed to be detected at the reported concentrations. Additional data validation results are described in Section 5 of this RI report.

### **9.2.3.2 Benzo(a)pyrene Equivalent Concentrations**

USEPA recommends using BEQ concentrations to assess carcinogenic PAHs (cPAHs) (USEPA, 1993b). Calculating equivalent concentrations is a common method of assessing chemicals with similar toxicology. Benzo(a)pyrene is assumed to be the standard, and the relative toxicities of other similar chemicals are determined through research.

The relative toxicity is reflected in the toxicity equivalence factors (TEFs) (USEPA, 1993b), listed in Table 9-1 (tables are located at the end of each section). The equivalent concentration is calculated by multiplying the TEF by the reported concentration of a given chemical. For example, if benzo(b)fluoranthene is reported at 5 mg/kg and the TEF for this chemical is 0.1, the equivalent concentration would be 0.5 mg/kg. Similar methods are used to determine slope factors for cPAHs.

## **9.3 Exposure Assessment and Conceptual Model**

This section of the HHRA will determine the magnitude of contact that a potential receptor may have with site-related chemicals. Exposure assessment documents the following for Site 41 wetlands:

- Physical setting and land use of the site
- Potential receptors under various land use or site condition scenarios, and the pathways through which they might be exposed
- Appropriate screening values and resulting COPCs
- Intake rates, or contact rates, of COPCs

### **9.3.1 Exposure Setting**

Site setting and land use are detailed in Section 2 of this RI report, and wetland-specific discussions are included in Sections 10 through 15. Exposure pathways and land-use scenarios are summarized in Table 9-2. Some wetlands could be impacted by NAS Pensacola IR sites, with effects potentially migrating from one wetland to another. Homeland security and other access issues isolated most Site 41 wetlands from human contact, as summarized in Table 9-3. Site-specific conceptual models are summarized in Sections 10 through 15.

### **9.3.2 Exposed Populations**

Site 41 wetlands are generally unused. Therefore, trespassers and site maintenance workers would be the most likely current and future receptors. Trespassers can be characterized as individuals who infrequently visit any given wetland to fish or collect frogs or crabs. The site maintenance workers can be characterized as individuals who infrequently landscape in and around the wetlands, or those who maintain NAS Pensacola storm water drainage ditches (many of NAS Pensacola's wetlands encompass portions of the base's storm water drainage system). Exposure assumptions for the trespasser are selected based on a reasonable maximum exposure scenario as recommended by USEPA. The maintenance worker scenario is similar to the default commercial/industrial worker scenario provided in RAGS Part B (USEPA, 1991b), except that the exposure frequency is expected to be much less for the maintenance worker.

Recreational fishing occurs near some wetlands, so human exposure could occur when fishing is not restricted or when restrictions are not enforced. Commercial fishing does not occur in Pensacola Bay or any Florida coastal water because of the net ban, so fishing is generally limited to a recreational activity pattern. Potential human receptors for the ingestion of contaminated fish species include hypothetical recreational fishermen. A hypothetical subsistence fishermen scenario is included for Wetland 64 due to site access and a lack of certain restrictions, as explained in Sections 10 through 15.

### **Security Restrictions**

Fishing near NAS Pensacola is limited by homeland security restrictions. NAS Pensacola Instruction 5500.1F contains the *Pensacola Complex Physical Security Plan* (NAS Pensacola, 2003), which details the security measures used to protect aviation and floating assets. Forrest Sherman Field, waterfront piers, and other areas are restricted to public access. The base is now protected by a waterborne security zone extending 500 feet from the shoreline, which is marked by permanently stationed buoys in Bayou Grande and Pensacola Bay. The buoys are clearly marked to warn unauthorized craft to stay clear of the waterborne security zone. Enforcement of the

Security Plan rests with the U.S. Coast Guard for security zone areas offshore and NAS Pensacola police for onshore areas (NAS Pensacola, 2003).

Consideration is given to homeland security issues and other restrictions that affect access to Site 41 wetlands. In restricted areas, only the site maintenance worker scenario is considered. In unrestricted areas where trespassing could occur, both the maintenance worker and child trespasser scenarios are evaluated. Table 9-3 shows a detailed summary conceptual site model for the Site 41 wetlands and the considerations given for pathway development. Table 9-4 details the models and receptors to be evaluated for each wetland.

### **9.3.3 Exposure Pathways and Media**

Exposure pathways and media considered for the Site 41 HHRA are explained in Table 9-2. For the Site 41 wetlands, the relevant pathways considered for the risk assessment include: (1) sediment ingestion and dermal exposure; (2) surface water ingestion and dermal exposure; and (3) game fish ingestion. From these exposure pathways, a summary conceptual site model is developed based on three scenarios.

- Some Site 41 wetlands experience seasonal periods of wetness and dryness. Depending on the seasonal conditions at these wetlands, a human receptor could be exposed to sediment and/or surface water. Sediment and surface water dermal exposure and ingestion pathways are evaluated at these wetlands. Water depth, habitat, or security restrictions preclude fishing in this scenario.
- Some Site 41 wetlands are inundated with surface water year round. Therefore, direct contact with sediment is excluded from the pathways assessed for these wetlands. Water depth and habitat are suitable for game fish, and security restrictions do not preclude fishing. At these wetlands, the sediment pathway is insignificant because sediments remain submerged year round. Surface water dermal exposures, surface water ingestion, and game fish ingestion pathways are evaluated at these wetlands.
- Some Site 41 wetlands include the same exposure pathways listed above with the exception of fish tissue exposure, because water depth and habitat are either not suitable for game fish, or security restrictions preclude this scenario. Only surface water dermal exposure and ingestion pathways were evaluated at these wetlands.

### 9.3.4 Identification of Chemicals of Potential Concern

COPCs in this assessment were quantified based on comparisons with reference concentrations. In accordance with RAGS Part A (USEPA 1989a), site screening for this HHRA focused on chemicals most likely to pose significant excess risk because of: (1) likely exposure pathways; (2) reference concentrations; and (3) reported concentrations. Fate and transport issues pertinent to the Site 41 wetlands are characterized in Section 7.

#### 9.3.4.1 Fish Tissue

As summarized in Table 9-5, biota sediment accumulation factors (BSAFs) were calculated to model fish tissue concentrations using sediment and fish tissue data. The data set for this exposure pathway is limited to whole fish data collected from preyfish. To account for the uncertainty associated with using bait fish tissue to evaluate the fish ingestion exposure route, a TTC (Suedel, et.al., 1994) is applied to the bait fish tissue in order to model the expected concentration in game fish (*Table IIID-3, Food-Chain Multipliers For Trophic Levels 2, 3, and 4*, of Vol. 63, No. 157 of the August 14, 1998 *Federal Register Notice* (USEPA, 1998b)).

#### 9.3.4.2 Sediment and Surface Water

As described in Section 4, a phased sampling approach was used to assess many of the Site 41 wetlands. A quantitative assessment is performed for sediment and surface water data independent of the fish consumption analysis, since consumption of fish tissue would not be expected to correlate with exposure to sediment and surface water (fishing would likely involve the use of a boat). The exposure assessments follow the models presented in Section 9.3.3 above. Table 9-6 outlines the exposure parameters used to develop the risk calculations for Site 41.

Each wetland corresponds with one of three conceptual site models, as outlined in Tables 9-3 and 9-4. Risk tables are developed for each wetland based on exposure pathways, as summarized below. Sections 10 through 15 contain the human health risk tables for each wetland.

Sediment Exposure	Surface Water Exposure	Fish Ingestion Exposure
Dermal absorbed dose/maintenance worker and/or child trespasser	Dermal absorbed dose/maintenance worker and/or child trespasser	Fish tissue ingestion/recreational and subsistence fishermen
Sediment dermal risk/maintenance worker and/or child trespasser	Surface water dermal risk/ maintenance worker and/or child trespasser	—
Sediment ingestion risk/maintenance worker and/or child trespasser	Surface water ingestion/ maintenance worker and/or child trespasser	—

Where access restrictions are enforced, the trespasser scenario is not evaluated (see Tables 9-3 and 9-4). The risk tables contain the equations used to calculate wetland risks and an explanation of the variables used in these equations. The exposure parameters used in the risk equations are listed in Table 9-6.

