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FINAL REMEDIAL INVESTIGATION REPORT ADDENDUM 1 SITE 40 NAS PENSACOLA FL
8/26/2003
ENSAFE, INC

FINAL REMEDIAL INVESTIGATION REPORT ADDENDUM 1 — SITE 40 — BAYOU GRANDE
NAVAL AIR STATION — PENSACOLA, FLORIDA August 26, 2003

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FINAL REMEDIAL INVESTIGATION
REPORT ADDENDUM 1
SITE 40 – BAYOU GRANDE
NAVAL AIR STATION
PENSACOLA, FLORIDA

SOUTHNAVFACENGCOM
CONTRACT NUMBER: N62467-89-D-0318

CTO — 036

Prepared for:

Comprehensive Long-Term
Environmental Action Navy
Naval Air Station
Pensacola, Florida

Prepared by:

EnSafe Inc.
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The contractor, EnSafe Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0318 are complete, accurate, and comply with all requirements of the contract.

Date: August 26, 2003
Signature: _____
Name: Allison Harris
Title: Task Order Manager

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19. Abstract

This report examines the potential for human exposure to contaminants detected in fish species inhabiting Site 40, which are then ingested by various receptors, such as recreational fishermen and subsistence fishermen. This assessment evaluated risk via these pathways by using site-specific values involving fish ingestion rates, fish behavior, receptor characteristics, etc. Bayou Grande is an estuarine water body adjacent to the northern border of the Naval Air Station Pensacola. Although some fishing does occur at Site 40, it is limited by land use, habitat, and commercial fishing restrictions. In addition, homeland security restrictions prohibit boats from coming within 500 feet of the naval air station. Site 40 extends from the shoreline fo NAS Pensacola to 300 feet offshore.

Several uncertainties were identified in developing the risk estimates. These included:

- PCBs are a common contaminant that are endemic to coastal areas
- the maximum detected concentration in the in prey fish from Site 40 was used as a health-protective surrogate for the mean for this risk assessment--it is very unlikely that all fish preyed on would be contaminated at the maximum detected level
- life history considerations for the red drum show the home range to be larger--the fish feed in a larger area which may be more or less contaminated, which may under or overestimate risk
- many gamefish feed on other food sources besides fish
- it was assumed that all of the contaminant was ingested regardless of the way the fish was cooked or eaten--it is likely that the estimated risks to the receptor populations were overestimated
- the risk calculated for Site 40 is below what the Food and Drug Administration considers allowable for human food
- subsistence fishing is not believed to occur in Bayou Grande--the use of the Region III RBC values may overestimate risk
- use of a trophic transfer coefficient to estimate the tissue concentration in upper trophic level species based on concentrations detected in lower trophic organisms
- surface water samples collected during Phase IIA were biased to areas of Phase IIA high sediment concentrations, and risk may be under or overestimated
- whole-body tissue data from prey species and calculated tissue data from predatory fish suggest a risk to humans greater than Florida's acceptable risk level of 10E-6, mainly from organochlorine pesticide and Aroclor-1260 concentrations, but it is very unlikely that all fish preyed on by upper trophic level fish (game fish) would be contaminated at the maximum detected level
- concentrations in upper trophic fish are based on a model and may differ from actual concentrations in game fish

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List of Abbreviations

g/day	Grams per day
g/kg	Grams per kilogram
kg	Kilograms
kg/day	Kilograms per day
kg-day/mg	Kilograms per day per milligram
mg/kg	Milligram per kilogram
mg/kg/day	Milligram per kilogram per day
ng/g	Nanograms per gram
a	Assimilation efficiency of mercury from food
AET	Apparent Effects Threshold
AT	Averaging Time
ATc	Averaging Time, carcinogens
ATn	Averaging Time, non-carcinogens
BW	Body weight
BWa	Body weight, adult
Cinv	Methyl mercury tissue concentrations in infaunal benthic invertebrates
%Cinv	Percent of red drum diet composed of benthic invertebrates
CCr	Methyl mercury tissue concentration in crustaceans
%Ccr	Percent of red drum diet composed of crustaceans, or 0.6
CDI	Chronic Daily Intake
CDIf	Chronic Daily Intake from fish
Cf	Concentration in upper trophic level fish/Methyl mercury tissue concentration in forage fish
%Cf	Percent of red drum diet composed of forage fish
Cg	Concentration in game fish tissue
COPC	Compounds of potential concern
Cp	Concentration in prey fish tissue
CPSo	Carcinogenic Potency Slope, oral
E/A&H	EnSafe/Allen and Hoshall
EDtot	Exposure Duration total
ED	Exposure Duration
EF	Exposure Frequency
EFr	Exposure Frequency
Fca	Fraction of contaminated area
FDA	Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
Fusf	Fraction of use and successful fishing
g	Growth rate coefficient
GIS	Geographic Information System

HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
IR	Ingestion Rate
IRF	Fish ingestion rate
K	Methyl mercury excretion rate from the red drum
LOAEL	Lowest Observed Adverse Effects Level
LWA	Lifetime Weighted Average
NAS	Naval Air Station
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
PCBs	Polychlorinated biphenyls
R	Feeding rate of the red drum
RBC	Risk-Based Concentration
RfD	Reference Dose
RfDo	Reference Dose, oral
RI	Remedial investigation
SAP	Sampling and Analysis Plan
SFF	Site Foraging Factor
THQ	Target Hazard Quotient
TR	Target Cancer Risk
TTC	Trophic level transfer coefficient
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

This report examines the potential for human exposure to contaminants detected in fish species inhabiting Site 40, which are then ingested by various receptors, such as recreational fishermen and subsistence fishermen. This assessment evaluated risk via these pathways by using site-specific values involving fish ingestion rates, fish behavior, receptor characteristics, etc.

Bayou Grande is an estuarine water body adjacent to the northern border of the Naval Air Station Pensacola. Although some fishing does occur at Site 40, it is limited by land use, homeland security restrictions, habitat, and commercial fishing restrictions.

Several uncertainties were identified in developing the risk estimates. These included:

- PCBs are a common contaminant that are endemic to coastal areas
- the maximum detected concentration in the in prey fish from Site 40 was used as a health-protective surrogate for the mean for this risk assessment--it is very unlikely that all fish preyed on would be contaminated at the maximum detected level
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- surface water samples collected during Phase IIA were biased to areas of Phase IIA high sediment concentrations, and risk may be under or overestimated
- whole-body tissue data from prey species and calculated tissue data from predatory fish suggest a risk to humans greater than Florida's acceptable risk level of 10E-6, mainly from organochlorine pesticide and Aroclor-1260 concentrations, but it is very unlikely that all fish

preyed on by upper trophic level fish (game fish) would be contaminated at the maximum detected level

- concentrations in upper trophic fish are based on a model and may differ from actual concentrations in game fish

1.0 INTRODUCTION

This report examines the potential for human exposure to contaminants detected in fish species inhabiting Site 40, which are then ingested by various receptors, such as recreational fishermen and subsistence fishermen. This assessment evaluated risk via these pathways by using site-specific values concerning fish ingestion rates, fish behavior, receptor characteristics, etc. This document integrates information and discussion from the following:

- Final Remedial Investigation (RI) Report Site 40 Naval Air Station Pensacola, Florida (January 20, 1999)
- Final Remedial Investigation Report Addendum 2 for Site 40-Bayou Grande Naval Air Station, Pensacola, Florida (August 9, 2002)

2.0 BACKGROUND

Bayou Grande is an estuarine water body adjacent to the northern border of the Naval Air Station (NAS) Pensacola. Bayou Grande extends roughly east to west, approximately 5 miles inland into the south-southwestern portion of Escambia County, and is part of the greater Pensacola Bay system. Site 40 represents the 8.5 mile shoreline of Bayou Grande that is adjacent to NAS Pensacola. The site extends from the western boundary of NAS Pensacola, near Jones Creek, to where Bayou Grande connects with Pensacola Bay at Magazine Point. Site 40 is considered to extend 300 feet from the shoreline between these points. This portion of Bayou Grande receives (directly or indirectly) storm water runoff from Forrest Sherman Field, roads, bridges, parking lots, and the A.C. Read Golf Course.

