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FINAL REMEDIAL INVESTIGATION REPORT ADDENDUM SITE 40 BAYOU GRANDE NAS PENSACOLA FL

4/24/2000

ENSAFE, INC

FINAL REMEDIAL INVESTIGATION REPORT
ADDENDUM — 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.
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

April 24, 2000

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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:	**April 24, 2000**
Signature:	
Name:	**Paul Stoddard**
Title:	**Technical Director**

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19. Abstract

In January 1999, EnSafe Inc. prepared a baseline risk assessment for Site 40 as part of a Final Remedial Investigation Report for the Naval Air Station in Pensacola, Florida (NAS Pensacola). Site 40, also known as Bayou Grande, is an estuarine water body adjacent to the northern border of NAS Pensacola in Escambia County. The results of the baseline risk assessment showed that seven constituents (4,4'-DDD, 4,4'-DDE, aldrin, Aroclor-1260, dieldrin, lindane and chlordane) posed a potential risk to human health as a result of ingestion of contaminated fish species that inhabit the Bayou Grande. Because the baseline risk assessment was conducted using conservative assumptions, it was agreed that a more detailed risk assessment would be conducted for the fish ingestion pathway using site-specific values. The results of this site-specific risk assessment could then be used to more accurately assess the potential risk to human health via the fish ingestion pathway for Site 40.

This addendum presents the results of this site-specific risk assessment for the fish ingestion exposure pathway at Site 40. Exposure pathways evaluated for this risk assessment included ingestion of fish by recreational fishermen and subsistence fishermen. Both 95th percentile and mean fish ingestion rates were evaluated for the recreational fishermen, while a reasonable maximum scenario exposure was evaluated for the subsistence fishermen. For recreational fishers, the cumulative noncarcinogenic effects are estimated to be 1 (based on 95th percentile fish ingestion rate) or below (based on mean fish ingestion rate). For subsistence fishers, HQs for noncarcinogenic effects are all below 1, except for mercury (HQ = 6). It has been demonstrated that subsistence fishing does not occur at or near Site 40, therefore this scenario is not valid. For carcinogenic risks, cumulative risks for subsistence fishermen were slightly above the 1E-06 threshold level for several compounds; however, it has been demonstrated that subsistence fishing does not occur at or near the site, therefore this scenario is not valid. Lastly, although the cumulative risks for recreational fishermen (2E-05) are slightly above the regulatory level of 1E-06, these risks are not considered significant due to the likelihood of overestimation of the risk, specifically, the use of the maximum detected value in trophic Level 3 fish, the use of estimated trophic transfer coefficients, the relatively high background concentration of PCBs in Pensacola Bay, and the fact that no allowances were made in the way the fish may be cooked, which may reduce the concentration of chemicals of potential concern in the fish prior to consumption.

In conclusion, based on the calculations of risks presented in Section 5 and the uncertainties associated with these risk calculations, it is believed that the risks associated with the ingestion of contaminated fish from Site 40 are within acceptable limits.

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Table of Contents

List of Tables

List of Attachments

EXECUTIVE SUMMARY

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This addendum presents the results of this site-specific risk assessment for the fish ingestion exposure pathway at Site 40. Exposure pathways evaluated for this risk assessment included ingestion of fish by recreational fishermen and subsistence fishermen. Both 95^{th} percentile and mean fish ingestion rates were evaluated for the recreational fishermen, while a reasonable maximum scenario exposure was evaluated for the subsistence fishermen. For recreational fishers, the cumulative noncarcinogenic effects are estimated to be 1 (based on 95^{th} percentile fish ingestion rate) or below (based on mean fish ingestion rate). For subsistence fishers, HQs for noncarcinogenic effects are all below 1, except for mercury (HQ = 6). It has been demonstrated that subsistence fishing does not occur at or near Site 40, therefore this scenario is not valid. For carcinogenic risks, cumulative risks for subsistence fishermen were slightly above the 1E-06 threshold level for several compounds; however, it has been demonstrated that subsistence fishing does not occur at or near the site, therefore this scenario is not valid. Lastly, although the cumulative risks for recreational fishermen (2E-05) are slightly above the regulatory level of 1E-06, these risks are not considered significant due to the likelihood of overestimation of the risk, specifically, the use of the maximum detected value in trophic Level 3 fish, the use of estimated trophic transfer coefficients, the relatively high background concentration of PCBs in Pensacola Bay, and the fact that no allowances were made in the way the fish may be cooked, which may reduce the concentration of chemicals of potential concern in the fish prior to consumption.

In conclusion, based on the calculations of risks presented in Section 5 and the uncertainties associated with these risk calculations, it is believed that the risks associated with the ingestion of contaminated fish from Site 40 are within acceptable limits.

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 presents a more detailed study of the potential risk via this pathway by using site-specific values concerning fish ingestion rates, fish behavior, receptor characteristics, etc.