### **Essential Nutrients**

In accordance with RAGS Part A (USEPA, 1989a), essential elements that are potentially toxic only at extremely high concentrations may be eliminated as COPCs in a risk assessment. Specifically, an essential nutrient may be screened out if it is present at concentrations not associated with adverse health effects. The following essential nutrients are excluded, because their potential for toxicity is low relative to the COPCs identified, and no sources were identified:

- Calcium
- Magnesium
- Potassium
- Sodium

### **9.3.5 Quantification of Exposure**

Equations for sediment and surface water dermal and ingestion risk, and fish ingestion risk can be found on each risk table in Sections 10 through 15, and exposure parameters used in the risk equations are summarized in Table 9-6. Most exposure parameters can be referenced to guidance documents, as noted in Table 9-6. However, parameters related to fish tissue ingestion are discussed in more detail below.

### **Ingestion of Edible Fish Tissue**

The ingestion rates for the various receptor populations are based on information provided by the *Exposure Factors Handbook* (USEPA, 1997b). The model involves several steps. The first step is determining the chemical concentration in fish tissue. Some tissue data were available, but data were limited to prey fish species. Bioaccumulation is often higher in higher trophic level predators, so a TTC is used to estimate tissue concentrations in game fish species based on concentrations reported in prey fish species.

The TTC is defined as the increase in tissue concentration of a particular contaminant as it moves through the food chain from Level 3 (e.g., bait fish) to Level 4 (e.g., game fish), and is used to predict the contaminant tissue concentration in Level 4 fish species. For this evaluation, TTCs are obtained from *Table IIID-3, Food-Chain Multipliers for Trophic Levels 2, 3, and 4*, of Vol. 63,

No. 157 of the August 14, 1998, *Federal Register Notice* (USEPA, 1998b). The TTC is multiplied by the concentration found in prey fish to estimate the concentration in game fish. Tables in Sections 10 through 15 document the TTC used for each chemical.

Tissue data were available for prey species at some wetlands, and bioaccumulation from prey species to higher trophic levels is possible. It is assumed that BSAFs would be similar for Site 41 wetlands. BSAFs are calculated when no tissue concentrations are available.

Fish tissue risk could not be estimated for chemicals that met one of two conditions:

- 1) A chemical was detected in sediment but not in tissue
- 2) A chemical was detected in tissue but not in sediment

Site-specific foraging factors (SFFs) are typically incorporated into fish tissue uptake models. The SFF represents the percent diet of the predator (trophic Level 4) fish species from a particular wetland and is apportioned based on the estimated foraging area of the predatory fish species. Given sufficient data, the SFF is calculated by dividing the total surface area (exposure area) of a wetland by the total surface area of Bayou Grande (960 acres). Site 41 data were collected during four separate sampling phases, spanning many years, and few samples were collected from each wetland. Therefore, no SFF adjustment is used in the human health calculations.

#### **9.3.5.1 Chronic Daily Intake for a Recreational Fisherman**

For recreational fishermen in the Gulf of Mexico, the 95th percentile and mean fish ingestion rates are 26 g/day and 7.2 g/day, respectively (USEPA, 1997b).

The USEPA *Exposure Factors Handbook* (USEPA, 1997b) also states that only 33% of the total fish consumed by recreational fishermen is actually caught locally and the remaining 66% is purchased commercially. To address the potential uncertainty and variability in modeled fish tissue concentrations, the unmodified ingestion rate for recreational fishers of 26 g/day is used.

USEPA (1997b) reports that between 25% to 50% of whole fish is edible. However, fish tissue ingestion rates are not modified based on edible fractions.

### 9.3.5.2 Chronic Daily Intake for a Subsistence Fisherman

The *Exposure Factors Handbook* (USEPA, 1997b) details how the recommended default fish ingestion rate for subsistence fishermen is 170 g/day for the 95th percentile. This rate is for Native American subsistence fishers living along the Columbia River. It should be emphasized that the rates above refer only to Native American subsistence fishing populations, not the Native American population in general. Several studies show intake rates of recreationally caught fish among Native Americans with state fishing licenses are 50% to 100% higher than intake rates among other anglers, but far lower than the above rates for Native American subsistence populations. As with recreational fishers, uncertainty and variability exist in trophic transfer models, fish tissue models, and data sets for most wetlands that are relatively small. Consequently, fish ingestion rates are not modified based on edible fractions. It is assumed that all fish consumed by subsistence fishers would be caught locally.

### 9.3.5.3 Summary Equations

Equations used to estimate sediment, surface water, and fish tissue intake are summarized below. These equations are also provided on corresponding tables.

#### Sediment

##### Dermal Absorbed Dose of Sediment:

$$DAD_{sd} = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

##### Where:

- DAD<sub>sd</sub> = Dermal Absorbed Dose-soil contact (mg/kg-day)
- DA<sub>event</sub> = Dermal absorbed dose per event (mg/cm<sup>2</sup>-event)
- SA = Skin surface area available for contact (cm<sup>2</sup>)
- EV = Event frequency (events/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- BW = Body weight (kg) 70 kg (adult) 45 kg (child)
- AT = Averaging time (days) noncarcinogenic effects AT = ED x 365 dy/yr  
 carcinogenic effects AT = 70 yr x 365 dy/yr

##### Equation for DA<sub>event</sub> for Sediment Contact:

$$DA_{event} = C_{sd} \times CF \times AF \times ABS_d$$

**Where:**

- Csd = Chemical concentration in sediment (mg/kg)
- CF = Conversion factor (10<sup>-6</sup> kg/mg)
- AF = Adherence factor of sediment to soil (mg/cm<sup>2</sup>-event); 0.2 (children playing in wet soil), 0.1 (construction worker)
- ABsd = Dermal absorption fraction from following sources, in order of choice:  
 (1) RAGS Part E, Exhibit 4-1 (USEPA, 2004a); (2) 2002 USEPA Region 9 RBC; Table;  
 (3) RAIS; (4) USEPA Region 4 OTS supplemental values

**Exposure Parameters:**

- EV = 1 event per day (child trespasser/adult maintenance worker)
- ED = 10 yrs (child trespasser); 25 yrs (adult maintenance worker)
- EF = 52 dys/yr (child trespasser/adult maintenance worker)
- SA = 5,000 cm<sup>2</sup> (child trespasser); 10,400 cm<sup>2</sup> (adult maintenance worker)  
 Source: Tables 6-6 and 6-8 *Exposure Factors Handbook (USEPA, 1997b)*
- BW = 45 kg (child trespasser); 70 kg (adult maintenance worker)
- AT = Noncancer — 3,650 days (child trespasser); 9,125 days (adult maintenance worker)  
 Cancer — 25,550 days (child trespasser/adult maintenance worker)

**Equations for Sediment Ingestion Intake:**

$$CDI = \frac{EPC_{sd} \times IR_{sd} \times EF \times ED \times CF}{BW \times AT}$$

**Where:**

- CDI = Chronic daily intake (mg/kg-day)
- EPCsd = Exposure point concentration in sediment (mg/kg)
- IRsd = Incidental ingestion rate for sediment (mg/day).
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- CF = Conversion factor (1E-6 kg/mg)
- BW = Body weight (kg) 70 kg (adult) 45 kg (child)
- AT = Averaging time (days) noncarcinogenic effects AT = ED x 365 dy/yr;  
 carcinogenic effects AT = 70 yr x 365 dy/yr