The total surface area covered by Bayou Grande is approximately 960 acres (1.5 square miles). The surface area of Site 40 is 310 acres, roughly one-third the size of Bayou Grande.

2.1 Site History

The Final Work Plan for Sites 40 and 42 (EnSafe/Allen and Hoshall [E/A&H], 1995) and the Sampling and Analysis Plan (SAP) Addendum for Site 40 (E/A&H, May 23, 1997) were submitted on September 25, 1995. Based on the plans, the Phase IIA sampling was conducted in late 1995 and early 1996. Data

collected were presented to the Tier 1 Partnering Team on April 16 and August 20, 1996. Because of the magnitude of ecological associated data, an Eco Subcommittee was developed to address those concerns. The RI identified the areas most likely to have received contaminants from sources on land, then studied these closely as agreed upon by the Tier 1 Team. Attachment A presents a summary of the sediment data results from the Phase IIA (1996 data-Table A-1), Phase IIB/III (1997 data-Table A-2), and 2001 sampling events (Table A-3) for Site 40.

2.2 Investigation Summary

The eco-subcommittee selected the assessment endpoints, measurement endpoints, and sample locations which the Tier 1 Team provided consensus on as recorded in meeting minutes, and documented in the SAP Addendum (E/A&H, May 23, 1997). Sample locations, shown in Figure 1, were agreed upon and were selected to address the following agreed upon Assessment Endpoints:

- Protection of Benthic Macroinvertebrate Community
- Protection of Reproductive Viability of Fish-Eating Birds
- Protection of Nursery Habitat for Aquatic Resources
- Protection of Fish Viability

Because mercury was not analyzed in fish because of a sampling error, a red drum mercury model(Evans, D.W. and Engel, D.W., 1994) was used to predict the mercury concentrations in fish based on the concentrations detected in Site 40 sediment. To validate the results of the model, sediment and whole-body prey fish samples were collected in 2001 at the same locations previously sampled and analyzed for mercury. Using the data, a maximum no observed adverse effects level (NOAEL) hazard quotient (HQ) of 4.45 at location 040MZ247 was calculated based on the estimated mercury in prey fish from the detected concentrations of mercury in sediment. Using the measured concentrations in the prey fish resulted in a maximum NOAEL HQ of 1.72 at location 040MZ247. Except for the offsite location, all lowest observed adverse effects level (LOAEL) HQs were below 1.

3.0 EXPOSURE ASSESSMENT

3.1 Selection of Exposure Scenarios

Fishing at Site 40 is limited by land use, homeland security restrictions, habitat, and commercial fishing restrictions. Although some fishing formerly occurred at Site 40, it was limited to boating traffic because of base restrictions on the southern side of the bayou and private residences on the north and west sides.

Since September 11, 2001, a 500-feet restricted area has been enforced along the shoreline adjacent to NAS Pensacola to enhance security at the base. This restricted area covers all of the NAS Pensacola shoreline, including the Intercoastal Waterway, Pensacola Bay, and Bayou Grande. Boats are instructed to stay out of the restricted area, which precludes fishing from a boat within Site 40 for as long as the security restrictions are in place.

Site 40 does not support sufficient game species for subsistence fishing based on the habitat and biota survey data in the ecological risk assessment and data received from the Florida Marine Patrol Office. The Marine Patrol Office reported that approximately 10 boats per day are in the bayou fishing between the months of April and September, while only one or two boats are typically observed between the months of October and March. A full bag limit (one redfish and five trout) is an infrequent occurrence and most boats only catch one redfish or one trout per day.

Commercial fishing does not occur in Pensacola Bay or any Florida coastal water because of the State's limit on marine net fishing (as stated in Article 10, Section 16 of the Florida Constitution and Title 28, Chapter 370.093 of the Florida Statutes). Therefore, fishing at Site 40 is limited to a recreational activity pattern.

Despite the evidence that subsistence fishing does not occur in the bayou, this pathway was also included in the risk assessment for comparison (FDEP, March 19, 2003). Consequently, ingestion of contaminated fish tissue was evaluated for recreational and subsistence fishing.

3.2 Identification of Compounds of Potential Concern (COPCs)

Table 1 compares the maximum detected values in fish tissue collected from Site 40 to fish ingestion

Figure 1 Sample Locations, Site 40

risk-based concentrations (RBCs) developed by the United States Environmental Protection Agency (USEPA), Region III (USEPA, April 2, 2002). This analytical data is provided in Appendix C of the

Table 1
Comparison of Maximum Detections in Whole Body Prey Fish to RBCs

		Fish RBCs (mg/kg)[1]		
Constituents	Max. Detected Concentrations[2] (mg/kg)	Carcinogens	Non-carcinogens	Exceeds RBC?
4,4'-DDD	3.8E-3[3]	1.3E-2	6.8E-1	No
4,4'-DDE	1.2E-2[3]	9.3E-3	6.8E-1	Yes
Aldrin	6.6E-4	1.9E-4	4.1E-2	Yes
Aroclor-1260	1.0E-1[4]	1.6E-3	2.7E-2	Yes
Dieldrin	1.3E-3	2.0E-4	6.8E-2	Yes
Lindane	7.4E-4	2.4E-3	4.1E-1	No
Chlordane	1.7E-3	9.0E-3	6.8E-1	No
Mercury	6.0E-2	NA	4.1E-1	No

Notes:
RBC = Risk-based concentration.
1 = Fish RBC values represent risk-based concentrations calculated for subsistence fishermen.
2 = Maximum detected concentrations from Phase IIB/III prey fish tissue samples except for mercury. Since mercury not analyzed for in Phase IIB/III, the maximum detected prey fish mercury concentration from 2001 samples was used.
3 = Reference dose for DDT used to calculate non-carcinogenic RBC.
4 = Reference dose for Aroclor-1254 used to calculate non-carcinogenic RBC.

Final Site 40 RI Report (January 20, 1999). The RBCs published in the 2002 document are based on the following equations:

Carcinogenic Effect of Concern:

RBC (in milligrams per kilogram [mg/kg]) = (TR * BWa * ATc) / ((EFr * EDtot * (IRF/1000 grams per kilogram [g/kg]) * CPSo))

Non-carcinogenic Effect of Concern:

RBC (mg/kg) = (THQ * RfDo * BWa * ATn) / ((EFr * EDtot * (IRF/1000 g/kg))

where:

RBC	=	Risk Based Concentration (mg/kg) (contaminant specific)
TR	=	Target Cancer Risk = 1E-6
THQ	=	Target Hazard Quotient = 1
BWa	=	Body weight, adult = 70 kilograms (kg)
ATc	=	Averaging Time, carcinogens, = 25,550 days
ATn	=	Averaging Time, non-carcinogens, = ED * 365 days/year (10,950 days)
Efr	=	Exposure Frequency = 350 days/year
Edtot	=	Exposure Duration, total = 30 years
IRF	=	Fish ingestion = 54 grams per day (g/day)
CPSo	=	Carcinogenic Potency Slope, oral (1/milligram per kilogram per day [mg/kg/day]) (contaminant specific)
RfDo	=	Reference Dose, oral (mg/kg/day) (contaminant specific)

4,4'-DDE, aldrin, Aroclor-1260, and dieldrin exceeded the RBC for fishermen. The RBC is based on a fish ingestion rate of 54 g/day, which is similar to a subsistence fish ingestion rate. Although the RBC was exceeded for four of the eight compounds detected in prey fish tissue samples, all eight constituents were identified as COPCs in this risk assessment to conservatively estimate the potential risk to various receptor populations.