2.0 BACKGROUND

Site 40, also known as Bayou Grande, is an estuarine water body adjacent to the northern border of the Naval Air Station Pensacola (NAS Pensacola) in Escambia County. Bayou Grande extends roughly east to west approximately 5 miles inland into the south-southwestern portion of Escambia County. The northern and central portions of NAS Pensacola, and areas of west Warrington adjacent to the bayou, drain into Site 40. Bayou Grande flows eastward into Pensacola Bay near NAS Pensacola's Magazine Point. The total surface area covered by Bayou Grande is approximately 1.5 square miles. The surface area of Site 40 is 310 acres. Site 40 is currently used for swimming, fishing and other boating activities. Seasonal water temperatures limit swimming to the warmer months, while fishing is generally a year-round activity.

In 1998, prey fish (pinfish and killifish) were collected from Site 40 and analyzed for pesticides and polychlorinated biphenyls (PCBs). Seven compounds were detected in the fish species collected: 4,4'-DDD, 4,4'-DDE, aldrin, Aroclor-1260, dieldrin, gamma-BHC (lindane) and gamma-Chlordane. Based on the results of the Site 40 baseline risk assessment as presented in the *Final Remedial Investigation Report* (EnSafe, 1999), these compounds pose a potential risk to subsistence fishermen. Therefore, these compounds were selected as constituents of concern and further evaluated in this assessment.

3.0 EXPOSURE ASSESSMENT

3.1 Selection of Exposure Scenarios

Potential human receptors for the ingestion of contaminated fish species include recreational fishermen and subsistence fishermen. Although some fishing does occur at Site 40, it is limited to boating traffic because of base restrictions on the southern side of the bayou and private residences on the north and west sides of the bayou. Additionally, 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 the data from the Florida Marine Patrol Office, which 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. In addition, commercial fishing does not occur in Pensacola Bay or any Florida coastal water because of the net ban, so fishing is limited to a recreational activity pattern. Despite this evidence that subsistence fishing does not occur in the bayou, this pathway was evaluated in this site-specific risk assessment for comparison, because this pathway was the only fish ingestion pathway considered in the original baseline risk assessment conducted for the *Final Remedial Investigation Report*.

3.2 Evaluation of Bioaccumulation Potential

Bioaccumulation is the uptake and retention of a chemical by an aquatic organism from all surrounding media (e.g., water, food, sediment), whereas bioconcentration refers to the uptake and retention of a chemical by an aquatic organism from water only. Generally, a bioaccumulation factor (BAF) can be estimated by multiplying the bioconcentration factor (BCF) for a compound by a food-chain multiplier (FCM). BCFs and BAFs vary from one invertebrate to another, from one fish to another, and from one tissue to another, and unlike nonpolar organic compounds, lipid normalization does not apply to inorganic compounds.

For many inorganic chemicals, the BCF will be equal to the BAF. In other words, for these chemicals, there is no measurable bioaccumulation from food or other nonwater sources. There are exceptions; however, such as mercury, which can bioaccumulate substantially. Measured values, such as a field-measured BAF, a laboratory-measured BCF multiplied by a field-measured FCM or a laboratory-measured BCF, are recommended for inorganic compounds because no method is available for reliably predicting BCFs or BAFs for inorganic chemicals.

3.3 Identification of Compounds of Potential Concern (COPCs)

Table 1 compares the maximum detected values in fish tissue collected from Site 40 to fish ingestion risk-based concentrations (RBCs) as developed by USEPA, Region III (USEPA, April 12, 1999). The RBCs published in the 1999 document are based on the following equations:

Carcinogenic Effect of Concern:

RBC (mg/kg) = (TR * BWa * ATc) / ((EFr * EDtot * (IRF/1000g/kg) * CPSo))

Noncarcinogenic Effect of Concern:

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

where:

RBC = Risk Based Concentration (milligrams per kilogram [mg/kg]) (contaminant specific)

TR = Target Cancer Risk = 1E-06

THQ = Target Hazard Quotient = 1

TABLE 1
Comparison of Maximum Detections in Whole Body Fish to RBCs

Constituents	Max. Detected Concentrations (mg/kg)	Fish RBCs (mg/kg)[1] Carcinogens	Non-carcinogens	Exceeds RBC?
4,4'-DDD	3.8E-03	1.3E-02	NA	No
4,4'-DDE	1.2E-02	9.3E-03	NA	Yes
Aldrin	6.6E-04	1.9E-04	9.5E-02	Yes
Aroclor-1260	1.0E-01	1.6E-03	NA	Yes
Dieldrin	1.3E-03	2.0E-04	1.6E-01	Yes
Lindane	7.4E-04	2.4E-03	9.5E-01	No
Chlordane	1.7E-03	9.0E-03	1.6E+00	No
Mercury[2]	5.7E+00	NA	3.2E-01	Yes

RBC: risk-based concentration

[1]Fish RBC values represent risk-based concentrations calculated for subsistence fishermen (USEPA, Region 3, April 12, 1999).

[2]Mercury concentrations in Level 4 fish tissue were modeled as described in Attachment A to the text.

BWa	=	Body weight, adult = 70 kg
ATc	=	Averaging Time, carcinogens, = 25,550 days
ATn	=	Averaging Time, noncarcinogens, = 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/mg/kg/day) (contaminant specific)
RfDo	=	Oral Reference Dose (mg/kg/day) (contaminant specific)

The results of this comparison show a potential risk to fish species from the following constituents for which the RBC was exceeded: 4,4'-DDE, aldrin, Aroclor-1260 and dieldrin. It should be noted that the RBC is based on a fish ingestion of 54 g/day, which is similar to a fish ingestion rate for subsistence fishers.

Although the RBC was exceeded for only four of the seven compounds detected in Level 3 fish tissue samples, all seven constituents were identified as COPCs in this risk assessment to conservatively estimate the potential risk to various receptor populations. In addition, mercury was included in this assessment because it was detected in the Site 40 sediment and has the potential to bioaccumulate.

3.4 Estimation of Concentrations in Fish Tissue

Since the fish tissue data presented in Table 1 are for prey species (the data are for pinfish and killifish) and not the gamefish species typically harvested and ingested by receptor populations, the estimated concentrations in gamefish species were modeled using trophic level transfer coefficients (TTCs). This model is detailed in Section 10 of the Remedial Investigation Report. For simplicity, the table presenting the results of the model is repeated in this text (Table 2).

TABLE 2
Estimated Concentrations in Level 4 Fish Species at Site 40

Constituents	Measured Conc. in Level 3 Fish (mg/kg)	TTC[1]	Estimated Conc. in Level 4 Fish with SFF[2] = 1 (mg/kg)	Estimated Conc. in Level 4 Fish with SFF[2] = 0.32 (mg/kg)
4,4'-DDD	3.8E-03	3.254	1.2E-02	4.0E-03
4,4'-DDE	1.2E-02	3.602	4.3E-02	1.4E-02
Aldrin	6.6E-04	1.006	6.6E-04	2.1E-04
Aroclor-1260	1.0E-01	3.733	3.7E-01	1.2E-01
Dieldrin	1.3E-03	1.063	1.4E-03	4.4E-04
Lindane	7.4E-04	1.021	7.6E-04	2.4E-04
Chlordane	1.7E-03	1.999	3.4E-03	1.1E-03
Mercury[3]	NA	NA	5.7E+00	1.8E+00

[1]TTC = trophic transfer coefficient from USEPA, Draft Water Quality Criteria Methodology Revisions: Human Health, Federal Register, August 14, 1998.

[2]SFF = Site Foraging Factor

[3]Mercury concentrations in Level 4 fish tissue were modeled as described in Attachment A to the text.

4.0 DOSE CALCULATIONS

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

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

where:

CDIf = Chronic Daily Intake from fish (mg/kg-day) (contaminant specific)

Cf = Concentration in Level 4 fish (mg/kg) (contaminant specific)

IR = Ingestion Rate of Level 4 fish (kg/day)

recreational fishermen = 0.026 kg/day and 0.0072 kg/day (for 95th percentile and mean values, respectively)

subsistence fishermen = 0.039 kg/day

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 noncarcinogens)

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

4.1 Chronic Daily Intake for the Recreational Fisher

For recreational fishermen in the Gulf of Mexico, the 95th percentile for fish ingestion is 26 g/day and 7.2 g/day is the mean fish ingestion rate (USEPA, 1997). The USEPA Exposure Factors Handbook also states that only 33% of the total fish consumed by recreational fishermen is actually caught locally. The rest is bought commercially. Therefore, the fish ingestion rates for recreational fishers were modified by one-third to reflect that 67% of the fish they consumed was commercially purchased. The modified fish ingestion rates for recreational fishers is therefore 8.6 g/day (95th percentile), and 2.4 g/day (mean value).

Additionally, the USEPA (1997) reports that only between 25 to 50 % of whole fish is edible. The exact percentage depends on the fish species. The bulk of the fish, e.g., bones and organs, are not edible and therefore would not be consumed by receptors. As a result, the fish ingestion rates were further modified by 50 % to reflect how much of the entire fish is edible. The final modified fish ingestion rates for recreational fishermen were therefore 4.3 g/day (95th percentile) and 1.2 g/day (mean value).

4.2 Chronic Daily Intake for the Subsistence Fisher

For subsistence fishers, the recommended default fish ingestion rate is 170 g/day for the 95th percentile. This rate is from the *Exposure Factors Handbook* (USEPA, 1997) 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 general Native American population generally. Several studies show that 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. Therefore, based on the ingestion rates for recreational fishers in the Gulf (i.e., the 95th percentile value of 26 g/day), the estimated fish ingestion rate for subsistence fishers in Florida is 39 g/day (26 g/day x 1.5). As with recreational fishers, this ingestion rate was further modified by 50 % to reflect how much of the fish is actually edible. Therefore, the fish ingestion rate used for subsistence fishermen was 19.5 g/day. It is assumed that all of the fish consumed by subsistence fishermen is caught locally.

4.3 Chronic Daily Intake Summary

Tables 3 and 4 present the results of the calculations for chronic daily intake for the various receptor populations using the receptor-specific fish ingestion rates. Table 3 presents the results for carcinogenic effects, while Table 4 presents the results for noncarcinogenic effects.

5.0 RISK CHARACTERIZATION

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

Carcinogenic Effects:

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

Noncarcinogenic Effects:

$$\text{Hazard Quotient (HQ)} = \text{CDI} / \text{RfD}$$

where:

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

TABLE 3
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue: Carcinogenic Effects

Constituents	Concentration in Level 4 Fish (mg/kg)	CDI for Carcinogenic Effects (mg/kg-day) Recreational Fishermen Based on 95th percentile fish intake rate	Recreational Fishermen Based on mean fish intake rate	Subsistence Fishermen Based on RME scenario
4,4'-DDD	4.0E-03	9.8E-08	3.2E-08	4.5E-07
4,4'-DDE	1.4E-02	3.4E-07	1.1E-07	1.6E-06
Aldrin	2.1E-04	5.3E-09	1.7E-09	2.4E-08
Aroclor-1260	1.2E-01	3.0E-06	9.6E-07	1.4E-05
Dieldrin	4.4E-04	1.1E-08	3.6E-09	5.1E-08
Lindane	2.4E-04	6.0E-09	1.9E-09	2.8E-08
Chlordane	1.1E-03	2.7E-08	8.8E-09	1.2E-07
Mercury	1.8E+00	NA[1]	NA	NA

RME = reasonable maximum exposure

[1]NA = Not applicable, methyl mercury is not a carcinogen.

TABLE 4
Calculation of Chronic Daily Intakes of Constituents in Fish Tissue:
Non-Carcinogenic Effects

		CDI for Carcinogenic Effects (mg/kg-day)		
		Recreational Fishermen		Subsistence Fishermen
Constitutents	Concentration in Level 4 Fish (mg/kg)	Based on 95th percentile fish intake rate	Based on mean fish intake rate	Based on RME scenario
4,4'-DDD	4.0E-03	2.3E-07	6.3E-08	1.1E-06
4,4'-DDE	1.4E-02	8.0E-07	2.2E-07	3.7E-06
Aldrin	2.1E-04	1.2E-08	3.4E-09	5.7E-08
Aroclor-1260	1.2E-01	6.9E-06	1.9E-06	3.2E-05
Dieldrin	4.4E-04	2.6E-08	7.1E-09	1.2E-07
Lindane	2.4E-04	1.4E-08	3.9E-09	6.5E-08
Chlordane	1.1E-03	6.3E-08	1.7E-08	2.9E-07
Mercury	1.8E+00	1.0E-04	2.9E-05	4.8E-04

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). The incremental cancer risk and HQ results for the various receptor populations are summarized in Tables 5 and 6 and discussed in the following subsections.

5.1 Risk Characterization Results for Recreational Fishers

For carcinogenic risks (Table 5), cumulative risks using the modified 95th percentile and mean fish ingestion rates (4.3 g/day and 1.2 g/day, respectively) were above the 1E-06 threshold level; however, the risk calculated for Aroclor-1260 accounted for 94% of the cumulative risk. As presented in Table 6, the calculated hazard for noncarcinogenic effects for recreational fishers are 1 or below (1 is the regulatory threshold level for noncarcinogens).

5.2 Risk Characterization Results for Subsistence Fishers

For carcinogenic risks (Table 5), the cumulative risks for subsistence fishers were above the 1E-06 threshold level. Again, Aroclor-1260 accounted for the majority of the risk (92%). As presented in Table 6, HQs for non-carcinogenic effects for subsistence fishers are all below 1, except for mercury, which is 6.

6.0 UNCERTAINTIES ASSOCIATED WITH THE ESTIMATED RISK

Various uncertainties are unavoidable when conducting human health risk assessments. Specific uncertainties associated with the calculating estimated risk from ingesting contaminated fish species from Site 40 are presented here.

PCB Concentrations in the Ambient Environment

The primary risk driver for carcinogens is Aroclor-1260. Because PCBs are a common contaminant in the region, background levels of PCBs were also evaluated for the Pensacola Bay region. Long, et al. (1997) conducted a study of the sediments in four bays of the

TABLE 5
Summary of Risk Characterization Results: Carcinogenic Effects

	CDI (mg/kg-day)				Carcinogenic Risk		
	Recreational Fishermen		Subsistence Fishermen		Recreational Fishermen		Subsistence Fishermen
Constituents	Based on 95th percentile fish intake rate	Based on mean fish intake rate	Based on RME scenario	Oral SF $(mg/kg\text{-}day)^{-1}$	Based on 95th percentile fish intake rate	Based on mean fish intake rate	Based on RME scenario
4,4'-DDD	9.8E-08	3.2E-08	4.5E-07	2.4E-01	2E-08	8E-09	1E-07
4,4'-DDE	3.4E-07	1.1E-07	1.6E-06	3.4E-01	1E-07	4E-08	5E-07
Aldrin	5.3E-09	1.7E-09	2.4E-08	1.7E+01	9E-08	3E-08	4E-07
Aroclor-1260	3.0E-06	9.6E-07	1.4E-05	2.0E+00	6E-06	2E-06	3E-05
Dieldrin	1.1E-08	3.6E-09	5.1E-08	1.6E+01	2E-07	6E-08	8E-07
Lindane	6.0E-09	1.9E-09	2.8E-08	1.3E+00	8E-09	3E-09	4E-08
Chlordane	2.7E-08	8.8E-09	1.2E-07	3.5E-01	9E-09	3E-09	4E-08
Mercury[1]	NA	NA	NA	NA	NA	NA	NA
				Total =	6E-06	2E-06	3E-05

[1]Methylmercury is not a carcinogen; therefore, these calculations were not conducted.
SF = slope factor

Table 6
Summary of Risk Characterization Results: Non-Carcinogenic Effects

	CDI (mg/kg-day)				Hazard Quotient		
	Recreational Fishermen		Subsistence Fishermen		Recreational Fishermen		Subsistence Fishermen
Constituents	Based on 95th percentile fish intake rate	Based on mean fish intake rate	Based on RME scenario	Oral RfD (mg/kg-day)	Based on 95th percentile fish intake rate	Based on mean fish intake rate	Based on RME scenario
4,4'-DDD	2.3E-07	6.3E-08	1.1E-06	NA	NA	NA	NA
4,4'-DDE	8.0E-07	2.2E-07	3.7E-06	NA	NA	NA	NA
Aldrin	1.2E-08	3.4E-09	5.7E-08	3.0E-05	4E-04	1E-04	2E-03
Aroclor-1260	6.9E-06	1.9E-06	3.2E-05	NA	NA	NA	NA
Dieldrin	2.6E-08	7.1E-09	1.2E-07	5.0E-05	5E-04	1E-04	2E-03
Lindane	1.4E-08	3.9E-09	6.5E-08	3.0E-04	5E-05	1E-05	2E-04
Chlordane	6.3E-08	1.7E-08	2.9E-07	5.0E-04	1E-04	3E-05	6E-04
Mercury	1.0E-04	2.9E-05	4.8E-04	1.0E-4[1]	1E+00	3E-01	5E+00
				Total =	1E+00	3E-01	5E+00

[1]Reported oral RfD value is for methylmercury.
RfD = reference dose

Florida panhandle, including Pensacola Bay. Twenty samples were collected from Pensacola Bay, including three samples from Bayou Grande. The three samples had detected total PCB concentrations of 16.76 ppm at two locations and 53.53 ppm at one location. Other samples in the Bayou Grande area had detectable levels of PCBs, ranging from 24.85 to 106.08 parts per billion (ppb). Based on the results of the 1997 study by Long, et al., approximately one-third of the PCB levels detected at Site 40 may be attributable to background concentrations. Because risk was calculated without considering background levels, it is probably overestimated.

Concentrations in Level 3 Fish Tissue

The maximum detected concentration in the Site 40 fish tissues was used for this risk assessment. It is very unlikely that all fish preyed on by upper trophic level fish would be contaminated at the maximum detected level. The maximum mercury concentration (2.2 ppm) used to calculate the Level 4 fish mercury concentration was not collected at the same location as the prey fish. The maximum mercury concentration was detected at a location over 2 miles away, upstream of the fish collection site. If the mercury concentration (0.22 ppm) in the sediment collected with the fish collection site were used, the calculated risk would be less. Using the maximum detected concentration of a contaminant therefore likely overestimates the calculated risk to receptor populations. It would be more realistic to use the mean or 95th percentile of the mean; however, due to the small sample size collected, this was impractical.

Collection of additional fish tissue samples from Bayou Grande is one method that has been suggested to eliminate some of the uncertainty with modeling the concentrations of contaminants in the red drum from Trophic Level 3 fish. In addition to logistical considerations, there are inherent factors which preclude using higher tropic level fish as a true indicator of risk. Specifically, given the absence of a species which spends its entire life within the confines of the Bayou, any contamination which may be detected in a higher tropic level tissue cannot be attributed to Bayou Grande alone. However, a significant number of red drum would need to be collected from Bayou Grande in order to obtain a realistic estimate of the average tissue concentration of the contaminants in that fish species. Additionally, even if this data were collected, there is limited toxicity information available specifically for the red drum for the compounds of concern for comparison purposes. Since the cumulative cancer risk for recreational fishermen is within an order of magnitude of the regulatory threshold level of 1E-06, and given the other conservative assumptions utilized in the model, collection of additional fish tissue samples is not warranted at this time.

Life History Considerations for the Red Drum

The red drum was selected as representative of trophic Level 4 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 the purposes of this risk assessment, red drum were assumed to spend all of their life in Bayou Grande, thereby overestimating the risk since adult fish would likely spend the majority of time in nearshore ocean waters and only coming 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 Level 4 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.

Diet Composition of Level 4 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. Therefore, the estimated risk may be overestimated because these other food sources may not bioaccumulate COPCs at the same rate as the trophic Level 3 fish (pinfish and killifish) that were used as the basis for predicting concentrations of COPCs in trophic Level 4 fish. As a result, the amount of contaminant ingested by the Level 4 fish may vary with the season and prey species available.

Concentrations in Fish Tissue Following Cooking

The concentration of the COPC in the gamefish is assumed to be constant, even after cooking. While this my be true of some chemicals such as mercury, which binds strongly to proteins, for many organic chemicals such as 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 the estimated risks to the receptor populations were overestimated.

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 the 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.

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 (i.e., lower trophic levels will generally accumulate contaminants at a lower rate than upper trophic levels so the percentage ingested from each trophic level can be an important variable), and the percent of organic carbon of the sediments.

7.0 CONCLUSIONS

Based on the risk calculations (Section 5) and the uncertainties associated with them (Section 6), it is thought that the risks associated with the ingestion of contaminated fish from Site 40 are within acceptable limits. The cumulative HIs for noncarcinogenic effects are all 1 or below (1 is the regulatory threshold level for noncarcinogens), except for mercury for subsistence fishermen (HI = 6). Since subsistence fishing does not occur at or near Site 40, this pathway is not considered to be valid.

For carcinogenic risks, the cumulative risks for subsistence fishermen were slightly above the 1E-06 threshold level; however, as stated previously, it has been demonstrated that subsistence fishing does not occur at or near the site; therefore, this scenario is deemed irrelevant to Site 40. Lastly, although the cumulative carcinogenic risks for recreational fishermen slightly exceed the regulatory level of 1E-06, these risks are not considered significant due to the likelihood of overestimating risk, specifically, the use of the maximum detected value in trophic Level 3 fish, the use of conservatively estimated TTCs, the relatively high background concentrations of PCBs in Pensacola Bay, and the fact that no allowances were made for the way the fish may be cooked, which may reduce the concentration of COPCs in the fish before consumption.

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Attachment A

Red Drum Mercury Exposure Model

RED DRUM MERCURY EXPOSURE MODEL

A model was performed which predicts mercury tissue concentration in the red drum (*Sciaenops ocellatus*) based on concentrations of mercury in the sediment of Site 40. This model is based on a mercury bioaccumulation model developed by NOAA (Evans and Engel, 1994). The model assumes that mercury uptake into the red drum occurs via prey ingestion exclusively. The three prey sources are small fish, crustaceans, and infaunal invertebrates.

The model is developed and performed in the following steps, which each builds on the information gathered from the previous step:

Step 1: Develop a formula which predicts methyl mercury accumulation in the three types of red drum prey based on sediment mercury concentrations and other physical factors.

Step 2: Develop a formula which predicts methyl mercury accumulation in red drum tissue based on the concentrations calculated in Step 1.

Step 3: Perform the model.

Step 4: Evaluate the predicted tissue concentrations against available data regarding mercury effects in fish in order to determine whether estimated methyl mercury concentrations in red drum are high enough to elicit an adverse effect.

METHODOLOGY AND RESULTS

Information relevant to the model that was used to estimate biotransfer of mercury from sediment to the red drum is described in this section.

STEP 1

Predicting mercury tissue concentrations in the food items (e.g., small fish, crustaceans, and infaunal invertebrates) is performed in this step.

Estimating Mercury Concentration in Small Fish

There is little data available for predicting contaminant concentrations in small fish based on mercury concentrations in sediment. In general, there is agreement that the larger species of marine fish with longer life spans usually have the highest concentrations of mercury. Mercury concentrations also increase in fish with increasing body weight. Methyl mercury is the predominant form of mercury that is accumulated.

In a study performed by Walter *et al.*, (1973) wet weight mercury concentrations in freshwater carp were compared to dry weight sediment mercury concentrations. These results are shown in the following table. Although a freshwater fish, the carp (*Cyprinus carpio*) and the yellow perch (*Perca flavescens*) are considered representative of prey species for the red drum in an estuarine environment.

Table 1
Mercury Concentrations in Sediment and Fish Tissue

Study Location	Sediment Concentration Range (mg/kg) Dry Weight	Carp Tissue Concentration Range (mg/kg) Wet Weight	Perch Tissue Concentration Range (mg/kg) Wet Weight
Upper Cheyenne	0.06 - 0.53	0.35 - 0.43	NA
Fishgut Creek	0.04 - 0.62	0.10 - 0.27	0.21
Oak Creek	0.04 - 0.5	0.16 - 0.24	0.15
Agency Creek	0.03 - 0.3	0.23 - 0.66	NA
Whitlocks Bay	0.04 - 0.09	0.17 - 0.29	0.14 - 0.67
Overall Range	0.03 - 0.62	0.10 - 0.66	0.14 - 0.67
Range Midpoint	0.33	0.38	0.41

Notes:
NA = Data not available
Source = Fish tissue concentrations and sediment concentrations are based on Walter et al., 1973.

Based on the carp tissue and perch tissue concentration range midpoint from this study, a coefficient of 1.2 (i.e., 0.38 mg/kg ¸0.33 mg/kg for carp and 0.41 mg/kg ¸0.33 mg/kg for perch) was chosen to represent the transfer of mercury from sediment to small fish tissue, as described below by Formula 1-1:

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

where:

Cf	=	Methyl Mercury in small fish (in ppm on a wet weight basis)
Cs	=	Total Mercury in sediment (in ppm reported on a dry weight basis)

It will also be assumed that 100% of the mercury present in small fish tissue is methyl mercury. Studies have shown that mercury predominantly occurs in the methyl form in fish muscle, which is also the tissue where most of the mercury body burden is maintained (Windom and Kendall, 1979). In a study performed on four freshwater fish species (Grieb *et al.*, 1990), methyl mercury accounted for 99% of the total mercury in fish muscle. Other studies have shown that mercury is converted to its methylated form in fish tissue or by sediment microbes, reducing the significance of the methyl mercury/total mercury ratio during initial deposition or before ingestion.

Estimating Mercury Concentration in Crustaceans and Infaunal Invertebrates

Based on reviews of multiple literature sources by Evans and Engel, 1994, a biota sediment factor (BSF) of 2 was derived for mercury accumulation by all benthic organisms. This means that the mercury concentration in sediment may be multiplied by a factor of 2 in order to estimate the concentration of methyl mercury in benthic tissue. The estimated methyl mercury concentration is divided by another factor of 5 to account for the dry weight to wet weight conversion in tissue.

Presented below are alternate formulae for estimating concentrations of methyl mercury in crustaceans and infaunal invertebrates.

Concentration of methyl mercury in crustaceans (Ccr):

$$Ccr = \left[\frac{(Cs * 2)}{5}\right] * (0.70) \quad \text{(Formula 1-2)}$$

Concentration of methyl mercury in infaunal invertebrates (Cinv):

$$Cinv = \left[\frac{(Cs * 2)}{5}\right] * (0.25) \quad \text{(Formula 1-3)}$$

STEP 2

The methyl mercury concentrations from the three prey species are then incorporated into the formula used to predict wet weight methyl mercury concentrations in the red drum. Red drum are postulated to accumulate mercury from two major sources, prey and surface water. However, surface water is considered to be a minimal exposure route. Within the prey pathway, crustaceans are assumed to comprise 60% of the red drum's diet, small fish 30% of the diet, and other infaunal invertebrates 10%.

For purposes of estimating concentrations of methyl mercury in the target tissues, it is assumed that input and excretion of methyl mercury are in balance at steady state, as described by the following formula:

$$a * R * C_o = C_1 * (g + K) \text{ (Formula 1-4)}$$

where:

a = Assimilation efficiency of methyl mercury from food; a default value of 0.8 is assumed.

R = Feeding rate of target species; assumed to be 0.02 g/g-day for the juvenile red drum

C_o = Methyl mercury concentration in food (ppm)

C_1 = Methyl mercury concentration in target species (ppm)

g = Growth rate coefficient; estimated to be 0.003/day for red drum

K = Methyl mercury excretion rate (expressed in terms of (day); a value of 0.00035/day is used

Bioaccumulation factor of methyl mercury

$$= C_1 / C_o$$

$$= \frac{a * R}{g + K} \qquad \text{(Formula 1-5)}$$

Total methyl mercury concentration in red drum tissue can be calculated using the following formula:

Methyl mercury concentration in red drum

$$= \left(\frac{a * R}{g + K} \right) * \left[(Cf)(\%Cf) + (Ccr)(\%Ccr) + (Cinv)(\%Cinv) \right] \qquad \text{(Formula 1-6)}$$

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
K	=	Methyl mercury excretion rate from the red drum, or 0.00035/day
Cf	=	Methyl mercury tissue concentration in small fish
$\%Cf$	=	Percent of red drum diet composed of small 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

STEP 3

The results of the model are calculated in this step. Mercury was detected in 20 of 143 sediment samples collected from Site 40 at levels ranging from 0.03 mg/kg (J-qualified data; i.e., estimated concentration) to 2.2 mg/kg on a dry weight basis (mean concentration: 0.0893 mg/kg). The mean total organic carbon concentration across Site 40 is 4.2%, which converts to approximately 8.4% organic matter. For the purpose of this modeling, both the mean and maximum concentrations of mercury in sediment were used in the calculations.

The concentration of methyl mercury in small fish is calculated below using Formula 1-1:

Cf (based on the mean concentration)

= (1.2)*(*Cs*)

= (1.2)*(0.0893 mg/kg)

= 0.107 mg/kg

Cf (based on the maximum concentration)

= (1.2)*(*Cs*)

= (1.2)*(2.2 mg/kg)

= 2.64 mg/kg

The concentration of methyl mercury in crustaceans is calculated below using Formula 1-2:

Ccr (based on the mean concentration)

= [(*Cs**2)/5]*(0.7)

= [(0.0893 mg/kg*2)/5]*(0.7)

= 0.025 mg/kg

Ccr (based on the maximum concentration)

= [(*Cs**2)/5]*(0.7)

= [(2.2 mg/kg*2)/5]*(0.7)

= 0.616 mg/kg

The concentration of methyl mercury in infaunal invertebrates is calculated below using Formula 1-3:

Cinv (based on the mean concentration)

= [(Cs*2)/5]*(0.25)
= [(0.0893 mg/kg*2)/5]*(0.25)
= 0.0089 mg/kg

Cinv (based on the maximum concentration)

= [(Cs*2)/5]*(0.25)
= [(2.2 mg/kg*2)/5]*(0.25)
= 0.22 mg/kg

Presented below is the methodology used for calculating the concentration of methyl mercury in red drum tissue using Formula 1-6. Concentrations of methyl mercury in crustaceans and infaunal invertebrates are estimated using Formula 1-2 and Formula 1-3, respectively.

Methyl mercury in red drum tissue (based on the mean concentration of mercury)

= [(*a***R*)/(g + *K*)]*[(*Cf*)(%*Cf*)+(*Ccr*)(%*Ccr*)+(*Cinv*)(%*Cinv*)]

= [(0.8*0.02 g/g-day)/(0.003/day + 0.00035/day)]*[(0.107 mg/kg)*(0.3)+(0.025 mg/kg)*(0.6) +(0.0089 mg/kg)*(0.1)]

= [4.78]*[(0.0321 mg/kg)+(0.015 mg/kg)+(0.00089 mg/kg)]

= 0.229 mg/kg (wet weight)

Methyl mercury in red drum tissue (based on the maximum concentration of mercury)

= [(*a***R*)/(g + *K*)]*[(*Cf*)(%*Cf*)+(*Ccr*)(%*Ccr*)+(*Cinv*)(%*Cinv*)]

= [(0.8*0.02 g/g-day)/(0.003/day + 0.00035/day)]*[(2.64 mg/kg)*(0.3)+(0.616 mg/kg)*(0.6) +(0.22 mg/kg)*(0.1)]

= [4.78]*[(0.792mg/kg)+(0.370mg/kg)+(0.022 mg/kg)]

= 5.660 mg/kg (wet weight)

STEP 4

The predicted concentration of mercury in red drum tissue is then compared to effect thresholds listed in the Environmental Residue Effect Database (ERED) (USACE, 1997) to determine whether it exceeds an effect threshold for fish species. In reviewing the database, the lowest no-observed-effects-dose (NOED) is 0.14 mg/kg wet weight (assumed methyl mercury) in the tissue of the rainbow trout, a predatory freshwater fish for the ingestion pathway. Based on the predicted mercury in red drum tissue, the HQ values are 1.6 (based on the average concentration of mercury in sediment) and 40 (based on the maximum concentration of mercury in sediment).

DISCUSSION AND UNCERTAINTY ANALYSIS

Presented in this section is an evaluation of the sources of uncertainties pertaining to the results of this modeling and a discussion of the results.

Uncertainty Analysis

Presented below are the types of uncertainties associated with the estimated HQ values.

Concentrations of Methyl Mercury in Fish Tissue

Concentrations of methyl mercury in Level 4 fish were estimated based on the conservative assumptions that 100% of the mercury in the prey fish is methyl mercury. Therefore, the estimated concentrations of methyl mercury in Level 4 fish represent upper-bound values and the true values are not expected to be higher than the estimated ones and, in fact, can be lower.

Site Foraging Factor (SFF)

The SFF represents the percentage of red drum's diet that is from prey species at Site 40. For the purpose of this modeling effort, it was conservatively assumed that red drum spend 100% of their time foraging for prey at Site 40.(i.e., an SFF of 1). The use of this conservative assumption is expected to result in an overestimate of concentrations in the red drum. In other words, the use of a more realistic SFF value of 0.32 based on the surface area of Site 40 in Bayou Grande, is likely to result in lower mercury concentrations in red drum.

Trophic Transfer Coefficient

Using trophic transfer values from one study on freshwater fish (Walter et. al., 1973) could also lead to uncertainty when trying to apply these data to the different sediment types within Site 40.

No Adverse Effects Level

Using the no adverse effects level for a freshwater fish that lives in a cool stream environment could also lead to uncertainty. Review of the ERED database presents a lowest adverse effects level for a winter flounder of 2 mg/kg for physiological effects from the injection pathway.

Sources of Mercury in Ambient Environment

Based on past research, it is known that mercury contamination in coastal sediments has resulted from non-point sources such as atmospheric deposition. To evaluate possible influence of non-point sources of mercury in Site 40, data from a comprehensive Pensacola Bay System (PBS) study (Long *et. al.*, 1997) was reviewed and compared to the Site 40 data. The data show that out of 40 sediment samples collected across the PBS, the mean mercury concentration in sediment was 0.23 mg/kg. The mean mercury concentration in sediment from the 143 samples collected in Site 40 was 0.0893 mg/kg (assuming that all non-detect values were equal to half the detection limit). In performing a non-parametric Mann-Whitney Confidence Interval and Test (also known as a Wilcox on Rank Sum Test) on both data sets, it is at least 95% confident that there is no statistically significant difference between the results of both data sets. Therefore, it is reasonable to assume that the mercury concentrations present in Site 40 could have originated from non-point sources not related to Naval activities in and around Site 40.

CONCLUSIONS

A model that was developed by NOAA was used to estimate concentration of mercury in the red drum based on the mercury concentrations reported in sediment samples collected at Site 40. HQs of 1.6 (using the mean mercury concentration reported in sediment samples) and 40 (using the maximum mercury concentration reported in sediment samples) were estimated. The maximum detected concentration of mercury used for this model was detected at one location of Site 40. In fact, mercury was detected at 20 of 143 locations in Bayou Grande. The mean concentration would therefore more realistically estimate risk. Therefore, the results of this modeling suggest that reported levels of mercury in sediment is not expected to result in adverse impacts to the red drum.

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