**Exposure Parameters:**

- IRsd = 100 mg/day for age groups greater than 6 years old
- EF = 52 days/yr (child trespasser/adult maintenance worker)
- ED = 10 yrs (child trespasser); 25 yrs (adult maintenance worker)
- BW = 45 kg (child trespasser); 70 kg (adult maintenance worker)
- AT = Noncancer — 3,650 days (child trespasser); 9,125 days (adult maintenance worker)  
 Cancer — 25,550 days (child trespasser/adult maintenance worker)

## Surface Water

### Dermal Absorbed Dose of Surface Water:

$$DAD_{sw} = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

#### Where:

- DAD<sub>sw</sub> = Dermal absorbed dose-water contact (mg/kg-day)  
 DA<sub>event</sub> = Dermal absorbed dose per event (mg/cm<sup>2</sup>-event)  
 SA = Skin surface area available for contact (cm<sup>2</sup>)  
 EV = Event frequency (events/day)  
 EF = Exposure frequency (days/year)  
 ED = Exposure duration (years)  
 BW = Body weight (kg) 70 kg (adult) 45 kg (child)  
 AT = Averaging time (days) noncarcinogenic effects AT = ED x 365 dy/yr  
 carcinogenic effects AT = 70 yr x 365 dy/yr

### Equation for DA<sub>event</sub> for Inorganic Constituents:

$$DA_{event} = K_p \times C_w \times t_{event}$$

#### Where:

- K<sub>p</sub> = Dermal permeability coefficient of compound in water (cm/hr);  
 Source: RAGS Part E, Exhibit B-3 or Exhibit B-4 (USEPA, 2004a)  
 C<sub>w</sub> = Chemical concentration in water (mg/cm<sup>3</sup>)  
 T<sub>event</sub> = Event duration (hr/event)

### Equation for DA<sub>event</sub> for Organics:

$$DA_{event} = FA \times K_p \times C_w \left[ \frac{t_{event}}{1 + B} + 2\tau_{event} \left( \frac{1 + 3B + 3B^2}{(1 + B)^2} \right) \right]$$

#### Where:

- FA = Fraction absorbed water (dimensionless). From RAGS Part E, Exhibit B-4 (USEPA, 2004a)  
 K<sub>p</sub> = Dermal permeability coefficient of compound in water (cm/hr);  
 Source: (1) RAGS Part E, Exhibit B-4 (USEPA, 2004a)  
 C<sub>w</sub> = Chemical concentration in water (mg/cm<sup>3</sup>)  
 T<sub>event</sub> = Event duration (hr/event)  
 Tau event = Lag time per event (hr/event). From RAGS Part E, Exhibit B-4 (USEPA, 2004a)

B = Dimensionless ratio of the permeability coefficient of a compound, calculated using the equation:

$$B = \frac{K_p \sqrt{MW}}{2.6}$$

**Where:**

Kp = Dermal permeability coefficient of compound in water (cm/hr)  
 Source: (1) RAGS Part E (USEPA, 2004a)

MW = Molecular weight

**Exposure Parameters:**

EV = 1 event per day (child trespasser/adult maintenance worker)  
 ED = 10 yrs (child trespasser); 25 yrs (adult maintenance worker)  
 EF = 52 days/yr (child trespasser/adult maintenance worker).  
 SA = 5,000 cm<sup>2</sup> (child trespasser); 10,400 cm<sup>2</sup> (adult maintenance worker);  
 Source: Tables 6-6 and 6-8 *Exposure Factors Handbook* (USEPA, 1997b)  
 BW = 45 kg (child trespasser); 70 kg (adult maintenance worker)  
 AT = Noncancer — 3,650 days (child trespasser); 9,125 days (adult maintenance worker)  
 Cancer — 25,550 days (child trespasser/adult maintenance worker)  
 Tevent = 2.6 hrs/day (child trespasser/adult maintenance worker)

**Fish**

**Equation for Fish Ingestion Intake Based on Sediment Concentrations:**

$$CDI = \frac{EPC_t \times IR_t \times EF \times ED \times CF}{BW \times AT}$$

**Where:**

CDI = Chronic daily intake (mg/kg-day)  
 EPC<sub>t</sub> = Exposure point concentration in sediment (mg/kg)  
 IR<sub>t</sub> = Incidental ingestion rate for sediment (mg/day).  
 EF = Exposure frequency (days/year)  
 ED = Exposure duration (years)  
 CF = conversion factor (0.001 kg/g)  
 BW = Body weight (kg) 70 kg (adult) 45 kg (child)  
 AT = Averaging time (days) noncarcinogenic effects AT = ED x 365 dy/yr;  
 carcinogenic effects AT = 70 yr x 365 dy/yr

**Exposure Parameters:**

IRt	=	Fish tissue ingestion rate for sediment (recreational: 26 g/day; subsistence: 170 g/day)
EF	=	52 days/yr (child trespasser/adult maintenance worker)
ED	=	10 yrs (child trespasser); 25 yrs (adult maintenance worker)
BW	=	45 kg (child trespasser); 70 kg (adult maintenance worker)
AT	=	Noncancer — 3,650 days (child trespasser) 9,125 days (adult maintenance worker) Cancer — 25,550 days (child trespasser/adult maintenance worker)

**9.3.6 Toxicity Assessment**

Risk information, usually obtained from the USEPA Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST) (USEPA, 1995b), is necessary to calculate risk and hazard estimates. This information is based on toxicological and epidemiological data critiqued and approved by the scientific and regulatory community.

There is a generally recognized uncertainty in human toxicological risk values developed from experimental data, primarily due to: (1) the uncertainty of approximating data from high to low-dose exposure, and (2) using animal data to approximate human experience. The site-specific uncertainty is mainly in the degree of accuracy of the exposure assumptions. Most assumptions used in this and any risk assessment have not been verified. For example, the degree of chemical absorption from the gut or through the skin or the amount of soil contact is not known with certainty.

USEPA has established slope factors (SFs) for carcinogenic compounds. The SF is defined as a “plausible upper-bound estimate of the probability of a response (cancer) per unit intake of a chemical over a lifetime” (RAGS, Part A [USEPA, 1989a]). Upper-bound estimates are likely to overestimate cancer potential.

In addition to potential carcinogenic effects, most substances may also produce other toxic responses at doses greater than experimentally derived threshold concentrations. USEPA has derived reference dose (RfD) values for these substances. A chronic RfD is defined as “an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure concentration for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.” These toxicological values are used in risk formulae to assess the upper-bound level of noncancer hazard associated with exposure to a given chemical concentration.

For carcinogens, the potential risk posed by a chemical is computed by multiplying the CDI (as mg/kg-day) by the SF (in kilograms per day per milligram [mg/kg-day]<sup>-1</sup>). The HQ (for noncarcinogens) is computed by dividing the CDI by the RfD (in mg/kg-day). USEPA has set points of departure to evaluate whether significant risk is posed by a chemical (or combination of chemicals). USEPA's acceptable risk range for carcinogens falls between one-in-10,000 (1E-4) and one-in-1 million (1E-6) excess cancer incidences resulting from exposure to toxic compounds from outside the body. The FDEP threshold for cancer risk is 1E-6. For noncarcinogens, other toxic effects are generally considered possible if the HQ (or sum of HQs for a pathway-hazard index) exceeds the threshold value of 1. Although both cancer and noncancer risks are generally additive only if the target organ is common to multiple chemicals, a most conservative estimate of each may be obtained by summing the individual risks or hazards, regardless of target organ. The Site 41 assessment uses the universal summation approach for each class of toxicant. Details regarding the risk formulae applied to site data are provided in Section 9.3.5, Quantification of Exposure.

Critical studies used by USEPA in establishing toxicity criteria are shown in the IRIS database, which is the primary source for information necessary to estimate risk (HEAST, 1995b, Fiscal Year 1995, is the secondary source). In addition, USEPA's National Center for Environmental Assessment (NCEA) will be used as a source when necessary. It is important to note that toxic effects reported in IRIS and HEAST are generally based on studies using single compounds, rather than mixtures. Therefore, synergistic or antagonistic mechanisms are possible when compound mixtures are involved. USEPA recommends the additive approach used in this assessment.