3.3 Estimation of Concentrations in Fish Tissue

Fish tissue data presented in Table 1 are for pinfish and killifish (prey species). Organic concentrations in game fish were estimated based on whole body tissue concentrations reported in the prey species using trophic level transfer coefficients (TTCs). TTCs are from USEPA, Draft Water Quality Criteria Methodology Revisions: Human Health, Federal Register, August 14, 1998. The equation used for estimating the game fish concentrations is shown below:

$$Cg = Cp \times TTC \times SFF$$

where:

Cg	=	Concentration in game fish tissue
Cp	=	Concentration in prey fish tissue
TTC	=	Trophic Transfer Coefficient
SFF	=	Site Forage Factor

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

Mercury concentrations were modeled as presented in the Final RI Addendum 2 (EnSafe Inc., August 9, 2002). Calculations are summarized below for the red drum mercury model, as outlined in Evans, D.W. and Engel, D.W. (1994):

where:

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

%Cinv = Percent of red drum diet composed of benthic invertebrates, or 0.1

The equation above 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). A portion of the above

$$Cf = (1.2)(Cs)$$

estimates the accumulation of methyl mercury from the prey pathway, based on the assumption of a diet comprised of 30% forage fish (Cf), 60% crustaceans (Ccr), and 10% infaunal invertebrates (Cinv) (Evans and Engel, 1994). The Site 40 Final RI Report Addendum 2 (EnSafe Inc., August 9, 2002) and Evans and Engel (1994) also explain how Cf, Ccr, and Cinv are calculated. These are reviewed below:

$$Ccr = \left[\frac{(Cs * 2)}{5}\right] * (0.70)$$

$$Cinv = \left[\frac{(Cs * 2)}{5}\right] * (0.25)$$

where:

Cs = the total mercury (in ppm) in sediment.

The Site 40 Final RI Report (EnSafe Inc., January 20, 1999) and Evans and Engel (1994) explain the other coefficients used in the above formulae.

4.0 DOSE CALCULATIONS

Estimated intakes for identified receptor groups (recreational fishermen and subsistence fishermen) were calculated according to the following general equation:

$$CDIf = Cf * IR * Fca * Fusf * EF * ED / BW * AT$$

where:

CDIf	=	Chronic Daily Intake from fish (mg/kg-day) (contaminant specific)
Cf	=	Concentration in game fish (mg/kg) (contaminant specific)
IR	=	Ingestion Rate of game fish (kilograms per day [kg/day])
Fca	=	Fraction of the contaminated area at Site 40
Fusf	=	Fraction of use and successful fishing at Site 40
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration (30 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time (25,550 days for carcinogens and 10,950 days for non-carcinogens)

The ingestion rates for the various receptor populations were based on information provided by the USEPA Exposure Factors Handbook (1997).

Table 2 lists the assumptions used in making the risk calculations. The table lists the adjustment factors used to determine the risks at Site 40.

4.1 Chronic Daily Intake for the Recreational Fisher

Exposure information was developed using the Florida Department of Health's (FDOH's) Florida Fish Consumption Advisories (January, 2003), USEPA's Exposure Factors Handbook (1997), fishing use, and other factors detailed below. Fishing use information obtained from the Florida Marine Patrol Office for Bayou Grande and was excerpted from the Final Site 40 RI Report (EnSafe Inc., January 20, 1999).

4.2 Fish Advisory and Ingestion Rate

The FDOH fish advisory of January, 2003 states that a limited consumption advisory is applicable to children under age 10 and women of childbearing ages (FDOH, January, 2003). The advisory states that fish consumption for the fish species from the specified water bodies should be no more than 8 ounces per four weeks (FDOH, January, 2003). This would be equivalent to 0.008 kg/day, assuming daily ingestion over four weeks. Other ingestion rates were obtained from USEPA's Exposure Factors Handbook (USEPA, 1997). These ingestion rates were used to calculate CDIs for the recreational fishing scenario shown in Tables 5 and 6.

Table 2
Risk Assessment Assumptions

Adjustment Factor[1]		Assumptions RME	Assumptions Most Conservative	Rationale
SFF		0.32	1.0	Fish forage equally throughout Bayou Grande; Site 40 is one-third of Bayou Grande
	Adjustment	2.0	NA	Site 40 may contain better forage.
		0.64	1.0	
Fraction Contaminated Area/Site 40 Area		GIS estimate	NA	Geographic sediment distribution ~ fish tissue distribution.
	Adjustment	2.0	NA	Fish are more widespread than sediment.
		2 x est.	NA	
Fraction Annual Use by Fishermen		1.0	NA	Fishing occurs year-round.
Fraction Annual Use by Fish		1.0	NA	Fish do not migrate.
Fraction Successful Fishing in Bayou Grande		0.5	1.0	Based on Florida Marine Patrol Office; remainder of bag limit assumed to be caught elsewhere; one-half of the 0.26 kg/day fish tissue would be obtained elsewhere.
Fraction Fishing at Site 40		0.15	0.3	
	Adjustment	2.0	2.0	
		0.3	0.6	Forested banks would be more attractive to fishermen.

Note:
RME = Reasonable maximum exposure.
SFF = Site foraging factor.
1 = Adjustment was made to account for uncertainty.

4.3 Body Weight

The adult BWs were used in all risk calculations for this HHRA. The child BW may also be appropriate because the fish advisory specifically mentions children under age 10. The lifetime weighted average (LWA) was used to estimate risk to a person following the fish advisory during childhood and while they are of child-bearing age. The LWA for a resident was assumed to represent this scenario when using the fish ingestion rate obtained from the FDOH fish advisory. The adult BW of 70 kg was used to estimate exposure. BW was obtained from USEPA's Exposure Factors Handbook (1997).

4.4 Site Forage Factor

The site foraging factor (SFF) accounts for the preference of fish to use Site 40 as a foraging area, and the fraction of 0.32 was developed based on the size of the site area relative to Bayou Grande. The Navy side of Bayou Grande appears to contain more detritus and cover, and the banks are more forested than the opposite sides of the bayou. The Navy side of Bayou Grande is also quieter. Consequently, fish may forage on the Navy side of Bayou Grande more frequently than at other areas of the bayou. The Navy doubled the SFF to 0.64 to account for the potential foraging preference of the Navy side of the bayou. An SFF of 1 is also presented (See Table 2). Table 3 shows the SFF and estimated concentrations in upper trophic level fish, as well as the SFF of 1. The table presents the range of estimated concentrations in upper trophic level fish for the six compounds identified in Table 1, based on the SFFs of 1 and 0.64.

4.5 Fraction of the Contaminated Area Within Site 40 Area

Figures in the Final Site 40 RI Report showed that sediment chemical distribution was limited to certain areas within Site 40. Therefore, using a geographic information system (GIS), the COPCs were contoured to estimate the contaminated fraction of Site 40 area.

The Final Site 40 RI Report (EnSafe Inc., January 20, 1999) did not contain figures for aldrin or chlordane because of the lack of a sediment screening value (SSV) for aldrin and because detected concentrations of chlordane did not exceed its SSV. Therefore, contoured estimations of the fraction of the aldrin and chlordane

Table 3
Estimated Concentrations in Game Fish Species

Constituents	Measured Conc. in Prey Fish (mg/kg)	TTC	Estimated Conc. in Game Fish (mg/kg) SFF = 1	Estimated Conc. in Game Fish (mg/kg) SFF = 0.64
4,4'-DDD	3.8E-3	3.254	1.2E-2	7.9E-3
4,4'-DDE	1.2E-2	3.602	4.3E-2	2.8E-2
Aldrin	6.6E-4	1.006	6.6E-4	4.2E-4
Aroclor-1260	1.0E-1	3.733	3.7E-1	2.4E-1
Dieldrin	1.3E-3	1.063	1.4E-3	8.8E-4
Lindane	7.4E-4	1.021	7.6E-4	4.8E-4
Chlordane	1.7E-3	1.999	3.4E-3	2.2E-3
Mercury[1]	6.0E-2	NA	2.6E-01	1.7E-1

Notes:
TTC = Trophic transfer coefficient from USEPA, Draft Water Quality Criteria Methodology. Revisions: Human Health, Federal Register, August 14, 1998.
SFF = Site foraging factor.
1 = Mercury concentrations in upper trophic level fish tissue refer to methylmercury and were modeled as described in Addendum 2.

contaminated areas within the total Site 40 area were calculated for this HHRA. Table 3 summarizes the calculated fractions. There is some uncertainty in using fractions based on sediment distribution because fish tissue concentrations were assumed to correlate with high sediment concentrations. Chemical uptake from sediment to fish could be distributed across a larger area when considering the food web. Therefore, the fractions calculated using sediment data may underestimate exposure. To address this uncertainty, contaminants were assumed to be more mobile within the food chain relative to sediments that were contoured, and fractions were increased 100%, as shown in Table 4. A factor of 1 is also presented.