The following two equations are used to estimate excess cancer risks and hazard quotients:

$$Risk = CDI \times SF_{oral} \qquad Hazard\ Quotient = \frac{CDI}{RfD_{oral}}$$

**Where:**

- CDI = Chronic daily intake (mg/kg-day)
- RfD<sub>oral</sub> = Oral reference dose from: (1) IRIS; or (2) RAIS
- SF<sub>oral</sub> = Oral Slope Factor from: (1) IRIS; or (2) RAIS

### 9.3.6.1 Evaluating Dermal Exposure and Resulting Toxicity

In accordance with RAGS Part E (USEPA, 2004a), dermal RfD values and SFs are derived using gastrointestinal absorption efficiencies (ABS<sub>GI</sub>). The ABS<sub>GI</sub> is expressed as a decimal to account for

the oral absorption efficiency relative to the gastro-intestinal system. For sediment,  $ABS_{GI}$ s were derived from the following priority of sources: (1) RAGS Part E, (USEPA, 2004a), (2) The USEPA Region 9 PRG table (USEPA, 2002), (3) the Risk Assessment Information System (RAIS), and (4) USEPA recommended interim default  $ABS_{GI}$ s from the Supplemental Guidance to RAGS (USEPA, 2004b). For surface water,  $ABS_{GI}$ s were derived from this priority of sources: (1) RAGS Part E, (USEPA, 2004a), (2) the RAIS, and (3) interim default  $ABS_{GI}$ s from Supplemental Guidance to RAGS (USEPA, 2004b).

Because dermal doses are expressed as absorbed rather than administered (intake) doses, the oral RfD is converted to a dermal RfD by multiplying the oral RfD by the appropriate  $ABS_{GI}$ .

For the same reasons, a dermal SF that is based on an administered dose is derived by dividing the oral SF by the appropriate  $ABS_{GI}$ . The oral SF is divided by an  $ABS_{GI}$  rather than multiplied because SFs are expressed as reciprocal doses.

**Risk Calculation Equation, Cancer:**

$$Risk = DAD_{sw} \times SF_{dermal}$$

**Risk Calculation Equation, Noncancer:**

$$Hazard\ Quotient = \frac{DAD_{sw}}{RfD_{dermal}}$$

**Where:**

- RfD<sub>derma</sub> = Dermal reference dose.
- RfD<sub>oral</sub> = Oral reference dose.
- $ABS_{GI}$  = GI absorption fraction from following sources, in order of choice: (1) RAGS Part E, Exhibit 4-1 (USEPA, 2004a); (2) 2002 USEPA Region 9 RBC Table (USEPA Region 9, 2002); (3) RAIS; (4) USEPA Region 4 OTS supplemental values.

**Equations for Dermal Reference Dose and Dermal Slope Factor:**

$$RfD_{dermal} = RfD_{oral} \times ABS_{GI} \qquad SF_{dermal} = \frac{RfD_{oral}}{ABS_{GI}}$$

### **9.3.6.2 Toxicity Profiles for COPCs**

In accordance with RAGS, toxicological summary paragraphs are presented in Appendix N for all human health risk COPCs. Most information for the profiles is obtained from Oak Ridge National Laboratory's RAIS, who maintain their toxicological summary information using IRIS, NCEA, HEAST, ATSDR and other cited supplemental sources. Any additional references are noted in the text. The profiles summarize adverse effects of COPCs and the chemical quantities associated with such effects.

### **9.3.7 Risk Characterization**

Risks are characterized separately for each wetland, and summary tables are included in Sections 10 through 15 that provide totals for the exposure media and land use scenarios. Chemicals identified as COCs are summarized for each wetland and exposure medium.

This document focuses on ecological risk, because it is more likely to drive decisions for Site 41 wetlands, human exposure is generally unlikely, and the human exposure models and data set used in this HHRA include uncertainty and variability that could over- or under-estimate risks. Consequently, no human health-based remedial goal options are developed for chemicals identified as ecological concerns. Risk-based remedial goal options are developed for chemicals identified as human health concerns only using target excess cancer risks of 1E-6, 1E-5, and 1E-4 and hazard indices of 0.1, 1.0, and 3 in accordance with USEPA Region 4 *Supplemental Guidance to RAGS Bulletins* (USEPA, 2000).

### **9.3.8 Uncertainty and Variability**

Uncertainty and variability are inherent in the risk assessment process and are addressed as a whole in this section. Uncertainty and variability in the analytical data are functions of matrix characteristics and heterogeneity, the precision and accuracy of sampling, and preparation and analysis methods used. Although data are typically considered exact values, they are, in reality, the laboratory's best estimate within a range defined by method control limits. As a result, reported concentrations for any chemical can under- or overestimate actual concentrations.

In general, conservative exposure assumptions would likely overestimate risk for the trespasser and maintenance worker land use scenarios in this HHRA; however, the lack of game fish tissue data could result in over- or under-estimates. Analytical data and different toxicological effects, test organisms, and endpoints introduce a wide range of variability, which is compounded when multiplied by many conservative assumptions.

### **9.3.8.1 Exposure**

Sources of uncertainty and variability are addressed in this section relative to fish tissue, sediment, and surface water. Variability in analytical data is evident by the QA/QC requirements, such as +/- 25% accuracy, etc.

Data reported as estimated concentrations, or "J" qualified data, are assumed to be detected concentrations. Although this allows smaller concentrations to be used that could otherwise be reported as not detected, use of estimated concentrations increases the variability in chemical concentrations because the reported results are estimates only. Variability in analytical data could under- or over-estimate exposure.

Data validation is detailed in Section 5.

#### **9.3.8.1.1 Fish Tissue**

Uncertainty and potential variability are high in this medium. Subsistence fishing at Site 41 would be unlikely, because areas attractive to fishermen are around Bayou Grande and in Pensacola Bay, homeland security restrictions limit access.

As described in the site ERAs, ingestion of game fish tissue could be a complete exposure pathway for some wetlands. As previously discussed, whole baitfish tissue data were collected from Wetlands 18 and 64 for the ecological risk assessment. Therefore, bioaccumulation in game fish is an uncertainty that could span orders of magnitude, over- or underestimating human exposure. In addition, the baitfish collected has relatively low lipid content, when compared to popular game fish, such as mullet or red drum. More bioaccumulation would be expected in species higher in the food chain and with higher lipid content. Although the TTC is used to account for differences in bioaccumulation between trophic levels, this is an additional source of uncertainty that could over or under estimate human exposure to chemicals in fish tissue.

Interspecies variability in lipids, metabolism, and, ultimately, accumulation, as well as preparation methods by human receptors, could over- or underestimate human exposure to tissue.

BSAFs are calculated and used to estimate tissue uptake, based on sediment concentrations for chemicals detected in both sediment and tissue. Limited tissue sampling events instill uncertainty and variability in the fish tissue data set. Upper-bound fish tissue ingestion rates and other exposure assumptions are used to address uncertainties in the fish tissue data set.

Chemicals that are not detected in both sediment and fish tissue are excluded from fish tissue risk estimates, because no information is available to develop a site-specific BSAF. For these chemicals, exposure could be underestimated, because uptake could occur from multiple, unknown sources.

Pesticides and PCBs were reported in prey fish tissue samples collected from Wetlands 18 and 64. They were also reported in Wetland 33, which is a reference wetland, so some uncertainties exist with respect to the source of these chemicals. Wetland 75 was designated a reference wetland but was subsequently deemed unsuitable because of the detected concentrations. Mosquito control and related applications could be a source of these pesticides, considering the absence of industrial activities in the area. Crabbing and mullet fishing could occur in some wetlands year round, although the Florida Marine Patrol Office indicated very limited fishing in Site 41 wetlands relative to Pensacola Bay and Bayou Grande, which would be considered more attractive to fishermen. Homeland security restrictions limit access to the shoreline of NAS Pensacola in these areas.