Assumptions were required to estimate the area affected by aldrin, because there is no FDEP or USEPA sediment screening value for aldrin. Other chemicals that were contoured using the lower of the FDEP and/or USEPA screening values. A buffer of 20 feet was assumed around each location where aldrin was detected to estimate the fraction of contaminated area within the total site area. Aldrin was detected in 13 of 139 samples. Assuming a 20-feet diameter buffer, the area affected

Table 4
Calculation of Fraction of Total Site Area

Compound	Area Compound Identified in Sediment [1] (sq. ft.)		Total Site 40 Area [1] (sq. ft.)		Fraction Site 40 Contaminated	Fraction Site 40 Contaminated X2
4,4'-DDD	559,529	/	27,309,178	=	0.0205	0.0410
4,4'-DDE	1,040,046	/	27,309,178	=	0.0381	0.0762
Aldrin	14,428	/	27,309,178	=	0.0005	0.0010
Aroclor-1260	2,010,467	/	27,309,178	=	0.0736	0.1472
Dieldrin	6,755,346	/	27,309,178	=	0.2474	0.4947
Lindane	5,938,125	/	27,309,178	=	0.2174	0.4349
Chlordane	2,391,993	/	27,309,178	=	0.0876	0.1752
Mercury[2]	5,872,803	/	27,309,178	=	0.2150	0.4300

Notes:
1 = Total Site 40 Area and Area Compound Identified in Sediment obtained from the 1999 Site 40 Remedial Investigation.
2 = Mercury form reported is methylmercury.

would be 16,328 square feet. Based on the site boundary, the area was recalculated to 14,428 square feet using GIS.

Using the 20 feet buffer area could underestimate aldrin exposure. Therefore, literature sources were reviewed to obtain a sediment screening value for aldrin. An Apparent Effects Threshold (AET) of 0.01 mg/kg (Buchman, M.F., 1999) was used as a screening value for aldrin. Site 40 aldrin concentrations reported in sediment ranged from nondetect to 0.0018 mg/kg, below the AET.

4.6 Fraction of Use of Contaminated Area By Fishermen and Successful Fishing

Bayou Grande is used for recreational fishing. As summarized in the RI report, the Florida Marine Patrol Office reported a fishing frequency of approximately 10 boats per day for Bayou Grande from April through September, and only one or two boats per day during October through March. Consequently, recreational fishing was assumed to occur year-round in Bayou Grande. The Florida Marine Patrol Office reported that a full bag limit (one redfish and five trout) is not frequently observed in Bayou Grande. This implies a fraction of less than 0.5 for obtaining a full bag limit from Bayou Grande. The Site 40

area is approximately one-third of Bayou Grande, so assuming fishing would occur equally throughout Bayou Grande, the fraction would be 0.5 x 0.3 = 0.15 to represent successful fishing within Site 40. Although some areas of Site 40 are inaccessible to recreational fishermen and other areas are shallow (and boats are now prohibited from the Site 40 area because of homeland security restrictions), the forested bank may be attractive to fishermen. The fraction of 0.15 was doubled to 0.3 as a conservative measure, assuming fishermen would find Site 40 more attractive than other areas in Bayou Grande. The fraction representing successful fishing within Site 40 was also revised upward to 0.6. Estimates based on both fractions representing successful fishing in Bayou Grande were presented. Thus, a range of assumptions were presented, representing those expected from a reasonable maximum exposure (less conservative) and those from a very conservative scenario.

5.0 RISK CHARACTERIZATION

The risk to the receptor populations is estimated by the following linear equations:

Carcinogenic Effects:

$$\text{Risk} = \text{CDI} * \text{Slope Factor}$$

Non-carcinogenic Effects:

$$\text{HQ} = \text{CDI} / \text{RfD}$$

where:

Risk	=	probability of a carcinogenic health impact from exposure to COPC
HQ	=	hazard quotient
CDI	=	receptor and route-specific chronic daily intake (mg/kg-day)
Slope Factor	=	toxicity value that relates dose to response (kilograms per day per milligram [kg-day/mg])
HQ	=	ratio of exceedance of a non-carcinogenic health impact
RfD	=	reference doses for no significant health impacts (mg/kg-day)

The slope factor and the RfD must be appropriate for the specific receptor and route and are determined for an administered dose for this risk assessment (based on fish ingestion).

5.1 Risk Characterization Results for Recreational Fishing

Risk estimates are summarized below. This HHRA includes the LWA risk for recreational fishermen who would be exposed under the conditions of the FDOH fish advisory (LWA risk estimate), risk to recreational fishermen who would not be restricted by the fish advisory (adult risk estimate), and risk to subsistence fishermen.

Table 5 shows CDI estimates based on the fractions discussed in Section 4 assuming a SFF of 0.64, a Fca as specified in Table 4, and a Fusf of 0.3. Table 6 shows the CDI estimates assuming SFF of 1.0, a Fca of 1.0 and a Fusf of 0.6. The tables reflect the range of assumptions outlined in Table 2. The tables show risk estimated for the 95th percentile fish intake rate, the LWA health advisory, and adult fish intake rates. For all assumptions used, the polychlorinated biphenyl (PCB) Aroclor 1260 was the primary contributor to the carcinogenic risk estimates (less conservative LWA estimate 5.5E-7/adult fish intake rate estimate 1.6E-06; most conservative LWA estimate 1.2E-5/adult fish intake rate estimate 3.4E-5).

Table 7 shows the non-carcinogenic risk for the recreational fishing scenario using the less conservative assumptions, while Table 8 shows non-carcinogenic recreational fishing risk using the most conservative assumptions.

Table 9 summarizes the carcinogenic risk for the recreational fishing scenario using a SFF of 0.64, a Fca as specified in Table 4, and a Fusf of 0.3. As can be seen in Table 9, total carcinogenic risk based on a LWA using the FDOH health advisory fish intake rate is 1.23E-6, while total carcinogenic risk based on the recommended adult fish intake rate (0.26 kg/day [USEPA, 1997]) is 3.6E-6. Table 10 summarizes the recreational fishing carcinogenic risk using a SFF of 1.0, a Fusf of 0.6, and a Fca area of 1.0. As can be seen in the table, total LWA carcinogenic risk based on the FDOH health advisory fish intake rate is 2.50E-5, while total carcinogenic risk based on the 0.26 kg/day adult fish intake rate is 7.33E-5.

Table 5
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue: Carcinogenic Effects;
Recreational Fishing Scenario (SFF 0.64, Fca from Table 4, Fusf 0.3)

Constituents	Concentration in Game Fish (mg/kg)	Ing. Rate Fish Advisory Child - rec 95	Ing. Rate Adult rec 95	FusF	Fca	CDI rec 95 Adult with no advisory	CDI rec 95 LWA	CDI for Carcinogenic Effects (mg/kg-day) Recreational Fishermen	
								Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate
4,4'-DDD	7.9E-3	8.0E-3	2.6E-2	3.0E-1	4.1E-2	1.5E-8	5.1E-9	5.1E-9	1.5E-8
4,4'-DDE	2.8E-2	8.0E-3	2.6E-2	3.0E-1	7.6E-2	9.6E-8	3.3E-8	3.3E-8	9.6E-8
Aldrin	4.2E-4	8.0E-3	2.6E-2	3.0E-1	1.1E-3	2.1E-11	7.E-12	7.E-12	2.1E-11
Aroclor-126	2.4E-1	8.0E-3	2.6E-2	3.0E-1	1.5E-1	1.6E-6	5.5E-7	5.5E-7	1.6E-6
Dieldrin	8.8E-4	8.0E-3	2.6E-2	3.0E-1	4.9E-1	2.E-8	6.9E-9	6.9E-9	2.0E-8
Lindane	4.8E-4	8.0E-3	2.6E-2	3.0E-1	4.3E-1	9.6E-9	3.3E-9	3.3E-9	9.6E-9
Chlordane	2.2E-3	8.0E-3	2.6E-2	3.0E-1	1.8E-1	1.7E-8	6.0E-9	6.0E-9	1.7E-8
Mercury[1]	1.7E-1	8.0E-3	2.6E-2	3.0E-1	4.3E-1	NA	NA	NA	NA

Notes:

LWA = Lifetime weighted average, based on the 2003 FDOH fish advisory for limited consumption (8oz fish/4 weeks ~ 0.008 kg/day). Adult only fish tissue intake rate is 0.026 kg/day (USEPA, 1997).

SFF = Site foraging factor.

Fca = Fraction of contaminated area; see Table 4.

Fusf = Fraction of use and successful fishing.

CDI = Chronic daily intake.

rec 95 = Recreational Reasonable Maximum Exposure (RME) estimate.

1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 6
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue: Carcinogenic Effects;
Recreational Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

								CDI for Carcinogenic Effects (mg/kg-day) Recreational Fishermen	
Constituents	Concentration in Upper Trophic Level Fish (mg/kg)	Ing. Rate Fish Advisory Child - rec 95	Ing. Rate Adult rec 95	FusF	Fca	CDI rec 95 Adult with no advisory	CDI rec 95 LWA	Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate
4,4'-DDD	1.2E-2	8.0E-3	2.6E-2	6.0E-1	1.0E+0	1.1E-6	3.9E-7	3.9E-7	1.1E-6
4,4'-DDE	4.3E-2	8.0E-3	2.6E-2	6.0E-1	1.0E+0	4.1E-6	1.4E-6	1.4E-6	4.E-6
Aldrin	6.6E-4	8.0E-3	2.6E-2	6.0E-1	1.0E+0	6.1E-8	2.1E-8	2.1E-8	6.1E-8
Aroclor-126	3.7E-1	8.0E-3	2.6E-2	6.0E-1	1.0E+0	3.4E-5	1.2E-5	1.2E-5	3.4E-5
Dieldrin	1.4E-3	8.0E-3	2.6E-2	6.0E-1	1.0E+0	1.3E-7	4.3E-8	4.3E-8	1.3E-7
Lindane	7.6E-4	8.0E-3	2.6E-2	6.0E-1	1.0E+0	6.9E-8	2.4E-8	2.4E-8	6.9E-8
Chlordane	3.4E-3	8.0E-3	2.6E-2	6.0E-1	1.0E+0	3.1E-7	1.1E-7	1.1E-7	3.1E-7
Mercury[1]	2.6E-1	8.0E-3	2.6E-2	6.0E-1	1.0E+0	NA	NA	NA	NA

Notes:

LWA = Lifetime weighted average, based on the 2003 FDOH fish advisory for limited consumption (8oz fish/4 weeks ~ 0.008 kg/day). Adult only fish tissue intake rate is 0.026 kg/day (USEPA, 1997).

SFF = Site foraging factor = 1.0.

Fca = Fraction of contaminated area = 1.0.

Fusf = Fraction of use and successful fishing = 0.6.

CDI = Chronic daily intake.

rec 95 = Recreational Reasonable Maximum Exposure (RME) estimate.

1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 7
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue:
Non-carcinogenic Effects; Recreational Fishing Scenario (SFF 0.64, Fca from Table 4, Fusf 0.3)

Constituents	Concentration in Upper Trophic Level Fish (mg/kg)	Ing. Rate Adult rec 95	Fusf	Fca	CDI for Non-carcinogenic Effects (mg/kg-day) Recreational Fishermen Based on Adult Fish Intake Rate
4,4'-DDD	7.9E-3	2.6E-2	3.0E-1	4.1E-2	3.5E-8
4,4'-DDE	2.8E-2	2.6E-2	3.0E-1	7.6E-2	2.3E-7
Aldrin	4.2E-4	2.6E-2	3.0E-1	1.1E-3	4.8E-11
Aroclor-1260	2.4E-1	2.6E-2	3.0E-1	1.5E-1	3.8E-6
Dieldrin	8.8E-4	2.6E-2	3.0E-1	4.9E-1	4.7E-8
Lindane	4.8E-4	2.6E-2	3.0E-1	4.3E-1	2.2E-8
Chlordane	2.2E-3	2.6E-2	3.0E-1	1.8E-1	4.1E-8
Mercury[1]	1.7E-1	2.6E-2	3.0E-1	4.3E-1	7.6E-6

Notes:
Adult only fish tissue intake rate is 0.026 kg/day (USEPA, 1997).
RME = Reasonable maximum exposure.
LWA = Lifetime weighted average, based on the 2003 FDOH fish advisory for limited consumption (8oz fish/4 weeks ~ 0.008 kg/day).
SFF = Site Foraging Factor = 0.64.
Fca = Fraction of contaminated area; see Table 4.
Fusf = Fraction of use and successful fishing = 0.3.
CDI = Chronic daily intake.
rec 95 = Recreational RME estimate.
1 = Mercury form reported is methylmercury.

Table 8
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue:
Non-carcinogenic Effects; Recreational Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

Constituents	Concentration in Upper Trophic Level Fish (mg/kg)	Ing. Rate Adult rec 95	Fusf	Fca	CDI for Non-carcinogenic Effects (mg/kg-day) Recreational Fishermen Based on Adult Fish Intake Rate
4,4'-DDD	1.2E-2	2.6E-2	6.0E-1	1.0E+0	2.6E-6
4,4'-DDE	4.3E-2	2.6E-2	6.0E-1	1.0E+0	9.2E-6
Aldrin	6.6E-4	2.6E-2	6.0E-1	1.0E+0	1.4E-7
Aroclor-1260	3.7E-1	2.6E-2	6.0E-1	1.0E+0	8.0E-5
Dieldrin	1.4E-3	2.6E-2	6.0E-1	1.0E+0	3.0E-7
Lindane	7.6E-4	2.6E-2	6.0E-1	1.0E+0	1.6E-7
Chlordane	3.4E-3	2.6E-2	6.0E-1	1.0E+0	7.3E-7
Mercury[1]	2.6E-1	2.6E-2	6.0E-1	1.0E+0	5.5E-5

Notes:
Adult only fish tissue intake rate is 0.026 kg/day (USEPA, 1997).
RME = Reasonable maximum exposure.
LWA = Lifetime weighted average, based on the 2003 FDOH fish advisory for limited consumption (8oz fish/4 weeks ~ 0.008 kg/day).
SFF = Site Foraging Factor = 1.0.
Fca = Fraction of contaminated area = 1.0.
Fusf = Fraction of use and successful fishing = 0.6.
CDI = Chronic daily intake.
rec 95 = Recreational RME estimate.
1 = Mercury form reported is methylmercury.

Table 9
Site 40 Summary of Risk Characterization Results: Carcinogenic Effects;
Recreational Fishing Scenario (SFF 0.64, Fca from Table 4, Fusf 0.3)

	CDI (mg/kg-day) Recreational Fishermen			Carcinogenic Risk Recreational Fishermen	
Constituents	Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate	Oral Slope Factor (mg/kg-day)	Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate
4,4'-DDD	5.1E-9	1.5E-8	2.4E-1	1.2E-9	3.6E-9
4,4'-DDE	3.3E-8	9.6E-8	3.4E-1	1.1E-8	3.3E-8
Aldrin	7.0E-12	2.1E-11	1.7E+1	1.2E-10	3.5E-10
Aroclor-1260	5.5E-7	1.6E-6	2.0E+0	1.1E-6	3.2E-6
Dieldrin	6.9E-9	2.0E-8	1.6E+1	1.1E-7	3.2E-7
Lindane	3.3E-9	9.6E-9	1.3E+0	4.3E-9	1.3E-8
Chlordane	6.0E-9	1.7E-8	3.5E-1	2.1E-9	6.1E-9
Mercury[1]	NA	NA	NA	NA	NA
			Total =	**1.23E-6**	**3.6E-6**

Notes:
CDI = Chronic Daily Intake.
LWA = Lifetime weighted average.
mg/kg/day = Milligrams per kilogram per day.
SFF = Site foraging factor = 0.64.
Fca = Fraction of contaminated area; see Table 4.
Fusf = Fraction of use and successful fishing = 0.3.
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 10
Summary of Risk Characterization Results: Carcinogenic Effects;
Recreational Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