PCBs, aldrin, dieldrin, endosulfan I, and lindane were reported in tissue samples from Wetlands 18 and 64 but not in reference-area fish tissue. However, game fish could contain these chemicals from bioaccumulation and bioconcentration due to various sources. Tissue data were not normalized for percent lipid content. Game fish data normalized for percent lipid content would be necessary to put risk estimates in perspective for risk managers.

Uncertainty exists about the potential for bioaccumulation in game species, which could result in higher risk estimates because most of these pesticides and PCBs tend to bioaccumulate. The limited sample size and lack of identified sources contribute to uncertainty and could result in over- or underestimated risk, with variability potentially spanning orders of magnitude.

However, the tissue data used in the risk assessment are from whole-body analysis, not edible tissue only. Bones, lipids, and organs, not typically eaten by humans, are where many contaminants accumulate, and food preparation methods are also unknown.

#### **9.3.8.1.2 Sediment**

Uncertainty and variability in the ingestion rate, exposure frequency and duration, bioavailability of chemicals in sediment, dermal contact uptake assumptions, and rinsing action of surface water result in highly uncertain exposure estimates such that USEPA Region 4 excludes direct sediment exposure pathways for wetlands that are inundated with water all the time. Variability among individuals as well as day-to-day variability in the same individual would influence these factors.

For wetlands that are sometimes dry, sediment exposure is assumed to be equivalent to soil exposure. Most wetlands would not likely be attractive to swimmers because of physical and biological hazards, so exposure would likely be overestimated.

When habitat and site access information indicate trespassers could catch game fish at a wetland, fish tissue concentrations are modeled based on tissue data and sediment data, as described in Section 9.3.8.1.1. When no fish tissue data are available for a wetland, sediment concentrations are used to estimate tissue concentrations. Although many sediment samples were collected, sample distribution was relatively limited within each wetland. Fish tissue sampling was limited to a few wetlands. Therefore, sampling was biased to find contamination to address the uncertainty in the number of samples collected from each wetland.

#### **9.3.8.1.3 Surface Water**

Incidental ingestion of and dermal contact with surface water are assessed assuming a trespasser would swim or wade in a wetland for 2.6 hours, with an ingestion rate of 50 ml/hour. A similar rate of exposure to surface water is assumed for maintenance workers, who may be required to provide grounds upkeep in the vicinity of certain wetlands. Most wetlands would not be attractive to swimmers or conducive to intensive exposure to surface water, primarily due to most wetlands' shallow depth and physical and biological hazards. Consequently, surface water exposure would be overestimated. Like sediment, variability between individuals and daily variability in the same individual could over- or underestimate exposure.

For surface water exposures, it is assumed that the VOC inhalation pathway is insignificant due to the unlimited dilutional capacity of the ambient air. Should these wetlands ever be contained in some manner, risks associated with VOCs could be underestimated in this risk assessment.

#### **9.3.8.2 Toxicological Data**

There is a generally recognized uncertainty in human risk values developed from experimental data, due primarily to the uncertainty of data extrapolation in the areas of: (1) high- to low-dose exposure, and (2) animal effects data to human effects data. The site-specific uncertainty is mainly in the degree of accuracy of the exposure assumptions. Most of the assumptions used in this and any risk assessment have not been verified. For example, the degree of chemical absorption from the gut or through the skin or the amount of soil contact is not known with certainty.

Due to the uncertainty of toxicological values from the IRIS and HEAST databases provided by USEPA, the USEPA and the risk assessor are obligated to make conservative assumptions to minimize the chance that the actual health risk will be greater than what the process determines.

### **9.3.8.3 Fish Tissue Assessment**

In general, sampling biased to locate existing contamination would over estimate site-wide exposure because some areas with little or no contamination would exist. Site 41 was sampled with a biased approach.

Game fish would be the most likely fish tissue ingested near NAS Pensacola. Prey species were sampled to support the ecological risk assessment for Site 41, and higher trophic level fish-tissue data were not available. Therefore, TTCs are used to model predator fish tissue concentrations and to account for the uncertainty associated with using bait fish tissue data to evaluate the fish ingestion exposure route. Intra- and inter-species variability exists in the TTC calculations as applied to prey fish data at NAS Pensacola.

Site-specific BSAFs are calculated to model fish tissue concentrations, using sediment and fish tissue data. The data set for this exposure pathway is limited to whole fish data collected from prey species. These BSAFs were used to estimate tissue concentrations when no tissue concentrations were available. It was assumed that BSAFs would be similar for various Site 41 wetlands. Variability in sediment to prey fish is a source of variability in the fish tissue concentrations.

Site 41 wetlands differ, so uptake could vary. Whole prey fish data are used. This is applicable because whole fish would be ingested by higher trophic level predator fish. However, humans would ingest only certain portions of the predator fish. Depending on the biological fate of chemicals within predator fish, the chemicals may or may not be ingested (e.g., fish liver vs. fillet).

Fish tissue BSAFs could not be estimated for some chemicals that are detected. A chemical detected in sediment but not in tissue could be below tissue detection limits or may not accumulate in prey species. Chemicals could accumulate at faster rates in higher trophic level species, so this is a source of uncertainty that could underestimate exposure to contaminants in fish tissue. Chemicals detected in tissue but not in sediment could be present at concentrations in sediment below the detection limit or could be present in sediment locations that have not been sampled. Therefore, this is another source of uncertainty that could underestimate exposure to contaminants in fish tissue.

SFF usually affect tissue uptake models. The SFF represents the percent diet of the predator (trophic Level 4) fish species from a particular wetland and would be apportioned based on the estimated foraging area of the predatory fish species. Given sufficient data, the SFF is calculated by dividing the total surface area (exposure area) of a wetland by the total surface area of Bayou Grande (960 acres). Uncertainties are inherent in Site 41 data due to four separate sampling phases, sampling over many years, and a relatively limited number of samples. Therefore, no SFF adjustment is used in the human health calculations. For fish that would forage in other areas, exposure would be overestimated (e.g., red drum).

The USEPA *Exposure Factors Handbook* (1997b) states that only 33% of the total fish consumed by recreational fishermen is caught locally and that the remaining 66% is purchased commercially. In addition, USEPA (1997b) reports that between 25% to 50% of whole fish is edible. Some of these issues are addressed in EPA's recommended fish tissue ingestion rates. Fish tissue ingestion rates are not modified based on edible fractions. The unmodified 95th percentile ingestion rate for recreational fishermen of 26 g/day is used. This could over estimate exposure for fishermen that do not collect 100% of their fish from Site 41 wetlands and do not eat 100% of the fish. However, the assumption is appropriate, considering the uncertainties in distribution and trophic level modeling necessary to address this exposure pathway.

The USEPA *Exposure Factors Handbook* (1997b) indicates the recommended default fish ingestion rate for subsistence fishers is 170 g/day for the 95th percentile for Native American subsistence fishermen living along the Columbia River. It should be emphasized that the rates above refer only to Native American subsistence fishing populations, not the Native American population in general. Several studies show intake rates of recreationally caught fish among Native Americans with state fishing licenses are higher than intake rates among other anglers but far lower than the above rates for Native American subsistence populations.

As with recreational fishermen, uncertainty and variability exist in trophic transfer models, fish tissue models, and data sets for most wetlands that are relatively small. Consequently, it is assumed that all fish consumed by subsistence fishermen would be caught locally.

Uncertainties and sources of variability have been identified in the biased sampling approach, limited sampling distribution, surface water, sediment, tissue portions analyzed, and exposure models used herein. Conservative assumptions are used to address uncertainties. Risk managers should consider these uncertainties in risks estimated based on fish tissue ingestion.