	CDI (mg/kg-day) Recreational Fishermen			Carcinogenic Risk Recreational Fishermen	
Constituents	Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate	Oral Slope Factor (mg/kg-day)	Based on LWA Health Advisory Fish Intake Rate	Based on Adult Fish Intake Rate
4,4'-DDD	3.9E-7	1.1E-6	2.4E-1	9.3E-8	2.7E-7
4,4'-DDE	1.4E-6	4.0E-6	3.4E-1	4.6E-7	1.3E-6
Aldrin	2.1E-8	6.1E-8	1.7E+1	3.5E-7	1.0E-6
Aroclor-1260	1.2E-5	3.4E-5	2.0E+0	2.3E-5	6.8E-5
Dieldrin	4.3E-8	1.3E-7	1.6E+1	6.9E-7	2.0E-6
Lindane	2.4E-8	6.9E-8	1.3E+0	3.1E-8	9.0E-8
Chlordane	1.1E-7	3.1E-7	3.5E-1	3.7E-8	1.1E-7
Mercury[1]	NA	NA	NA	NA	NA
			Total =	**2.5E-5**	**7.33E-5**

Notes:
CDI = Chronic Daily Intake.
LWA = Lifetime weighted average.
mg/kg/day = Milligrams per kilogram per day.
SFF = Site foraging factor = 1.0.
Fca = Fraction of contaminated area = 1.0.
Fusf = Fraction of use and successful fishing = 0.6.
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 11 summarizes the non-carcinogenic risks to recreational fishermen assuming a SFF of 0.64, a Fca as specified in Table 4, and a Fusf 0.3; showing total recreational fishing risk to be 2.35E-10 with mercury the primary contributor to non-carcinogenic risk (2.3E-9). Table 12 summarizes the non-carcinogenic risk to recreational fishermen assuming a SFF of 1.0, a Fca of 1.0 and a Fusf 0.6; showing total recreational fishing risk to be 2.45E-8, with mercury also the primary non-carcinogenic risk contributor (1.7E-8).

5.2 Risk Characterization Results for Subsistence Fishers

To address the unlikely possibility of subsistence fishing occurring in Bayou Grande (FDEP, November 4, 2002 and March 19, 2003), CDI estimates were revised using the USEPA recommended fish intake rate for subsistence fishers of 170 kg/day (USEPA, 1997). Table 13 shows the revised CDI estimates using a Fca of 1.0, Fusf of 0.6, and a SFF of 1.0; Aroclor-1260 was the primary was the primary contributor in the subsistence fishing scenario (2.2E-4). Table 14 shows the total carcinogenic risk (4.79E-4) for subsistence fishers at Site 40 using these assumptions.

Table 15 shows the non-carcinogenic risks to subsistence fishermen assuming a SFF of 1.0, a Fca of 1.0 and a Fusf 0.6. Aroclor 1260 was the primary non-carcinogenic risk contributor for this scenario (5.2E-4). Table 16 summarizes the non-carcinogenic risks to subsistence fishermen using the same assumptions; non-carcinogenic subsistence fishing risk is 1.60E-7.

6.0 UNCERTAINTIES

General uncertainties are inherent in HHRAs. Specific uncertainties and their effect on the HHRA are listed below.

6.1 PCB Concentrations in the Ambient Environment

The primary risk driver for carcinogens is Aroclor-1260. PCBs are a common contaminant that are endemic to coastal areas. There is no continuing source of PCB contamination at Site 40. Attachment B presents the results of the literature search performed to obtain reference game fish tissue concentrations for PCBs. It is not known whether the PCBs in game fish are from NAS Pensacola. However, this was assumed for the purposes of this HHRA.

Table 11
Summary of Risk Characterization Results: Non-carcinogenic Effects;
Recreational Fishing Scenario (SFF 0.64, Fca from Table 4, Fusf 0.3)

Constituents	CDI (mg/kg-day) Recreational Fishermen Based on Adult Fish Intake Rate	Oral RfD (mg/kg-day)	Non-carcinogenic Risk Recreational Fishermen Based on Adult Fish Intake Rate
4,4'-DDD	3.5E-8	5.0E-4[2]	1.7E-11
4,4'-DDE	2.3E-7	5.0E-4[2]	1.1E-10
Aldrin	4.8E-11	3.0E-5	1.4E-15
Aroclor-1260	3.8E-6	2.0E-5[3]	7.5E-11
Dieldrin	4.7E-8	5.0E-5	2.3E-12
Lindane	2.2E-8	3.0E-4	6.7E-12
Chlordane	4.1E-8	5.0E-4	2.0E-11
Mercury	7.6E-6	3.0E-4[1]	2.3E-9
		Total =	**2.35E-10**

Notes:
SFF = Site foraging factor = 0.64.
Fca = Fraction of contaminated area; see Table 4.
Fusf = Fraction of use and successful fishing = 0.3.
CDI = Chronic daily intake.
1 = Reported oral RfD value is for elemental mercury.
2 = Reference dose for DDT used to calculate non carcinogenic RBC.
3 = Reference dose for Aroclor-1254 used to calculate non carcinogenic RBC.

Table 12
Summary of Risk Characterization Results: Non-carcinogenic Effects;
Recreational Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

Constituents	CDI (mg/kg-day) Recreational Fishermen Based on Adult Fish Intake Rate	Oral RfD (mg/kg-day)	Non-carcinogenic Risk Recreational Fishermen Based on Adult Fish Intake Rate
4,4'-DDD	2.6E-6	5.0E-4[2]	1.3E-9
4,4'-DDE	9.2E-6	5.0E-4[2]	4.6E-9
Aldrin	1.4E-7	3.0E-5	4.3E-12
Aroclor-1260	8.0E-5	2.0E-5[3]	1.6E-9
Dieldrin	3.0E-7	5.0E-5	1.5E-11
Lindane	1.6E-7	3.0E-4	4.8E-11
Chlordane	7.3E-7	5.0E-4	3.6E-10
Mercury	5.5E-5	3.0E-4[1]	1.7E-8
		Total =	**2.49E-8**

Notes:
SFF = Site foraging factor.
Fca = Fraction of contaminated area; see Table 4.
Fusf = Fraction of use and successful fishing.
CDI = Chronic daily intake.
1 = Reported oral RfD value is for elemental mercury.

Table 13
Site 40 Calculation of Chronic Daily Intakes of Constituents in Fish Tissue:
Carcinogenic Effects; Subsistence Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

Constituents	Concentration in Upper Trophic Level Fish (mg/kg)	Ing. Rate Adult Subsistence Fisherman	Fusf	Fca	CDI for Carcinogenic
4,4'-DDD	1.2E-2	1.7E-1	6.0E-1	1.0E+00	7.4E-6
4,4'-DDE	4.3E-2	1.7E-1	6.0E-1	1.0E+00	2.6E-5
Aldrin	6.6E-4	1.7E-1	6.0E-1	1.0E+00	4.0E-7
Aroclor-1260	3.7E-1	1.7E-1	6.0E-1	1.0E+00	2.2E-4
Dieldrin	1.4E-3	1.7E-1	6.0E-1	1.0E+00	8.3E-7
Lindane	7.6E-4	1.7E-1	6.0E-1	1.0E+00	4.5E-7
Chlordane	3.4E-3	1.7E-1	6.0E-1	1.0E+00	2.0E-6
Mercury[1]	2.6E-1	1.7E-1	6.0E-1	1.0E+00	NA

Notes:
Subsistence fisherman fish tissue intake rate is 0.170 kg/day (USEPA, 1997).
CDI = Chronic Daily Intake.
Fca = Fraction of contaminated area =1.0.
Fusf = Fraction of successful fishing = 0.6.
SFF = Site foraging factor = 1.0.
mg/kg/day = Milligrams per kilogram per day.
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 14
Summary of Risk Characterization Results: Carcinogenic Effects;
Subsistence Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

Constituents	CDI (mg/kg-day) Subsistence Fishermen	Oral Slope Factor (mg/kg-day)	Carcinogenic Risk Subsistence Fishermen
4,4'-DDD	7.4E-6	2.4E-1	1.8E-6
4,4'-DDE	2.6E-5	3.4E-1	8.8E-6
Aldrin	4.0E-7	1.7E+1	6.8E-6
Aroclor-1260	2.2E-4	2.0E+0	4.5E-4
Dieldrin	8.3E-7	1.6E+1	1.3E-5
Lindane	4.5E-7	1.3E+0	5.9E-7
Chlordane	2.0E-6	3.5E-1	7.1E-7
Mercury[1]	NA	NA	NA
		Total =	**4.79E-4**

Notes:
CDI = Chronic Daily Intake.
SFF = Site foraging factor = 1.0.
Fca = Fraction of contaminated area = 1.0
Fusf = Fraction of successful fishing = 0.6.
mg/kg/day = Milligrams per kilogram per day.
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 15
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue:
Non-carcinogenic Effects; Subsistence Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

Constituents	Concentration in Upper Trophic Level Fish (mg/kg)	Ing. Rate Adult Subsistence Fisherman	Fusf	Fca	CDI for Non-carcinogenic Effects (mg/kg-day) Subsistence Fishermen
4,4'-DDD	1.2E-2	1.7E-1	6.0E-1	1.0E+0	1.7E-5
4,4'-DDE	4.3E-2	1.7E-1	6.0E-1	1.0E+0	6.0E-5
Aldrin	6.6E-4	1.7E-1	6.0E-1	1.0E+0	9.3E-7
Aroclor-1260	3.7E-1	1.7E-1	6.0E-1	1.0E+0	5.2E-4
Dieldrin	1.4E-3	1.7E-1	6.0E-1	1.0E+0	1.9E-6
Lindane	7.6E-4	1.7E-1	6.0E-1	1.0E+0	1.1E-6
Chlordane	3.4E-3	1.7E-1	6.0E-1	1.0E+0	4.7E-6
Mercury[1]	2.6E-1	1.7E-1	6.0E-1	1.0E+0	3.6E-4

Notes:
Subsistence fisherman fish tissue intake rate is 0.17 kg/day (USEPA,1997).
SFF = Site Foraging Factor = 1.0.
Fca = Fraction of contaminated area = 1.0.
Fusf = Fraction of use and successful fishing = 0.6.
CDI = Chronic daily intake
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 16
Summary of Risk Characterization Results: Non-carcinogenic Effects;
Subsistence Fishing Scenario (SFF 1.0, Fca 1.0, Fusf 0.6)

	CDI (mg/kg-day)		Non-carcinogenic Risk
Constituents	Subsistence Fishermen Based on Adult Fish Intake Rate	Oral RfD (mg/kg-day)	Subsistence Fishermen Based on Adult Fish Intake Rate
4,4'-DDD	1.7E-5	5.0E-4[2]	8.6E-9
4,4'-DDE	6.0E-5	5.0E-4[2]	3.0E-8
Aldrin	9.3E-7	3.0E-5	2.8E-11
Aroclor-1260	5.2E-4	2.0E-5[3]	1.0E-8
Dieldrin	1.9E-6	5.0E-5	9.7E-11
Lindane	1.1E-6	3.0E-4	3.2E-10
Chlordane	4.7E-6	5.0E-4	2.4E-9
Mercury	3.6E-4	3.0E-4[1]	1.1E-7
		Total =	**1.60E-7**

Notes:
SFF = Site foraging factor = 1.0.
Fca = Fraction of contaminated area = 1.0.
Fusf = Fraction of use and successful fishing = 0.6.
CDI = Chronic daily intake.
1 = Reported oral RfD value is for elemental mercury.
2 = Reference dose for DDT used to calculate non carcinogenic RBC.
3 = Reference dose for Aroclor-1254 used to calculate non carcinogenic RBC.

6.2 Concentrations in Prey Fish Tissue

The maximum whole-body detected concentration in the in prey fish from Site 40 was used as a health-protective surrogate for the mean for this risk assessment. It is unlikely that all fish preyed on by upper trophic level fish would be contaminated at the maximum detected level.

6.3 Life History Considerations for the Red Drum

The red drum was selected as representative of predatory fish since it is one of the most important sport and commercial coastal species in the Gulf of Mexico (U.S. Fish and Wildlife Service, 1985). Red drum are dependent on estuaries for at least the first few years of life. Larvae and juveniles are generally found in shallow waters, in areas not greatly affected by tides, with grassy or muddy bottoms and moderate salinities. Adult red drum move out to nearshore ocean waters and only come back to the estuaries to spawn. For this risk assessment, red drum were assumed to spend all of their life in Bayou Grande. This likely overestimated the risk since adult fish likely spend the majority of time in nearshore ocean waters and only come back to Bayou Grande to spawn (i.e., exposure to contaminants in the sediments of Site 40 would only be constant during the first few years of life, with the adult red drum only being exposed during periods of spawning). The bioaccumulation model predicting the tissue concentration in the predatory fish assumes that the red drum is feeding only on prey within Bayou Grande, when in reality, the adult red drum would be feeding primarily on prey from Pensacola Bay and the Gulf of Mexico.

6.4 Diet Composition of Predatory Fish

Many gamefish feed on other food sources besides fish. For example, red drum are major predators in estuaries with prey consisting primarily of crustaceans (crabs and shrimp) and other fish. Fish are generally more prevalent in the diet of red drum during winter and spring months, and crustaceans become increasingly more important during late spring and summer.

6.5 Concentrations in Fish Tissue After Cooking

The concentration of COPCs in the gamefish is assumed to be constant, even after cooking. While this may be true of some chemicals (mercury; which binds strongly to proteins), for many organic chemicals (PCBs), some cooking processes tend to decrease the toxicant mass, thus reducing the concentration

in fish tissue (USEPA, 1998). Also, different chemicals tend to accumulate in different parts of the fish. Therefore, the way the fish is prepared before cooking (i.e., trimming away fat where many lipophilic compounds such as pesticides and PCBs tend to accumulate) can also be a factor in estimating actual intake of a COPC. Because it was assumed that all of the contaminant was ingested regardless of the way the fish was cooked or where a COPC may tend to accumulate, it is likely that risks to the receptor populations were overestimated.

6.6 FDA PCB Action Level

The Food and Drug Administration (FDA) action level for PCBs in fish is 2,000 parts per billion which would result in a risk estimate of 1.2 x 10E-03. FDA's action levels are based "on the unavoidability of the poisonous or deleterious substances". Although not appropriate for use in a HHRA, the FDA action level may be useful as a risk management tool. The risk calculated for Site 40 is below what FDA considers allowable for human food. Because it was assumed that all of the contaminant was ingested regardless of the way the fish was cooked or where a contaminant may tend to accumulate, it is likely that the estimated risks to the receptor populations were overestimated.

6.7 Hypothetical Subsistence Fishermen

Estimated risks to subsistence fishermen were calculated for comparisons. However, the frequency of fishing in the Bayou Grande, as obtained from the Florida Marine Patrol Office, suggests that subsistence fishing does not occur in the bayou. This assumption is based on the observation of only10 boats per day in Bayou Grande between April and September. Between October and March, only one or two boats per day are typically observed and the full bag limit of one redfish and five trout is a rare occurrence. It also assumes that fishermen only fish at Site 40. This is an unlikely assumption, given the amount of fishing habitat available along the Gulf Coast, which also leads to an overestimation of risk. In addition, boat traffic within the Site 40 area is now prohibited because of Homeland Security restrictions.

6.8 Use of Trophic Transfer Coefficient

Another source of uncertainty is the use of an estimated TTC, which estimates the tissue concentration in upper trophic level species based on concentrations detected in lower trophic organisms. A number

of factors can influence how much of a contaminant is passed to another trophic level. These factors may include the metabolism of the fish species involved, the percent of the diet according to the trophic level of the prey species, and the percent of organic carbon of the sediments.

6.9 Excess Risk from Contaminants in Surface Water

In the Final Site 40 RI Report (EnSafe inc., January 20, 1999), excess risk from contaminants in surface water was assessed using three surface water samples from Bayou Grande. The surface water samples were biased to areas of high sediment concentrations based on the Phase IIA results. With only three surface water samples, risk may be under or overestimated. The only constituent identified above Federal water quality criteria was arsenic; however, arsenic was later eliminated a potential chemical of concern based on the risk-based evaluation of the fish tissue data.