**Table 9-1**  
**Toxic Equivalents for Carcinogenic PAHs**

<b>PAH</b>	<b>TEF</b>
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1

**Table 9-2  
Summary Justification for Eliminating Human Exposure Pathways Site 41  
NAS Pensacola**

<b>Potentially Exposed Population</b>	<b>Medium and Exposure Pathway</b>	<b>Pathway Selected for Evaluation</b>	<b>Reason for Selection or Exclusion</b>
<b>Current &amp; Future Site Trespassers (Adolescents)</b>	Air/Inhalation of gaseous contaminants emanating from soil.	No.	Site 41 contains no soil. Accordingly, this pathway was considered insignificant.
	Air/Inhalation of chemicals entrained in fugitive dust.	No.	Site 41 contains no soil. Accordingly, this pathway was considered insignificant.
	Groundwater/Ingestion of contaminants during potable or general use	No.	Direct exposure to groundwater was considered an incomplete pathway for Site 41 wetlands.
	Groundwater/Inhalation of volatilized groundwater contaminants.	No.	Direct exposure to groundwater was considered an incomplete pathway for Site 41 wetlands.
	Surface Water/Incidental Ingestion of contaminants during recreational or maintenance events.	Yes.	Swimming is allowed near some wetland areas. The natural salinity of surface water precludes ingestion as a drinking water source, but incidental ingestion while swimming or wading could occur.
	Surface Water/Inhalation of volatilized contaminants.	No.	Exposure via this pathway is possible during swimming or wading activities. However, this pathway was considered insignificant.
	Surface Water/Dermal Contact.	Yes.	Exposure via this pathway is possible during swimming or wading activities.
	Soil/Incidental Ingestion.	No.	Site 41 contains no soil. Accordingly, this pathway was considered insignificant.
	Soil/Dermal Contact.	No.	Site 41 contains no soil. Accordingly, this pathway was considered insignificant.
	Sediment/Incidental Ingestion.	Yes.	According to RAGS Part A (USEPA, 1989), ingestion of sediments is not a relevant pathway for commercial/industrial land use. This pathway was therefore only considered relevant at Site 41 wetland sample locations where water is likely to at least occasionally recede or dry up.
	Sediment/Dermal Contact.	Yes.	According to RAGS Part E (USEPA, 2001b), sediments which are consistently covered with water for considerable amounts of time are likely to wash off before an individual reaches the shore. This pathway was therefore only considered relevant at Site 41 wetland sample locations where water is likely to at least occasionally recede or dry up.
<b>Recreational and Subsistence Fishermen</b>	Fish/Ingestion of tissue impacted by contaminated media.	Yes.	Fishing and crabbing do occur in some Site 41 wetlands. However, little data fishing occurrence was available. Despite the uncertainties associated with this pathway, the HHRA assessed risk to recreational and hypothetical subsistence fisherman at wetlands where game fish habitats might be found.
	Fruits and Vegetables/Ingestion of plant tissues grown in media.	No.	No agriculture occurs at NAS Pensacola. Aquaculture is not a proposed land use and would not be expected to occur at the base

**Table 9-3**  
**Site 41 Summary Conceptual Site Model**

Wetland	Access		Notes	Always Inundated?	Maintenance Worker		Child Trespasser		Notes	Game Fish Habitat	Type of Game Fish Present	Trespasser Fishing?	Rationale
	Maintenance	Trespasser			SW	Sed	SW	Sed					
<b>OU 1 Wetlands</b>													
1A	✓		near cemetery		✓	✓	✓	✓					
1B			near cemetery		✓	✓	✓	✓					
3			adj. John Tower Road, culvert		✓	✓	✓	✓					
4D	✓	✓	golf course pond	✓	✓		✓	✓		✓	Bass, Bream	No	Access restricted by MWR and HSR
15	✓	✓	on golf course		✓	✓	✓	✓					
16	✓	✓	Along trail near campground/picnic area	✓	✓		✓	✓		✓	Mullet, Trout	No	Along trail near campground/picnic area
17	✓	✓	Along trail near campground/picnic area	✓	✓		✓	✓		✓	Mullet, Trout	No	Along trail near campground/picnic area
18A	✓	✓	Along trail near campground/picnic area		✓	✓	✓	✓					
18B	✓	✓	Along trail near campground/picnic area		✓	✓	✓	✓					
<b>OU 2 Wetlands</b>													
5A	✓	✓	adj road			✓	✓	✓					
5B	✓	✓	adj road	✓	✓		✓	✓					
6	✓	✓	adj road, NATTC complex	✓	✓		✓	✓					
64	✓	✓	adj road, yacht basin	✓	✓		✓	✓		✓	Mullet, Trout, Redfish	Yes	Fishing from piers at Yacht Basin
<b>OU 10 Wetlands</b>													
10	✓		adj road			✓	✓						
12	✓		near IWTP, access restricted to authorized personnel			✓	✓						
13	✓		near IWTP, access restricted to authorized personnel			✓	✓						
<b>Chevalier Field Wetlands</b>													
63A	✓	✓	near NATTC			✓	✓	✓					
63B	✓	✓	near NATTC, picnic pavillions			✓	✓	✓					
<b>UST 18 Wetlands</b>													
52	✓		near airfield, access restricted to authorized personnel			✓	✓			✓	Bass, Bream	No	Access restricted to authorized personnel
W1	✓		near airfield, access restricted to authorized personnel			✓	✓						
72	✓		near airfield, access restricted to authorized personnel	✓		✓				✓	Bass, Bream	No	Access restricted to authorized personnel
<b>Miscellaneous Wetlands</b>													
19A	✓		near airfield, access restricted to authorized personnel			✓	✓			✓	Bass, Bream	No	Access restricted to authorized personnel
19B	✓		near airfield, access restricted to authorized personnel	✓		✓					Bass, Bream	No	Access restricted to authorized personnel
48	✓		near airfield, access restricted to authorized personnel			✓	✓						
49	✓		near airfield, access restricted to authorized personnel			✓	✓						
56	✓	✓		✓		✓							
57	✓	✓				✓	✓	✓	✓				
58	✓	✓				✓	✓	✓	✓				
W2	✓		near airfield, access restricted to authorized personnel	✓		✓					Bass, Bream	No	Access restricted to authorized personnel

**Notes:**

Unauthorized boat traffic is prohibited within 500 feet of NAS Pensacola shoreline under Homeland Security restrictions.

✓ indicates applicable

**Table 9-4  
Wetland Specific Conceptual Site Model**

Wetland	Scenario	Medium	Pathway		
			Ingestion	Dermal	Fish Tissue
1A	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			
1B	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			
3	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			
15	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			√
16	Maintenance	Sediment			
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			√
17	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			√
18A	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			

**Table 9-4  
Wetland Specific Conceptual Site Model**

Wetland	Scenario	Medium	Pathway		
			Ingestion	Dermal	Fish Tissue
18B	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment				
4D	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment			√	
5A/B	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment				
6	Maintenance	Sediment			
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment				
64	Maintenance	Sediment			
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment			√	
10	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
Fisherman	Fish Tissue Uptake from Sediment				
12	Maintenance	Sediment	√	√	
		Surface water	√	√	

**Table 9-4  
Wetland Specific Conceptual Site Model**

Wetland	Scenario	Medium	Pathway		
			Ingestion	Dermal	Fish Tissue
12 (cont.)	Trespasser	Sediment Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
13	Maintenance	Sediment	√		
		Surface water	√		
	Trespasser	Sediment			
		Surface water			
Fisherman	Fish Tissue Uptake from Sediment				
63A	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			
63B	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			
52	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
W1	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			

**Table 9-4  
Wetland Specific Conceptual Site Model**

Wetland	Scenario	Medium	Pathway		
			Ingestion	Dermal	Fish Tissue
72	Maintenance	Sediment	√	√	
		Surface water			
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
19A	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
19B	Maintenance	Sediment	√	√	
		Surface water			
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
48	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
49	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment			
		Surface water			
	Fisherman	Fish Tissue Uptake from Sediment			
56	Maintenance	Sediment	√	√	
		Surface water			