6.10 Concentrations in Prey Fish Tissue and Game Fish

Whole-body tissue data from prey species and calculated tissue data from predatory fish (game fish/upper trophic level fish) suggest a risk to humans greater than Florida's acceptable risk level of 1.0E-6, mainly from organochlorine pesticide and Aroclor 1260 concentrations. Game fish samples were not collected during the Site 40 RI; without data from the edible portion of game species, the actual exposure to humans is unknown. It is very unlikely that all fish preyed on by upper trophic level fish would be contaminated at the maximum detected level. The maximum detected concentration in the prey fish from Site 40 was used as a health-protective surrogate for the mean for this HHRA. Excess risk to human health was assessed from two composite whole-body prey fish samples collected at the same location during Phase IIb/III of the RI. Organochlorine pesticides and Aroclor 1260 (a PCB) tend to accumulate in the fatty tissue of fish. Bones, organs, and fatty tissue are not typically eaten by humans, and are usually where most contaminants accumulate. Therefore, assuming whole body consumption in this HHRA may overestimate actual risk. It is also assumed that the game fish eaten are predatory fish that feed in only the most contaminated area of Bayou Grande. The home range of the predatory fish is actually much larger, meaning the fish feed in a larger area which may be more or less contaminated. This factor may under or overestimate risk.

6.11 Modeling Upper Trophic Level Fish Concentrations

Concentrations in upper trophic fish are based on a model and may differ from actual concentrations in game fish. 4,4'-DDT has been banned from the U.S. since 1972 and PCBs were banned since 1977. 4,4'- DDT is breaking down to its daughter products, 4,4'-DDE and 4,4'- 4-DDD as demonstrated by the higher concentrations of 4,4'-DDE and 4,4'- DDD in sediment and the prey fish. 4,4'-DDT was not detected in the prey fish samples. Except for one concentration of 4,4'-DDT, all detected concentrations of 4,4'-DDT and its metabolites in sediment are below their respective basewide levels. Concentrations in upper trophic fish are based on a model and may differ from actual concentrations in game fish. The model is showing the upper boundary of the COPC based on whole body, not edible tissue only. Further, 4,4'-DDT and its metabolites and PCBs have not been identified as potential ecological parameters of concern for any of the terrestrial IRP sites potentially impacting Bayou Grande.

7.0 CONCLUSIONS

Table 17 provides a summary of carcinogenic risks for the constituents evaluated in this HHRA, while Table 18 provides a summary of the non-carcinogenic risks for these constituents.

Table 17
Carcinogenic Risk Estimate Summary

	RME Assumptions		Most Conservative Assumptions		
Constituents	**Recreational FDOH Advisory Fish Intake Rate**	**Recreational Adult Fish Intake Rate**	**Recreational FDOH Advisory Fish Intake Rate**	**Recreational Adult Fish Intake Rate**	**Subsistence Fishermen**
4,4'-DDD	1.2E-9	3.6E-9	9.3E-8	2.7E-7	1.8E-6
4,4'-DDE	1.1E-8	3.3E-8	4.6E-7	1.3E-6	8.8E-6
Aldrin	1.2E-10	3.5E-10	3.5E-7	1.0E-6	6.8E-6
Aroclor-1260	1.1E-6	3.2E-6	2.3E-5	6.8E-5	4.5E-4
Dieldrin	1.1E-7	3.2E-7	6.9E-7	2.0E-6	1.3E-5
Lindane	4.3E-9	1.3E-8	3.1E-8	9.0E-8	5.9E-7
Chlordane	2.1E-9	6.1E-9	3.7E-8	1.1E-7	7.1E-7
Mercury[1]	N/A	N/A	N/A	N/A	N/A

Notes:
1 = Mercury form reported is methylmercury; cancer risk not applicable because methyl mercury is not a carcinogen.

Table 18
Non-carcinogenic Risk Estimate Summary

	RME Assumptions	Most Conservative Assumptions	
Constituents	**Recreational Adult Fish Intake Rate**	**Recreational Adult Fish Intake Rate**	**Subsistence Fishermen**
4,4'-DDD	1.7E-11	1.3E-9	8.6E-9
4,4'-DDE	1.1E-10	4.6E-9	3.0E-8
Aldrin	1.4E-15	4.3E-12	2.8E-11
Aroclor-1260	7.5E-11	1.6E-9	1.0E-8
Dieldrin	2.3E-12	1.5E-11	9.7E-11
Lindane	6.7E-12	4.3E-11	3.2E-10
Chlordane	2.0E-11	3.6E-10	2.4E-9
Mercury	2.3E-09	1.7E-8	1.1E-7

8.0 RISK MANAGEMENT/RECOMMENDATIONS

To eliminate some of the uncertainty associated with modeling the concentrations of contaminants in the red drum from prey fish, collection of additional fish tissue samples from Bayou Grande is one method that has been suggested. In addition to logistical considerations, there are inherent factors

which preclude using higher tropic level fish as a true indicator of risk in Site 40. Specifically, given the absence of a species which spends its entire life confined to the bayou, contamination detected in a higher tropic level tissue sample cannot be attributed to Bayou Grande alone. Further, in order to obtain a realistic estimate of fish tissue concentrations, a significant number of red drum would need to be collected from the bayou. Additionally, even if this data were collected, limited toxicity information is specifically available for the red drum for the compounds identified. Since the cumulative cancer risk for recreational fishermen is within an order of magnitude of the regulatory threshold level of 1E-6, and given the extremely conservative assumptions used in the model, collection of additional fish tissue samples is not warranted at this time.

9.0 REFERENCES

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Attachment A

Sediment Data Summary

Attachment B

Literature Search Results

EnSafe prepared a human health risk assessment for Bayou Grande that was revised based on recommendations from the Tier 1 Partnering Team. To address FDEP comment #4 on the Final RI Report Addendum 1 (FDEP, November 4, 2002), a literature search was performed to obtain reference game fish tissue concentrations for PCBs. Results of the literature search are summarized below.

Fish tissue quality in near-coastal areas of the Gulf of Mexico receiving point source discharges

Fish tissue quality in near-coastal areas of the Gulf of Mexico receiving point source discharges (Lewis et al., 2002) was reviewed. In this study, fish were collected from two reference locations, and the sampled fish were filleted prior to analysis for PCBs. The average total PCB concentration reported in fish samples collected from the two reference areas was 4.81 nanograms per gram (ng/g); equivalent to 0.00481 mg/kg. Catfish were collected from the St. Joseph's Bay reference location, while largemouth bass were collected from the Blackwater River reference location (Lewis et al., 2002).

National Study of Chemical Residues in Fish

The National Study of Chemical Residues in Fish (USEPA, 1992- formerly referred to as the National Bioaccumulation Study), was also reviewed. This document contains fish data for sample locations throughout the United States, and includes background fish tissue data. Background PCB concentrations reported in the study range from nondetect to 44.8 ng/g (equivalent to 0.0448 mg/kg). These data were from fish samples collected from select locations only, with the fish filleted prior to analysis (USEPA, 1992).

Sediment Toxicity in Four Bays of the Florida Panhandle

The Magnitude and Extent of Sediment Toxicity in Four Bays of the Florida Panhandle: Pensacola, Choctawhatchee, St. Andrew and Apalachicola (Long et al., 1997) was also reviewed. This study revealed that PCBs in Bayou Grande sediment were elevated when compared to PCB concentrations in the main basin (Long et al., 1997). This document shows that the average sediment PCB concentrations exceeded the Effects Range Medium in Pensacola Bay.

Discussion

Table 1 compares the maximum detections found in whole body prey fish from Site 40 to the RBCs for subsistence fishermen. The fish tissue samples reported in Table 1 were collected from the Site 40

sediment sample location having the highest reported PCB concentration. Table 1 also shows that the whole-body sample analyzed contained 0.1 mg/kg total PCBs. Table 3 of the Final RI Addendum 1 shows the estimated concentrations in upper trophic level fish species at Site 40. This table estimates the concentration for total PCBs in upper trophic level fish tissue to be 0.24 mg/kg. Lewis et al. (2002) cited an average total PCB concentration (from filleted fish samples) from two reference areas to be 0.00481 mg/kg. This value was used because the background values cited from other studies reviewed were not limited to the Gulf or were collected near outfalls.

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