**Table 9-4  
Wetland Specific Conceptual Site Model**

Wetland	Scenario	Medium	Pathway		
			Ingestion	Dermal	Fish Tissue
56 (cont.)	Trespasser	Sediment			
		Surface water	√	√	
	Fisherman	Fish Tissue Uptake from Sediment			√
57	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√		
		Surface water	√		
Fisherman	Fish Tissue Uptake from Sediment				
58	Maintenance	Sediment	√	√	
		Surface water	√	√	
	Trespasser	Sediment	√	√	
		Surface water	√	√	
Fisherman	Fish Tissue Uptake from Sediment				
W2	Maintenance	Sediment			
		Surface water	√	√	
	Trespasser	Sediment			
Surface water					
Fisherman	Fish Tissue Uptake from Sediment				

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
<b>OU 1 Wetlands</b>							
Wetland 1A	a, b	001M000101 001W000101 041M010101 041M010201	M W M W M W M W	N/A	N/A	N/A	N/A
Wetland 1B	a, b	041M010301 041W010301 041M010401	M W M W M W	N/A	N/A	N/A	N/A
Wetland 3	a, trespassing possible	001M000301 001W000301 001M000302 001W000302 001M000303 001W000303 041M030101 041W030101 041W030101* 041M030201 041M030201* 041W030102 041M030301 041W030103 041M030401 041M030501 041M030601 041M030701 041M030701*	MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland 4D	c, trespassing possible	041M04D501	MW/CT	041M04D101 041W04D101 041M04D201 041M04D301 041M04D401 041W04D401	F MW/CT/F F F MW/CT/F	N/A	N/A
Wetland 15	N/A	041M150101 041W150101 041M150201 041W150201 041M150301 041M150401 041W150102**	MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT	N/A	N/A	N/A	N/A

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
Wetland 16	N/A	N/A	N/A	001M001601 001W001601 041M160101 041W160101 041M160201 041W160201 041M160301 041M160301 041M160301*	F MW/CT/F F MW/CT/F F MW/CT/F F F F	N/A	N/A
Wetland 17	N/A	N/A	N/A	041M170101 041W170101 041M170102 041M170103 041W170102**	F MW/CT/F F F MW/CT/F	N/A	N/A
Wetland 18A	N/A	001M001801 001W001801 041M18A101 041M18A201 041W18A201 041M18A301	MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland 18B	N/A	041M18B101 041W18B101 041M18B101*	MW/CT MW/CT MW/CT	N/A	N/A	N/A	N/A
<b>OU 2 Wetlands</b>							
Wetland 5A	N/A	041M5A0101 041W5A0101 041M5A0201 041W5A0201 041M5A0301 041M5A0401 041W5A0401 041M5A0701 041W5A0701 041M5A0401* 041W5A0401*	MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT MW/CT	N/A	N/A	041M5A0501 041W5A0501 041M5A0601 041W5A0601 041M5A0501* 041W5A0501* 041M5A0601* 041W5A0601*	N/A MW/CT N/A MW/CT N/A MW/CT N/A MW/CT

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
Wetland 5B	N/A	N/A	N/A	N/A	N/A	041M5B0101 041M5B0201 041W5B0201 041M5B0202** 041M5B0301** 041M5B0401** 041M5B0501** 041M5B0601**	N/A N/A MW/CT N/A N/A N/A N/A N/A
Wetland 6	N/A	N/A	N/A	N/A	N/A	010M000101 041M060101 041M060201 041M060301 041W060301 041M060401 041M060501 041M060601 041M060701 041W060701 041M060801 041M060901 041M061001 041W061001 041M061101 041W061002**	N/A N/A N/A N/A MW/CT N/A N/A N/A N/A MW/CT N/A N/A N/A MW/CT N/A N/A MW/CT
Wetland 64	N/A	N/A	N/A	041M640101 041M640201 041M640301 041M640401 041M640501 041M640601 041M640701 041M640801 041M640901 041M641001 041M641101 041M641201 041M641301 041M641401	F F F F F F F F F F F F F F	N/A	N/A

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
Wetland 64 (cont.)				041M641501	F		
				041M641601	F		
				041M641701	F		
				041M641801	F		
				041M641901	F		
				041M642001	F		
				041M642101	F		
				041M642201	F		
				041M642301	F		
				041M642401	F		
				041W640101*	MW/CT/F		
				041M640401*	F		
				041M640501*	F		
				041W640501*	MW/CT/F		
				041M640601*	F		
				041M640202***	F		
				041M640302***	F		
041M640502***	F						
041M640602***	F						
041M640702***	F						
041M641102***	F						
041M642402***	F						
<b>OU 10 Wetlands</b>							
Wetland 10	b	N/A	N/A	N/A	N/A	041M10A101 041M10A201 041M10A301 033M001001 033W001002 033M002001 033W002002 033M003001 033W003002 033M004001 033W004002 033W000102**	N/A N/A N/A N/A MW N/A MW N/A MW N/A MW MW
Wetland 12	b	041M120201	MW	N/A	N/A	041M120101 041W120101	N/A MW
Wetland 13	b	041M130101 041W130101	MW MW	N/A	N/A	N/A	N/A

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
<b>Chevalier Field Wetlands</b>							
Wetland 63A	N/A	041M63A301 041M63A401 041M63A501	MW/CT MW/CT MW/CT	N/A	N/A	041M63A101 041M63A201 041W63A201 041W63A202**	N/A N/A MW/CT MW/CT
Wetland 63B	N/A	041M63B101	MW/CT	N/A	N/A	041M63B201 041W63B201 041M63B301 041M63B401 041W63B401	N/A MW/CT N/A N/A MW/CT
<b>UST 18 Wetlands</b>							
Wetland 52	b	041M52A101 041W52A101 041M52D101 041M52E101 041M52E201 041M52E301 041W52E301	MW MW MW MW MW MW MW	041M52A101 041W52A101 041M52D101 041M52E101 041M52E201	F MW/F F F F	N/A	N/A
Wetland W1	b	003M000101 003M000201 003M000401 003M000501 003M000601 003M000701 003M000801 003M000901 003M001001 003M001101 003M001201 003M001301 041WW10101 041WW10201 041WW10301	MW MW MW MW MW MW MW MW MW MW MW MW MW MW MW	N/A	N/A	N/A	N/A
Wetland 72	b	N/A	N/A	041M720101 041W720101 041M720201 041W720102**	MW MW MW MW	N/A	N/A

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
<b>Miscellaneous Site Wetlands</b>							
Wetland 19	b	041M19A101 041W190101 041M19A101** 041W19A102**	MW MW MW MW	041M19A201	F	N/A	N/A
Wetland 19B	b	N/A	N/A	041M19B101 041W190301	F F	N/A	N/A
Wetland 48	b	041M480101 041W480101	MW MW	N/A	N/A	N/A	N/A
Wetland 49	b	041M490101 041W490101 041M490201 041M490301 041W490301	MW MW MW MW MW	N/A	N/A	N/A	N/A
Wetland 56	N/A	N/A	N/A	041M56A101 041W56A101	F MW/CT/F	N/A	N/A
Wetland 57	N/A	041M570101 041W570101	MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland 58	N/A	041M580101 041W580101	MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland 75	N/A	041M750101 041W750101	MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland W2	b	N/A	N/A	041MW20101 041MW20201 041WW20201 041MW20301	F F MW/F F	N/A	N/A
<b>Reference Wetlands</b>							
Wetland 25	b	041M250101 041W250101 041M250201 041M250301 041W250301	MW MW MW MW MW	N/A	N/A	N/A	N/A
Wetland 27	b	041M270101 041M270201 041W270201	MW MW MW	N/A	N/A	N/A	N/A

**Table 9-4  
Human Health Risk Conceptual Site Models  
Site 41 Wetlands**

Wetland	Access Restrictions	Model 1: Sediment/Surface Water Exposure and Pathways		Model 2: Surface Water Exposure and ; Gamefish Tissue Pathways		Model 3: Surface Water Exposure and Pathways	
		Sample Locations	Human Receptors	Sample Locations	Human Receptors	Sample Locations	Human Receptors
Wetland 32	b	041M320101 041W320101 041M320201 041M320301 041W320301	MW/CT MW/CT MW/CT MW/CT MW/CT	N/A	N/A	N/A	N/A
Wetland 33	b	N/A	N/A	041M330101 041W330101 041M330201 041M330301 041W330301 041M330101* 041W330101* 041M330201* 041W330201*	F MW/CT/F F F MW/CT/F F MW/CT/F F MW/CT/F	N/A	N/A

**Notes:**

- a = Access restricted by OU-1 LUCIP.
- b = Access restricted by homeland security restrictions.
- c = Golf course restrictions do not allow recreational use for fishing or swimming.
- \* = Phase IIB/III sample.
- \*\* = 2004 sample.
- \*\*\* = 2001 sample.
- MW = Maintenance worker receptor.
- CT = Child trespasser receptor.
- F = Recreational/subsistence fishermen receptors.

**Table 9-5  
OU 1 and OU2 Wetlands Phase III  
Biota Sediment Accumulation Factor (BSAF)**

Contaminant	Tissue Concentrations		Sediment Concentrations	BSAF
		mg/kg	mg/kg	
<b>OU1 Wetlands (Phase III)</b>				
Mercury	Max	ND	0.1	NA
	Average	ND	0.06	NA
Aldrin	Max	ND	ND	ND
	Average	8.5	2.5125	3.383084577
Total BHC	Max	ND	ND	ND
	Average	34	9.575	3.550913838
Total Chlordane	Max	9.9	2.54	3.897637795
	Average	9.9	4.76	2.079831933
Total DDT	Max	132.85	152.1	0.873438527
	Average	132.85	68.7	1.933770015
Total Endrin	Max	ND	18.8	NA
	Average	49.5	12.34	4.011345219
Total PCB	Max	1247	ND	NA
	Average	1247	388	3.213917526
Chromium	Max	0.45	24.6	0.018292683
	Average	0.45	14.825	0.030354132
Copper	Max	2.3	16	0.14375
	Average	2.3	5.675	0.405286344
Iron	Max	40.2	246000	0.000163415
	Average	40.2	87725	0.00045825
Zinc	Max	33.9	234	0.144871795
	Average	33.9	88.5	0.383050847
BEHP	Max	92	500	0.184
	Average	92	517.5	0.177777778
<b>OU 2 Wetlands Phase III</b>				
Mercury*	Max	0.096	0.26	0.369230769
	Average	0.0364	0.175	0.208
Aldrin	Max	0.00038	ND	NA
	Average	0.00104	0.005276	0.19711903
Total BHC	Max	0.00571	0.02169	0.263254956
	Average	0.00435	0.02739	0.158817087
Total Chlordane	Max	0.0031	0.0124	0.25
	Average	0.001815	0.0143	0.126923077
Total DDT	Max	0.0259	0.196	0.132142857
	Average	0.0216	0.1168583	0.184839245
Total Endrin	Max	ND	0.0065	NA
	Average	0.007425	0.032	0.23203125
Total PCB	Max	0.4595	1.22	0.376639344
	Average	0.36525	1.18867	0.307276199
Arsenic	Max	0.44	7.8	0.056410256
	Average	0.415	3.779	0.109817412
Barium*	Max	20	17.2	1.162790698
	Average	8.125	14.32	0.567388268

**Table 9-5**  
**OU 1 and OU2 Wetlands Phase III**  
**Biota Sediment Accumulation Factor (BSAF)**

Contaminant	Tissue Concentrations		Sediment Concentrations	BSAF
		mg/kg	mg/kg	
BEHP	Max	ND	3.9	NA
	Average	0.165	1.772	0.093115124
Cadmium	Max	0.23	20.2	0.011386139
	Average	0.067	10.62	0.006308851
Chromium	Max	1.1	868	0.001267281
	Average	0.895	365.4	0.002449371
Copper	Max	2	146	0.01369863
	Average	1.6	86.35	0.018529241
Dieldrin	Max	0.00066	0.02	0.033
	Average	0.00053	0.01626	0.032595326
Endosulfan I	Max	0.0012	0.0052	0.230769231
	Average	0.000695	0.00608	0.114309211
Total Heptachlor	Max	0.0021	ND	NA
	Average	0.0019	0.01369	0.138787436
Iron	Max	51.8	13600	0.003808824
	Average	43.35	7276	0.005957944
Lead	Max	2.5	346	0.007225434
	Average	2.2	233.8	0.009409752
Manganese	Max	4.9	65.8	0.074468085
	Average	4.45	34.13	0.130383827
Selenium	Max	ND	1.6	NA
	Average	0.43	0.878	0.489749431
Vanadium	Max	0.28	18.4	0.015217391
	Average	0.265	10.2	0.025980392
Zinc	Max	33.2	468	0.070940171
	Average	31.65	279.7	0.113156954

**Notes:**

BSAF = Tissue Concentration/Sediment Concentration

ND = Not Detected

\* = Tissue concentrations for mercury derive from 2001 sample data.

Tissue Data collected in 1997 and 2001 from Wetland 64

**Table 9-6  
Exposure Parameters Used for the Site 41 Wetland Risk Calculations**

Exposure Parameter	Pathway	Sediment Receptor		Surface Water Receptor		Fish Ingestion Receptor	
		Child Trespasser	Maintenance Worker	Child Trespasser	Maintenance Worker	Recreational Fisherman	Subsistence Fisherman
Event Frequency (EV)(events/day)	Dermal	1	1	1	1		
Exposure Frequency (EF) (days/year)	Dermal/Ingestion	52	52	52	52	52	52
Exposure Duration (ED)(years)	Dermal/Ingestion	10	25	10	25		
Body Weight (kg) <sup>a</sup>	Dermal/Ingestion	45	70	45	70		
Averaging Time (AT)-noncancer risk (days) <sup>b</sup>	Dermal/Ingestion	3,635	9,125	3,635	9,125		
Averaging Time (AT)-cancer risk (days) <sup>c</sup>	Dermal/Ingestion	25,550	25,550	25,550	25,550		
Event Duration ( $t_{event}$ ) (hrs/event)	Dermal	N/A	N/A	2.6	2.6	N/A	N/A
Lag time per event ( $\tau_{event}$ ) (hrs/event) <sup>d</sup>	Dermal	N/A	N/A	RAGS Part E	RAGS Part E	N/A	N/A
Dermal permeability coefficient of compound in water (Kp) (cm/hr) <sup>e</sup>	Dermal	N/A	N/A	RAGS Part E	RAGS Part E	N/A	N/A
Skin surface area available for contact (SA) (cm <sup>2</sup> ) <sup>f</sup>	Dermal	5,000	10,400	5,000	10,400	N/A	N/A
Incidental ingestion rate for sediment (IR <sub>sd</sub> ) (mg/day) <sup>g</sup>	Ingestion	100	100	N/A	N/A	N/A	N/A
Incidental ingestion rate for surface water (L/day) <sup>h</sup>	Ingestion	N/A	N/A	0.01	0.01	N/A	N/A
Incidental ingestion rate for sediment (IR <sub>t</sub> ) (g/day) <sup>i</sup>	Ingestion	N/A	N/A	N/A	N/A	26	170

**Notes:**

- a = USEPA (1989) Risk Assessment Guidance for Superfund Vol. I, Human Health Evaluation Manual (Part A).
- b = Calculated as the product of ED (years) x 365 days/year.
- c = Calculated as the product of 70 years (assumed lifetime) x 365 days per year.
- d = From Exhibit B-3, RAGs Part E (USEPA, 2001b).
- e = From Exhibit B-3 (organics) or B-4 (inorganics), RAGS Part E (USEPA, 2001b).
- f = SA contact with sedin
- g = IRsd of 100 mg/day f
- h = IRsw of 0.01 L/day b:
- i = IRT from Exposure F: