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UPDATED TECHNICAL MEMORANDUM FOR RISK ASSESSMENT AT SITE 3 CAUSEWAY LANDFILL MCRD PARRIS ISLAND SC

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TETRA TECH NUS

Updated Technical Memorandum for Risk Assessment at Site 3 – Causeway Landfill

Marine Corps Recruit Depot

Parris Island, South Carolina

Southern Division
Naval Facilities Engineering Command

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1.0 BACKGROUND

Site 3 consists of a causeway constructed across a tidal marsh in the northern portion of MCRD Parris Island. The marsh south of the causeway is a vast expanse of thickly vegetated cordgrass, intersected by several tidal channels. The marsh on the northern side of the causeway is essentially a ponded area of open water, with scattered areas of cordgrass. The ponded area north of the site occasionally receives tidal inflow via two sets of three culverts beneath the causeway.

Based on the results of various investigations at Site 3 from 1988 to 1999, an Interim Record of Decision was signed in September 2000 that addressed waste materials and the most significantly impacted sediments at the site. As a result of these investigations, four sediment areas (on the pond side of the causeway) were identified as representing a potentially significant environmental risk that warranted environmental action; and these areas were covered as part of the interim remedy at Site 3. Contaminant concentrations within the covered areas generally exceeded ecological effect range - median (ER-M) values from Long et al., (1995). Detected chemical concentrations near the edges of the areas were generally similar to background or ecological screening values. The contaminants associated with the four areas, Areas 1, 2, 3, and 4, were PAHs, PCBs, pesticides, and pesticides, respectively.

NAVY SAMPLES

After the interim remedy was completed, 20 post-interim construction sediment samples were collected at the site. Fifteen samples were collected on the pond side of the causeway, and five samples were collected on the marsh side. The samples were collected at a distance of 2 to 15 feet from the toe of the recently built slope, in depressions just beyond the edge of the newly installed rip-rap and cover fabric. The samples were scooped from the sediment using a stainless-steel spoon, mixed in a stainless-steel bowl, and transferred to the sample jars for analysis. The locations of the sampling points are shown on Figure 1 (PAI-03-SD-41-01 through PAI-03-SD-60-01). A screening level ecological risk assessment (SERA) was conducted as part of the Technical Memorandum Post-Interim Construction Risk Assessment Site/SWMU 3 – Causeway Landfill MCRD Parris Island, South Carolina (TtNUS, 2002) [Tech Memo] to determine whether there were potential risks to sediment invertebrates, mammals, and/or birds from exposure to chemicals in sediment remaining at the site after an interim remedy was implemented.

This updated 2008 Technical Memorandum details the subsequent evaluation of that 2003 Tech Memo by the Marine Corps Recruit Depot Parris Island (MCRD) Partnering Team. The Partnering Team consists of representatives of the US Navy, MCRD, US Environmental Protection Agency (US EPA), South Carolina Department of Health and Environmental Control (SCDHEC) and Natural Resource Trustees. The Natural Resource Trustees include South Carolina Department of Natural Resources

(SCDNR), National Oceanic and Atmospheric Administration (NOAA), and the Fish and Wildlife Service (FWS).

EPA SAMPLES

In order to verify the initial post-remedy SERA conclusion that no excessive ecological risk remained in sediment sampled outside the landfill cover, the US EPA performed limited confirmatory sediment sampling at the site. These marsh-side samples were analyzed for PAHs, select metals (arsenic, copper, lead, mercury, and zinc), and select pesticides (DDT, DDE, DDD, alpha chlordane, and gamma chlordane) (five samples, PAI-03-SD-41 through -45). Area 1 samples were analyzed for PAHs and select metals (four samples, PAI-03-SD-46 through -49). Area 2 samples were analyzed for PCBs and select metals (three samples, PAI-03-SD-50 through -52). Areas 3 (three samples, PAI-03-SD-53 through -55) and Area 4 (five samples, PAI-03-SD-56 through -60) samples were analyzed for select pesticides (DDT, DDE, DDD, alpha chlordane, and gamma chlordane) and select metals. The data from these new samples were initially evaluated for the SERA qualitatively and informally in MCRD Partnering Team meetings. The Navy feels this was appropriate since (1) the Team generally supported that the original post-remedy numerical risk assessment did not indicate significant unacceptable risk, and (2) the EPA sample concentrations substantially confirmed that high concentrations of contamination did not extend further out into the marsh beyond Area 4. The EPA sampling points are shown on Figure 2.

PATH FORWARD

The Team has determined that a formal documentation of the evaluation of the Navy and EPA sample results for purposes of SERA and HHRA is appropriate and necessary in order to support the selection of a final remedy at Site 3. This Technical Memorandum serves as that documentation.

2.0 HUMAN HEALTH RISK ASSESSMENT

This section presents an evaluation of the human health risks resulting from potential exposures to sediment at Site 3 using the data collected by TtNUS in October 2001 and U.S. EPA in April 2003. The Human Health Risk Assessment (HHRA) presented in the Site 3 RFI/RI Report (TtNUS, 1999) evaluated potential exposures to sediments by construction workers, maintenance workers, and recreational users. Potential risks for direct contact exposures (e.g., incidental ingestion, dermal contact) to sediments were within U.S. EPA acceptable risk levels. The HHRA also used the sediment data to estimate risks to human health through theoretical partitioning of contaminants to fish and human consumption of fish by recreational users. Risks for exposures through ingestion of fish using stringent exposure assumptions exceeded U.S. EPA target risk levels. Consequently this HHRA will only evaluate potential exposures to recreational users through ingestion of fish.

The following current U.S. EPA and United States Navy risk assessment guidance documents were used to develop the framework for this HHRA:

- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) (U.S. EPA, 1989).

- Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins (U.S. EPA, 2000).

- Exposure Factors Handbook. Office of Health and Environmental Assessment (U.S. EPA, 1997a).

- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (U.S. EPA, 2001).

- Conducting Human Health Risk Assessments under the Environmental Restoration Program (DON, 2001).

This HHRA follows the methodology presented in the approved Site 3 RFI/RI Report (TtNUS, 1999).

This HHRA consists of five components: selection of chemicals of potential concern (COPCs), exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. Sections 2.1 through 2.5 contain detailed discussions of the five components of the HHRA.

2.1 SELECTION OF COPCS

The selection of COPCs is a qualitative screening process used to limit the number of chemicals quantitatively evaluated in the baseline HHRA to those site-related constituents that dominate overall potential risks. Data compiled from samples collected during the 2001 and 2003 field investigations were used in the selection of COPCs. In general, a chemical was selected as a COPC and retained for further quantitative risk evaluation if the maximum concentration detected in a sediment medium exceeded the conservative screening level(s). Chemicals eliminated from further evaluation during this evaluation are assumed to present minimal risks to potential human receptors.

2.1.1 Derivation of Screening Criteria

U.S. EPA Region IV risk assessment guidance recommends using U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for the selection of COPCs. There are no PRGs available for ingestion of fish, consequently the U.S. EPA Region III Risk-Based Concentrations (RBCs) were used as the risk-based screening levels. The risk-based screening concentrations correspond to a systemic Hazard Quotient (HQ) of 0.1 (for noncarcinogens) or a lifetime cancer risk of 1×10^{-6} (for carcinogens). Note that the Region 3 RBCs are based on a HQ of 1.0 and the screening concentrations are based on a HQ of 0.1. The RBCs used as screening levels for non-carcinogenic chemicals have been divided by a factor of 10 to further account for the potential cumulative effects of several chemicals affecting the same target organ or producing the same adverse noncarcinogenic health effect.

Because of the lack of toxicity data, risk-based COPC screening levels are not available for some compounds [e.g., benzo(g,h,i)perylene, phenanthrene, and alpha- and gamma-chlordane]. Surrogates were selected for these chemicals based on similar chemical structures. In the COPC screening, pyrene was selected as a surrogate for benzo(g,h,i)perylene and phenanthrene, and chlordane was selected as a surrogate for alpha- and gamma-chlordane.

2.1.2 Estimation of Fish Tissue Concentrations

No fish tissue samples were collected at Site 3. Fish tissue concentrations were estimated using sediment concentrations and biota sediment accumulation factors (BSAFs) with the following equation:

$$C_{fish} = BSAF \times (C_{sed} / f_{oc}) \times f_i$$

Where

C_{fish}	=	estimated chemical concentration in fish tissue (mg/kg)
C_{sed}	=	chemical concentration in sediment (mg/kg)
BSAF	=	biota-sediment accumulation factor
f_{oc}	=	total organic carbon (TOC) of sediment expressed as a decimal fraction
f_i	=	organism lipid content expressed as a decimal fraction.

Sediment samples collected in October 2001 were not analyzed for TOC, so a value of 0.01 was used for f_{oc}. The lipid content was assumed to be 0.01. The BSAFs are shown in Table 2-1 and were obtained from the following sources:

- Organic compounds: The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, National Sediment Quality Survey (U.S. EPA, 2004).

- Inorganic compounds: Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for Oak Ridge Reservation (ORNL, 1998).

Because sediment-to-fish BSAFs are not available for metals, sediment-to-aquatic invertebrate BSAFs from ORNL (1998) were used to estimate tissue concentrations in fish. The BSAFs for metals are not normalized to lipids or TOC, so concentrations of metals in benthic invertebrates were estimated by multiplying each COPC's sediment concentration by its associated BSAF.

2.1.3 COPCs Selected for HHRA

A comparison of the maximum estimated fish tissue concentrations to screening levels for ingestion of fish tissue is presented in Table 2-1. Estimated concentrations of the following chemicals exceeded the risk-based COPC screening levels for fish; therefore, these chemicals were retained as COPCs for fish at Site 3.

- SVOCs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene).

- Pesticides [4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and alpha-chlordane

- Inorganics [arsenic, copper, mercury, and zinc.]

In accordance with U.S. EPA Region IV guidance (2000), since several carcinogenic PAHs have maximum concentrations exceeding the screening criteria, all carcinogenic PAHs were retained as COPCs for fish tissue.

2.2 EXPOSURE ASSESSMENT

This portion of the risk assessment defines and evaluates, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, to identify potentially exposed populations and applicable exposure pathways, to calculate concentrations of COPCs to which receptors might be exposed, and to estimate chemical intakes under the identified exposure scenarios.

A detailed exposure assumption was presented in the Site 3 RFI/RI (TtNUS, 1999). This section presents only the information that was used to evaluate exposures to recreational users through the ingestion of fish.

2.2.1 Exposure Point Concentrations

As discussed in Section 2.1.2, no fish tissue samples were collected at Site 3 therefore fish tissue concentrations were estimated using sediment concentrations and BSAFs. In the Site 3 HHRA two sets of exposure point concentrations (EPCs) were estimated. The first set used maximum concentrations of COPCs in sediment which represents a worse case scenario. The second set used the average concentration of COPCs in sediment and was designed to represent a more realistic condition in that migratory fish species are unlikely to be exposed to sediment from only one location. The same methodology was used to estimate EPCs in this HHRA.

U.S. EPA Region IV has adopted a Toxicity Equivalence Factor (TEF) approach to evaluate potentially carcinogenic PAHs. These TEFs are based on the relative potency of each compound relative to that of benzo(a)pyrene. TEFs for the individual carcinogenic PAHs are as follows:

Compound	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

The TEFs are used to convert each individual carcinogenic PAH concentration into an equivalent concentration of benzo(a)pyrene. Using individual benzo(a)pyrene equivalent concentrations, an exposure point concentration for carcinogenic PAHs derived.

The fish tissue concentrations were estimated using the equation presented in Section 2.2.1 and are summarized in Table 2-2.

2.2.2 Chemical Intake Estimation for Ingestion of Fish

The fish consumption exposure pathway was evaluated for adult recreational users who consume fish that were caught at Site 3. Intakes for the fish ingestion exposure route were estimated using the following equation (U.S. EPA, 1989):

$$\text{Intake} = \frac{(C_{fish})(IR)(FI)(EF)(EF)}{(BW)(AT)}$$

where:

Intake	=	recreational fish ingestion intake (mg/kg-day)
C_{fish}	=	chemical concentration in fish tissue (mg/kg)
IR	=	ingestion rate (kg/meal)
FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (meals/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/yr;
		for carcinogens, AT = 70 yr x 365 days/yr

Exposure assumptions are summarized in Table 2-3. The two scenarios that were evaluated for the adult recreational user in the Site 3 RFI/RI (TtNUS, 1999) were evaluated in this HHRA. The first scenario used U.S. EPA Region IV default values (2000), which assumed an individual ingested 0.054 kg-fish per meal (IR) for 350 meals per year (EF) over a 30 year period (ED). The second scenario was based on site-specific considerations. It was assumed that the recreational user fished at the site 45 days per year, which is approximately 1 day per week. It was also assumed that the fish the adult recreational user caught at the site supplied one meal a week, for a total of 45 meals per year (EF). The U.S. EPA Region IV suggested default value of 0.145 kg-fish/meal for site-specific evaluations was used for the fish ingestion rate (IR). It was assumed the adult recreational user was a military personnel stationed at the

base who spent two 3-year tours of duty or 6 years at the site (ED). All other exposure parameters for ingestion of fish tissue are standard U.S. EPA default values.

2.3 TOXICITY ASSESSMENT

The objective of a toxicity assessment is to identify the potential for human health hazards and adverse effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects will be defined for the identified COPCs. Quantitative toxicity values (CSFs and RfDs) determined during this component of the risk assessment will be integrated with outputs of the exposure assessment to characterize the potential for adverse health effects for each receptor group. A CSF is an indicator of the potency of a chemical carcinogen (i.e., the greater the CSF, the more potent the carcinogen). More formally, a CSF is an upper bound estimate, approximating a 95-percent confidence limit, on the increased cancer risk from a lifetime exposure to a carcinogen. This estimate is usually expressed in units of proportion (of a population) affected per mg/kg/day of a carcinogen. An RfD is the dose at which and below which adverse noncarcinogenic effects are not anticipated.

Oral and inhalation RfDs and CSFs to be used in the site-specific risk assessments will be obtained from the following primary EPA sources (U.S. EPA, 2003):

- Integrated Risk Information System (IRIS) (Online).

- EPA Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical specific basis when requested by EPA's Superfund program.

- Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and the Annual Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997b).

Although RfDs and CSFs can be found in several toxicological sources, EPA's IRIS on-line database is the preferred source of toxicity values. This database is continuously updated and values presented have been verified by U.S. EPA. Oral RfDs and CSFs for the constituents identified as COPCs for Site 3 are presented in Tables 2-4 and 2-5.

2.4 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposure to COPCs at Site 3. Section 2.4.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for Site 3 is provided in Section 2.4.2.

2.4.1 Quantitative Analysis

Quantitative estimates of risk were calculated according to risk assessment methods outlined in U.S. EPA guidance (1989).

Lifetime cancer risks are expressed in the form of dimensionless probabilities, referred to as ILCRs, based on CSFs. Noncarcinogenic risk estimates are presented in the form of HQs that are determined through a comparison of intakes with published RfDs. ILCR estimates were generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$\text{ILCR} = (\text{Estimated Exposure Intake})(\text{CSF})$$

If the above equation resulted in an ILCR greater than 0.01, the following equation was used:

$$\text{ILCR} = 1-[\exp(-\text{Estimated Exposure Intake})(\text{CSF})]$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million people.

As mentioned previously, noncarcinogenic risks were assessed using the concepts of HQs and HIs. The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$\text{HQ} = (\text{Estimated Exposure Intake}) / (\text{RfD})$$

An HI was generated by summing the individual HQs for all COPCs. The HI is not a mathematical prediction of the severity of toxic effects and, therefore, is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

2.4.2 Comparison of Quantitative Risk Estimates to Benchmarks

To interpret the quantitative risk estimates and to aid risk managers in determining the need for remediation, quantitative risk estimates were compared to typical U.S. EPA risk benchmarks. The U.S. EPA has defined a "target cancer risk" range of 1×10^{-6} to 1×10^{-4} (i.e., a one-in-ten thousand to one in-one-million chance of developing cancer). Individual or cumulative ILCRs greater than 1×10^{-4} are typically not considered as protective of human health, and ILCRs less than 1×10^{-6} are typically regarded as protective. HQs and HIs are typically evaluated using a value of 1.0. Generally, adverse noncarcinogenic health effects are not anticipated if an HQ or HI, developed on a target organ-/effect-specific basis, does not exceed 1.0 (unity). If an HI exceeds unity, a segregation of target organ effects associated with exposure to COPCs was performed. Only those chemicals that affect the same target organ(s) or exhibit similar critical effect(s) were regarded as truly additive. Consequently, it may be possible for a cumulative HI to exceed 1.0, but no adverse health effects are anticipated if the COPCs do not affect the same target organ or exhibit the same critical effect.

2.4.3 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for Site 3. Two scenarios were evaluated for adult recreational users exposed to COPCs via ingestion of fish tissue. The first scenario (conservative) used U.S. EPA Region IV default exposure assumptions. The second scenario (site-specific) used exposure assumptions based on site-specific considerations. For each scenario, HIs and ILCRs were estimated using fish tissue concentrations based on the maximum detected and average concentrations of COPCs in sediments. Potential cancer risks and HIs for the evaluated scenarios are summarized in Table 2-6. Sample calculations and the results of the risk assessment in RAGS Part D format are included in Appendix A.

Under the conservative scenario, the HI based on the maximum concentrations of COPCs in sediments was 7, which exceeds the acceptable level of 1. Copper (HQ = 3) and zinc (HQ = 2) were the major contributors to the HI. The HI based on average concentrations of COPCs in sediment was 0.8, which is less than the acceptable level of 1.

The ILCR based on the maximum concentrations of COPCs in sediment under the conservative scenario was 4×10^{-4}, which exceeds the U.S. EPA target risk range of 10^{-4} to 10^{-6}. Carcinogenic PAHs and arsenic were the major contributors to the ILCRs. The ILCR based on the average concentration of COPCs in sediment was 6×10^{-5}, which is within the U.S. EPA target risk range.

Under the site-specific scenario, the HI based on the maximum concentration of COPCs in sediments was 2, which exceeds the acceptable level of 1, although the HQs for the individual target organs were all

less than 1. The HI based on average concentrations of COPCs in sediment was 0.2, which is less than the acceptable level of 1.

The ILCRs based on the maximum detected and average concentrations of COPCs in sediment under the site-specific scenario were 3×10^{-5} and 4×10^{-6}, respectively, which are within the U.S. EPA target risk range.

In summary, under the conservative scenario, the HI and ILCR based on the maximum detected concentrations of COPCs in sediment exceeded acceptable levels. The HI and ILCR based on average concentrations of COPCs in sediment under the conservative scenario; and HIs and ILCRs based on the maximum detected and average concentrations of COPCs in sediments under the site-specific scenario were within acceptable levels.

2.5 UNCERTAINTY ANALYSIS

A detailed discussion of uncertainties associated with the various aspects of the HHRA, in general, was presented in Site 3 HHRA. Uncertainties specific to this HHRA are presented below.

Site-specific fish tissue samples were not collected as part of this investigation. Therefore, chemical concentrations in fish tissues were estimated using BSAFs. These bioaccumulation factors were derived from literature, and do not take into account site-specific factors such as pH that can affect bioaccumulation. The sediment-to-fish BSAFs for organic chemicals, however, do incorporate the lipid contents of fish, and TOC of the sediment into the estimation of chemical concentrations in fish tissue. Even so, there are uncertainties as to the actual bioaccumulation of organic chemicals in fish tissue samples.

The sediment samples were collected along the sides of the causeway in areas where contamination was suspect to be present before the interim action. Therefore the sediment concentrations used in this HHRA are most likely higher than the concentrations to which the fish are routinely exposed.

The methodology for estimating fish tissue concentrations using sediment concentrations assumes that the home range of the fish is restricted to the sediment in the immediate vicinity of the site. In actuality the fish's home range will consist of an area that is much larger than the site. Consequently there is uncertainty associated with the estimation of fish tissue concentrations using site sediment concentrations.

2.6 RECREATIONAL FISHING / FISH CONSUMPTION

The HHRA for Site 3 evaluated potential risks from ingestion of fish caught at the site. Assuming that fish caught at the site supplied 45 meals a year (approximately one meal a week), this resulted in an incremental lifetime cancer risk (ILCR) of 4×10^{-6} and a hazard index (HI) of 0.2. Carcinogenic PAHs were the main contributor to the ILCR. Copper and mercury were the major contributors to the HI. Next an evaluation was performed to determine how much fish caught at the site could be consumed without exceeding a target risk level of 1×10^{-4} or an HI of 1. Using the USEPA Region 4 recommended meal size of 0.145 kg, an individual could consume 686 meals a year or approximately 1.8 meals per day. The HI for mercury is the limiting factor on the number of meals per year.

The following items should be considered for the fish ingestion pathway:

- No fish tissue samples were collected at Site 3. Fish tissue concentrations used in the evaluation were estimated from sediment concentrations.

- Concentrations of mercury in the post-interim construction sediment samples ranged from non-detect to 0.2 mg/kg. Concentrations of mercury in background samples collected from the Site 3 RFI (TtNUS, 1999) ranged from non-detect to 0.1 mg/kg.

- The sediment samples were collected along the sides of the causeway in areas where contamination was suspect to be present before the interim action. Therefore the sediment concentrations used in this evaluation are most likely higher than the concentrations to which the fish are routinely exposed

- The estimated concentration of mercury in fish tissue used in this evaluation was 0.12 mg/kg. This is at the low end of the range of the mean concentrations of mercury in fresh water fish (0.09 mg/kg to 0.52 mg/kg) reported in USEPA's Mercury Update: Impact on Fish Advisories, June 2001.

- South Carolina has issued mercury advisories for water bodies upgradient of Parris Island, although there is no data for the Parris Island area. USEPA recommends eating only one meal per week if no advisories are available.

2.7 HHRA REFERENCES

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TABLE 2-1
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - FISH TISSUE
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CAS Number	Chemical	Minimum Sediment Concentration[1]	Maximum Sediment Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	BSAF[3]	Estimated Fish Tissue Concentration[4]	Range of Background Concentrations[5]	USEPA Region 3 RBCs for Fish Ingestion (mg/kg)[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Semivolatile Organic Compounds													
83-32-9	Acenaphthene	28 J	28 J	ug/kg	PAI-03-SD-41-01-D	1/9	26 - 70	0.29	8.12	NA	8100 N	No	BSL
120-12-7	Anthracene	14 J	78 J	ug/kg	PAI-03-SD-41-01-D	2/9	26 - 70	0.29	22.6	NA	41000 N	No	BSL
56-55-3	**Benzo(a)anthracene**	12 J	300 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	87.0	NA	**4.3 C**	**Yes**	ASL
50-32-8	**Benzo(a)pyrene**	11 J	170 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	49.3	NA	**0.43 C**	**Yes**	ASL
205-99-2	**Benzo(b)fluoranthene**	10 J	230 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	66.7	NA	**4.3 C**	**Yes**	ASL
191-24-2	Benzo(g,h,i)perylene	12 J	71 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	1	71.0	NA	4100 N[8]	No	BSL
207-08-9	Benzo(k)fluoranthene	7 J	82 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	23.8	NA	43 C	No	BSL
218-01-9	Chrysene	6 J	190 J	ug/kg	PAI-03-SD-41-01-D	6/9	28 - 70	0.29	55.1	NA	430 C	No	BSL
53-70-3	**Dibenzo(a,h)anthracene**	12 J	26 J	ug/kg	PAI-03-SD-41-01-D	2/9	28 - 70	0.29	7.54	NA	**0.43 C**	**Yes**	ASL
206-44-0	Fluoranthene	21 J	470 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	136	NA	5400 N	No	BSL
86-73-7	Fluorene	8 J	37	ug/kg	PAI-03-SD-41-01-D	2/9	26 - 70	0.29	10.7	NA	5400 N	No	BSL
193-39-5	**Indeno(1,2,3-cd)pyrene**	18 J	120 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	34.8	NA	**4.3 C**	**Yes**	ASL
85-01-8	Phenanthrene	7 J	320 J	ug/kg	PAI-03-SD-41-01-D	5/9	28 - 70	1	320	NA	4100 N[8]	No	BSL
129-00-0	Pyrene	12 J	330 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	95.7	NA	4100 N	No	BSL
Pesticides/PCBs													
72-54-8	**4,4'-DDD**	1.4 J	58	ug/kg	PAI-03-SD-59-01	8/16	5.5 - 19	0.28	16.2	NA	**13 C**	**Yes**	ASL
72-55-9	**4,4'-DDE**	1.2 J	26	ug/kg	PAI-03-SD-59-01	15/16	5.7 - 5.7	7.7	200	NA	**9.3 C**	**Yes**	ASL
50-29-3	**4,4'-DDT**	1.1 J	12 J	ug/kg	PAI-03-SD-41-01	5/16	4.3 - 19	1.67	20.0	NA	**9.3 C**	**Yes**	ASL
5103-71-9	**alpha-Chlordane**	2.8 J	6.6	ug/kg	PAI-03-SD-42-01	2/13	2.2 - 9.6	4.77	31.5	NA	**9 C[9]**	**Yes**	ASL
5103-74-2	gamma-Chlordane	2 J	3.4	ug/kg	PAI-03-SD-54-01	2/13	2.2 - 9.6	2.22	7.55	NA	9 C[9]	No	BSL
Inorganics													
7440-38-2	**Arsenic**	0.84	13.6	mg/kg	PAI-03-SD-44-01	23/23	- - -	0.69	0.375	NA	**0.0021 C**	**Yes**	ASL
7440-50-8	**Copper**	1.1	27.1	mg/kg	PAI-03-SD-44-01	20/20	- - -	5.25	142	NA	**5.4 N**	**Yes**	ASL
7439-92-1	Lead	4.2	44.9 J	mg/kg	PAI-03-SD-60-01	23/23	- - -	0.607	27.3	NA	NA	No	NTX
7439-97-6	**Mercury**	0.01	0.2	mg/kg	PAI-03-SD-48-01	20/23	0.2 - 0.2	2.868	0.574	NA	**0.041 N[10]**	**Yes**	ASL
7440-66-6	**Zinc**	6.7	93.3 J	mg/kg	PAI-03-SD-58-01	20/20	- - -	7.527	702	NA	**41 N**	**Yes**	ASL

Footnotes:
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - Sediment to invertebrate biotransfer factors were used for the inorganics without sediment to fish biotransfer factors.
4 - For organics the estimated fish tissue concentration = BSAF x Sediment Concentration x f_i / f_{oc}.
f_i = lipid content (0.01), foc= fraction organic carbon (0.01).
For inorganics the estimated fish tissue concentration = BASF x Sediment Concentration.
5 - No background soil samples were collected
6 - The EPA Region 3 RBC for fish ingestion is presented. Value represents the risk based screening level divided by 10 to correspond to a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag), or an incremental cancer risk of 1.0E-6 for carcinogens (denoted with a "C" flag) (USEPA, April 2006).
7 - The chemical is selected as a COPC if the estimated fish tissue concentration exceeds the risk-based COPC screening level.
8 - Pyrene is used as a surrogate for benzo(g,h,i)perylene and phenanthrene.
9 - Chlordane is used as a surrogate for alpha- and gamma-chlordane.
10 - Value is for methylmercury.
Shaded criterion indicates that the maximum detected concentration exceeds one or more screening criteria. Shaded chemical name indicates that the chemical was retained as a COPC.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirements To Be Considered
BSAF = Biota sediment accumulation factor
C = Carcinogen
COPC = Chemical Of Potential Concern
J = Estimated value
N = Noncarcinogen
NA = Not Applicable/Not Available

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level and site background.

For elimination as a COPC:
BSL = Below COPC Screening Level
NTX = No toxicity criteria

Associated Samples

PAI-03-SD-41-01	PAI-03-SD-45 PAI-03-SD-51-01	PAI-03-SD-57-01
PAI-03-SD-41-01-D	PAI-03-SD-46 PAI-03-SD-52-01	PAI-03-SD-58-01
PAI-03-SD-42-01	PAI-03-SD-47 PAI-03-SD-53-01	PAI-03-SD-59-01
PAI-03-SD-43-01	PAI-03-SD-48 PAI-03-SD-54-01	PAI-03-SD-60-01
PAI-03-SD-44-01	PAI-03-SD-49 PAI-03-SD-55-01	
PAI-03-SD-45-01	PAI-03-SD-50 PAI-03-SD-56-01	

TABLE 2-2
EXPOSURE POINT CONCENTRATIONS
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical	Maximum Detected Concentration in Sediment (mg/kg)	BSAF[1]	Maximum Estimated Fish Tissue Concentration[2] (mg/kg)	Average Concentration in Sediment (mg/kg)	BSAF[1]	Average Estimated Fish Tissue Concentration[2] (mg/kg)
Benzo(a)pyrene Equivalents	0.262	0.29	0.076	0.063	0.29	0.017
4,4'-DDD	0.058	0.28	0.016	0.011	0.28	0.003
4,4'-DDE	0.026	7.7	0.200	0.005	7.7	0.036
4,4'-DDT	0.012	1.67	0.020	0.007	1.67	0.010
alpha-Chlordane	0.0066	4.77	0.031	0.004	4.77	0.019
Arsenic	13.6	0.69	0.375	4.70	0.143	0.027
Copper	27.1	5.25	142	9.10	1.556	14.2
Mercury	0.2	2.868	0.574	0.087	1.136	0.099
Zinc	93.3	7.527	702	40.6	1.936	78.5

Notes:

1 - Biota sediment accumulation factor (BSAF).
BSAFs for organics are from The Incidence and Sevirty of Sediment Contamination in Surface Waters of the United States, National Sediment Quality Survey:Second Edition, USEPA, November 2004.
BSAFs for inorganics are from Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation, Oak Ridge National Laboratory, March 1998. The 90th percentile values are used to estimate the maximum fish tissue concentrations and the mean values are used to estimate the average fish tissue concentrations.

2 - Estimated concentration = BSAF x (Sediment Concentration / 0.01) x 0.01.

TABLE 2-3

SUMMARY OF EXPOSURE INPUT PARAMETERS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Exposure Parameter	Conservative	Site-Specific
All Exposures		
Ingestion Rate (kg/meal)	0.054	0.145
Fraction Ingested (unitless)	1	1
Exposure Frequency (meals/year)	350	45[(1)]
Exposure Duration (years)	30	6[(2)]
Body Weight (kg)	70	70
Averaging Time - noncarcinogens (days)	10,950	2,190
Averaging Time - carcinogens (days)	25,550	25,550

Notes:
All exposure assumptions are USEPA Region IV default values unless otherwise noted.
1 - Assumes approximately one meal per week.
2 - Assumes a recreational user is a military personnel stationed at the base who spends two 3-year tours of duty at the site.

TABLE 2-4
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds										
Benzo(a)pyrene Equivalents	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticides										
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	Chronic	5.0E-04	mg/kg/day	1	5.0E-04	mg/kg/day	Liver	100/1	IRIS	2/14/2008
alpha-Chlordane	Chronic	5.0E-04	mg/kg/day	1	5.0E-04	mg/kg/day	Liver	300/1	IRIS	2/14/2008
Inorganics										
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, CVS	3/1	IRIS	2/14/2008
Copper	Chronic	4.0E-02	mg/kg/day	1	4.0E-02	mg/kg/day	GS	NA	HEAST	7/1997
Mercury	Chronic	3.0E-04	mg/kg/day	0.07	2.1E-05	mg/kg/day	Autoimmune	1000/1	IRIS	2/14/2008
Zinc	Chronic	3.0E-01	mg/kg/day	1	3.0E-01	mg/kg/day	Blood	3/1	IRIS	2/14/2008

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005.
2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.

Definitions:
CVS = Cardiovascular system
GS = Gastrointestinal
IRIS = Integrated Risk Information System
NA = Not Applicable

TABLE 2-5
CANCER TOXICITY DATA -- ORAL/DERMAL
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds								
Benzo(a)pyrene Equivalents	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	2/14/2008
Pesticides								
4,4'-DDD	2.4E-01	$(mg/kg/day)^{-1}$	1	2.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	2/14/2008
4,4'-DDE	3.4E-01	$(mg/kg/day)^{-1}$	1	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	2/14/2008
4,4'-DDT	3.4E-01	$(mg/kg/day)^{-1}$	1	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	2/14/2008
alpha-Chlordane	3.5E-01	$(mg/kg/day)^{-1}$	1	3.5E-01	$(mg/kg/day)^{-1}$	B2	IRIS	2/14/2008
Inorganics								
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	2/14/2008
Copper	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	C	IRIS	2/14/2008
Zinc	NA	NA	NA	NA	NA	D	IRIS	2/14/2008

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.
IRIS = Integrated Risk Information System.
NA = Not Available.

EPA Group:
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.
E - Evidence of noncarcinogenicity.

TABLE 2-6

SUMMARY OF CANCER RISKS AND HAZARD INDICES
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an HI > 1
Recreational Users	Fish (Maximum Concentration)	Conservative	4E-04	cPAHS, Arsenic	4,4'-DDE	4,4'-DDT, alpha-Chlordane	7	Copper, Zinc
		Site-Specific	3E-05	--	--	cPAHs, Arsenic	2	--
	Fish (Average Concentration)	Conservative	6E-05	--	cPAHs	Arsenic, 4,4'-DDE, alpha-Chlordane	0.9	--
		Site-Specific	4E-06	--	--	cPAHs	0.2	--

cPAHs - Carcinogenic polynuclear aromatic hydrocarbons.
Conservative - USEPA Region IV default exposure assumptions (see Table 6-3).
Site-Specific - Values based on site-specific considerations (see Table 6-3).

DRAWING NO. FIGURE 1 REV. 0

HORSE ISLAND

CAUSEWAY ASPHALT ROAD

HISTORICAL EDGE OF CAUSEWAY

HISTORICAL EDGE OF CAUSEWAY

PAI 03 SD 46

PAI 03 SD 47

PAI 03 SD 48

SEDIMENT AREA 1

PAI 03 SD 49

EDGE OF COVER

PAI 03 SD 41

EDGE OF COVER

PAI 03 SD 50

PAI 03 SD 51

SEDIMENT AREA 2

PAI 03 SD 52

PAI 03 SD 42

CULVERT

MALECON DRIVE

PARRIS ISLAND

POND SIDE

PAI 03 SD 43

PAI 03 SD 44

CULVERT

MARSH SIDE

PAI 03 SD 53

PAI 03 SD 54

PAI 03 SD 55

SEDIMENT AREA 3

PAI 03 SD 45

PAI 03 SD 56

PAI 03 SD 57

SEDIMENT AREA 4

PAI 03 SD 58

PAI 03 SD 59

PAI 03 SD 60

RIBBON CREEK

TEMPORARY ROAD

CAUSEWAY ASPHALT ROAD

LEGEND:

- 1998 SEDIMENT SAMPLE LOCATION
- 1999 SEDIMENT SAMPLE LOCATION
- 2001 SEDIMENT SAMPLE LOCATION
- 2001 EXTENT OF LANDFILL COVER
- TREE LINE 1998
- SEDIMENT COVER AREAS (2001)

0 240 480
SCALE IN FEET

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

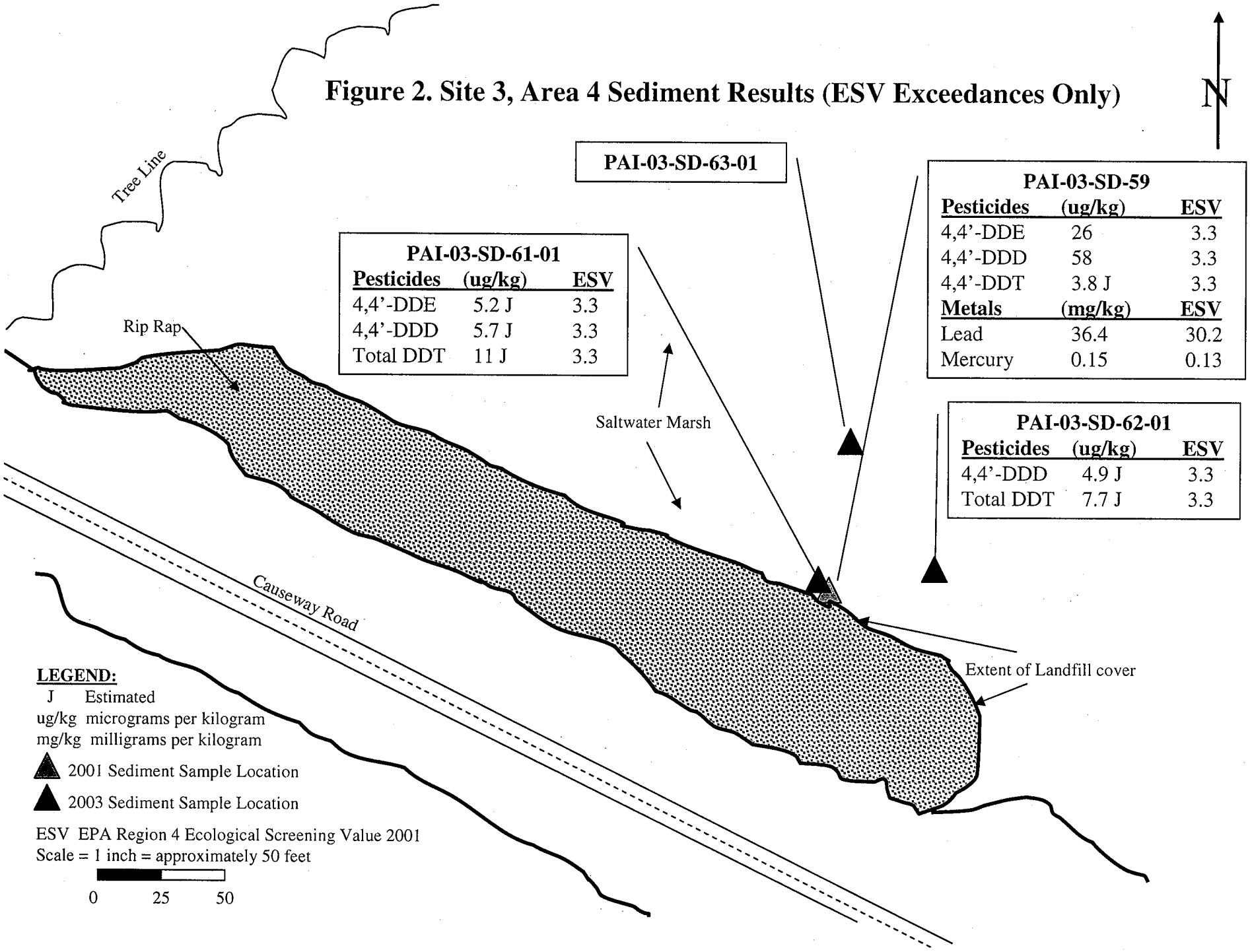
DRAWN BY HJB	DATE 1/18/02
CHECKED BY ----	DATE ----
REVISED BY ----	DATE ----
SCALE AS NOTED	

POST CONSTRUCTION SEDIMENT SAMPLE LOCATIONS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 3920	
OWNER NO. ----	
APPROVED BY	DATE
DRAWING NO. FIGURE 1	REV. 0

ACAD: 3920CM11.dwg 04/18/02 HJB PIT

Figure 2. Site 3, Area 4 Sediment Results (ESV Exceedances Only)



3.0 SUMMARY OF SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT (SERA)

3.1 SERA

3.1.1 Ecological Habitat

Site 3 consists of a causeway constructed across a tidal marsh in the northern portion of MCRD Parris Island. The marsh south of the causeway is a vast expanse of thickly vegetated cordgrass, intersected by several tidal channels. The marsh on the northern side of the causeway is essentially a ponded area of open water, with scattered areas of cordgrass.

The ponded area north of the site occasionally receives tidal inflow via two sets of three culverts beneath the causeway. This tidal flow results in saline conditions in the pond, thereby limiting aquatic organisms in the pond to marine species. Fish such as red drum, spotted seatrout, flounder, whiting, and striped mullet are known to occur in the marsh on both sides of the causeway. Small, schooling fish species such as mud minnows and mummichogs and a variety of mollusks and crustaceans also occur there.

Several species of animals prey upon the fish, mollusks, and crustaceans in the marsh and pond. These include ospreys, wading birds such as the tricolored heron, great blue heron, green heron, and snowy egret. Various shorebirds and wintering waterfowl forage in the marsh. Mammals that are known or expected to forage along the edge of the marsh include the raccoon, mink, river otter, opossum, marsh rabbit, and rice rat.

Based on the receptors at the site, risks to benthic organisms, fish, mammals, and birds were evaluated in the SERA (TtNUS, 2002). See Appendix B for the body of the original SERA.

3.1.2 Screening Step and Step 3a Refinement

In the initial steps of the SERA, maximum concentrations of chemicals detected in sediment were compared to United States Environmental protection Agency (EPA) Region 4 ecological screening values for sediment (EPA, 2000a and 2000b). Sediment PAH data were assessed primarily by evaluating total PAH concentrations.

DDD, DDE, DDT, alpha-chlordane, gamma-chlordane, arsenic, copper, mercury, lead, and total PAHs were present in the marsh south of the causeway or one of the four areas (Area 1 through Area 4) at concentrations greater than their respective ecological screening values.

Subsequent to the initial screening, other factors were considered to further refine COPCs. These factors included background data, toxicological evaluation of COPCs, comparisons of COPC concentrations to alternate guidelines, food chain modeling, and area-use factors (EPA, 1997 and 2001; DON, 1999). The receptors evaluated as part of the food chain modeling were fish, piscivorous birds, and piscivorous mammals

Some food-chain no-observed-adverse-effects level (NOAEL) Hazard quotients for DDD, DDE, and DDT exceeded 1.0 for the heron and osprey using maximum concentrations. Lead NOAEL HQs exceeded 1.0 for the mink, heron, and osprey using maximum concentrations, and some arsenic and mercury NOAEL HQs exceeded 1.0 for the mink, heron, mummichog, and osprey using maximum concentrations.

Food chain NOAEL HQs for representative receptors using average concentrations were greater than 1.0 for DDE (heron and osprey), DDT (heron), arsenic (mink), lead (heron, and osprey), and mercury (mink, heron, and osprey).

3.1.3 Overall Summary

The following paragraphs present the summary of the screening and Step 3a discussion from the SERA (TtNUS, 2002).

Marsh Area: Concentrations of PAHs, pesticides, and metals in marsh samples were low relative to ecological screening values, alternate sediment guidelines, and background/typical facility concentrations. PCBs were not detected in any sample. Concentrations of DDT and alpha-chlordane could pose potential risk to benthic receptors in samples SD-41 and SD-42, respectively, but concentrations of these pesticides were much lower than typical facility concentrations at MCRD Parris Island and do not appear to be site related. Based on the analyses of samples collected in October 2001, site-related concentrations of chemicals of potential concern (COPCs) pose minimal risk to benthic invertebrates and upper-level receptors.

Area 1: Sediment concentrations of PAHs and most metals in Area 1 pose negligible potential risks to benthic invertebrates and upper-level aquatic receptors. Concentrations of mercury pose negligible or minor risk (at worst) to sediment-dwelling invertebrates in a single sample, and potential food-chain impacts from mercury are minor for piscivorous mammals and birds, based on the small area of contamination compared to the area used by wide-ranging receptors and other factors. The potential risks from mercury to small fish represented by the mummichog are also probably minor.

Area 2: PCBs were not detected in October 2001 samples despite relatively low detection limits. Concentrations of metals were low relative to ecological screening values, alternate sediment guidelines,

and/or background/typical facility concentrations. Based on the analyses of samples collected in October 2001, site-related concentrations of these chemicals pose minimal risk to benthic invertebrates and upper-level receptors.

Area 3: Concentrations of pesticides and metals were low relative to ecological screening values, alternate sediment guidelines, and/or background/typical facility concentrations. Concentrations of gamma-chlordane could pose potential risk to benthic receptors in the vicinity of one sample, but concentrations of this pesticide do not appear to be site related. Otherwise, concentrations of pesticides and metals pose negligible risk to benthic invertebrates and upper level receptors.

Area 4: Metals, as well as the pesticides DDT, alpha-chlordane, and gamma-chlordane in Area 4 sediments, pose negligible risk to benthic and upper-level receptors. The DDE concentration in one sample (SD-59) poses potential risk benthic receptors but the concentration was less than typical facility-wide DDE concentrations at MCRD Parris Island. The DDD concentration in one sample (SD-59) poses potential risk to benthic receptors and was greater than typical facility-wide DDD concentrations at MCRD Parris Island. Concentrations of these pesticides pose potential risk to piscivorous birds only if such receptors forage exclusively in Area 4; this seems highly unlikely.

3.2 REGULATORY REVIEW COMMENTS

After the draft Technical Memorandum was submitted, the Navy received comments from the regulators, and the memorandum was discussed during several Partnering Team meetings in 2002 and 2003. Although a formal response to comment document was not prepared, potential risks to ecological receptors and the need for additional actions were discussed in the Partnering Team meetings. A summary of the applicable portions of the meeting minutes is presented below:

August 20-21, 2002 Partnering Meeting

Ms. Priscilla Wendt (South Carolina Department of Natural Resources [SCDNR)) said that she feels that in three of the four areas the conclusion (for no further action for sediment) is justified that nothing more needs to be done. However, for Area 4, with elevated pesticide concentrations, additional sampling should be done beyond the ‘clean line’ because the extent of contamination is not fully identified beyond this point.

Mr. Rob Pope (US Environmental Protection Agency [US EPA]) said he was on the fence with this whole discussion [regarding long-term monitoring (LTM)]. The sediment results are not very high, but on the other hand, they are not ‘clean’. Mr. Don Hargrove (South Carolina Department of Health and Environmental Control [SCDHEC]) asked the Trustees where they sit with respect to LTM. Mr. Tom

Dillon (National Oceanic and Atmospheric Administration {NOAA]) said that a typical concern would be discharge to surface water, which would be tough to pin down at this site. Mr. David Scaturo (SCHDEC) said that South Carolina would look at risk-based numbers, and that ecological impacts would be a factor.

November 12-13, 2002 Partnering Meeting

Mr. Rob Pope (US EPA) described what he expected the path forward would be. Regarding the sediment, the original EPA comments were geared towards 'is this adequate for NFA?', but the trustees have indicated that too many questions remain. Since we're already in LTM for groundwater, it probably is not a big deal to add LTM for sediment also. Or, EPA field guys could do sediment sampling. Ms. Priscilla Wendt (SCDNR) said we don't really know how far out the sediment could extend; if EPA sampling could show that contamination is isolated to the one or two hits we know about now, this could be adequate to avoid sediment LTM. Rob said that he's hearing that we need to see if there are outliers in Area 4 past the original sampling, and sample for pesticides only. Mr. Tom Dillon (NOAA) said mercury should also be sampled, adding that elevated mercury was found in biota samples way back, and there has not been any biota samples since. Rob said, so, if sampling shows we're limited to an area just outside the cover, we're OK, and Tom said probably so. Priscilla said we need to consider the tropic eco risk analysis and modified use factor. Mr. Art Sanford (Naval Facilities South East [NAVFAC SE]) said that, OK, the EPA will sample sediment, then, if OK, the Navy will propose a record of decision (ROD) for groundwater LTM only.

Rob had an action item to set up the EPA doing sediment sampling. Tom said they would need to sample Hg, Pb, As, and the DDX series (but no PAH). Priscilla asked how many samples and where, and David added what sampling method. Tom said whatever is appropriate for the site – ponar, hand cores, whatever to retain the fines. Rob asked, so we can't do the ROD until after this sampling, and Art agreed. Rob said that this sampling, plus the existing tech memo would form the baseline. Art said if the sampling results came back less than satisfactory, then the ROD would be for LTM for sediment and groundwater, and Rob and Tom agreed.

August 12-13, 2003 Partnering Meeting

Mr. Rob Pope discussed the sampling results, which had previously been emailed to the team. Mr. Tom Dillon asked if there was any speculation on why there was an apparent difference in contaminant concentrations between older and current samples. Rob said that a good amount of time has elapsed, and that materials may have settled following the construction. Rob noted that some results were still above ecological screening values (ESVs). Mr. Tim Harrington (Marine Corps Recruit Depot [MCRD] Parris Island) said that ESVs are artificially low, however. Rob said the results were typically within an order of magnitude of ESVs anyhow. Tom said this shows the value of the total organic carbon analysis.

The high organics would be expected to sorb with any DDT present, but even so, we still have low DDT levels

Mr. Tom Dillon (NOAA) said that Ms. Priscilla Wendt (SCDNR) and he think the sediment question has been answered, and that sediment LTM is not necessary. Mr. Dave Scaturo (SCDHEC) said that if SCDNR is satisfied, then he is too. Mr. Art Sanford (NAVFAC SE) asked then, if this meant the team was in agreement on the final ROD for Site 3 to specify long term groundwater monitoring plus land use controls (LUCs), and the team agreed.

Ms. Priscilla Wendt (SCDNR) asked if the EPA's data gets appended to some report, and Rob said that it would be a separate Contractor Oversight Field Record. Rob said that the final ROD will need to refer to or include this data.

3.3 CONCLUSIONS

The results of the SERA conducted as part of the Technical Memorandum determined that risks in the in the Marsh Area and in Areas 1 through 4 were relatively low, but one sediment sample in Area 4 (SD-59) had an elevated detection of DDD (TtNUS, 2002). See Figure 1 for the location of Area 4. Although the Navy received regulatory review comments on the Technical Memorandum, based on discussions during the Partnering Meetings it was determine that if additional sediment sampling in Area 4 by SD-59 showed that the pesticide contamination was not widespread, then the ROD for LTM would only need to include groundwater monitoring. EPA collected additional sediment samples in April 2003 in Area 4 near SD059. The sediment samples collected in Area 4 were analyzed for DDD, DDE, DDT, arsenic, lead, mercury, total organic carbon, and grain size. The chemical concentrations were very low. The data from these new samples were initially evaluated for the SERA qualitatively and informally in MCRD Partnering Team Meetings. The Navy feels this was appropriate since (1) the Team generally supported that the SERA did not indicate significant unacceptable risk, and (2) the EPA sample concentrations substantially confirmed that high concentrations of contamination did not extend further out into the marsh beyond Area 4. The Team agreed that the "sediment question" had been answered, and that sediment LTM would not need to be a component of the final remedy. Therefore, the team agreed that the final remedy only needed to specify long term groundwater monitoring plus LUC.

3.4 ERA REFERENCES

DON (Department of the Navy), 1999. Navy Policy for Conducting Ecological Risk Assessments. Office of the Chief of Naval Operations, Washington, D.C., April 6.

EPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Edison, New Jersey. June 5,

EPA, 2000a. Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders. Memorandum from Ted. W. Simon, Region 4 EPA Office of Technical Services, Atlanta, Georgia, June 23.

EPA, 2000b. Region 4 Ecological Risk Assessment Bulletins – Supplement to RAGs, Waste Management Division, Atlanta, Georgia, March 9. http://www.epa.gov/region4/waste/oftecser/ecolbul.htm

Long E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder, 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." In Environmental Management. 19:81-97.

Tetra Tech NUS, Inc., 2002. Technical Memorandum Post-Interim Construction Risk Assessment for Site/SWMU 3 – Causeway Landfill, Marine Corps Recruit Depot, Parris Island, South Carolina. Prepared for SOUTHNAVFACENGCOM, May.

4.0 SURFACE WATER

Consistent with reviewing and/or confirming the status of the HHRA and ERA, Navy and MCRD desired to reiterate and reaffirm the conclusions from the previously-approved Site 3 RI Report regarding the surface water assessment. See Table 4 -1 for a tabular presentation of this review.

Table A-2 in the November 1999 Site 3 Feasibility Study clarifies the ecological risk from surface water by calculation of RGOs that would be protective. Table A-2 has been modified and included in this Tech Memo as follows:

- Table 4-3 is based on Table A-2 but adds a column for maximum concentration detected for each of the Preliminary COCs.
- Table 4-4 is based on Table A-2 but adds a column for average concentrations detected for each of the Preliminary COCs.

While Table 4-3 does indicate maximum concentrations of several Preliminary COCs that exceed benchmarks shown, Table 4-4 indicates that no Preliminary COC concentrations exceed the benchmarks shown. Note that Table 4-4 does indicate that the observed silver concentration would exceed EPA salt water ecological screening value for chronic exposure, however the based on the selection of site-specific food chain receptors, silver was not selected as a Preliminary COC.

The review concludes that based on the agreed risk assessment methods and exposure scenarios as detailed in the RI, no unacceptable risk results from human health or ecological exposure to the surface water as characterized during the RI.

TABLE 4-1
SURFACE WATER RISK ASSESSMENT SUMMARY – HUMAN HEALTH
DEVELOPED FROM DATA AND ANALYSIS ORIGINALLY PROVIDED IN THE SITE 3 RI
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

	ORIGINAL SITE 3 HHRA	UPDATED 2008 HHRA REVIEW
1	HHRA only evaluated exposures to surface water by construction workers. Recreational exposures to surface water were not evaluated because there are alligators in the area.	The original analysis is still valid. The area is currently posted for alligators.
2	Surface water is saline, ranging from 1,950 mg/L to 6,820 mg/L. The EPA standard is 500 mg/L, therefore the surface water is not suitable for use as a drinking water source.	The original analysis is still expected to be valid – the surface water salinity is not expected to have changed significantly.
3	The cancer risks for construction workers exposed to surface water were 1×10^{-5} which is within USEPA's target risk range of 10^{-4} to 10^{-6}.	If the cancer risks were recalculated using current EPA guidance they would be less (more favorable) than the target risk range. The risk was driven by dermal contact with PAHs. The methodology for evaluation of dermal contacts has changed. EPA (RAGS Part E) now recommends that potential dermal exposures to PAHs are not numerically calculated and are instead identified in the uncertainties section of the risk assessment.
4	Risks from the ingestion of fish were based on surface water concentrations. Risks for subsistence fishing exceeded USEPA acceptable levels. Risks for fishing based on site-specific considerations were within the target risk range.	See Section 2.6 of this Technical Memorandum. Note that current methodology considers only sediment results for both organic and inorganics compounds, while the original methodology employed included both surface water (organics) and sediment (inorganics). According to the EPA, ingestion of surface water contributes less than 0.0001 percent of the total exposure. Therefore excluding the water ingestion exposure route has no significant impact on the evaluation with respect to sediment results (U.S. EPA, 2004)[1].
	CONCLUSION:	**No unacceptable human health risk exists in surface water at Site 3 based on review of the original data and assumptions.**

1 The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, US EPA, November 2004.

TABLE 4-2
SURFACE WATER RISK ASSESSMENT SUMMARY – ECOLOGICAL RISK
DEVELOPED FROM DATA AND ANALYSIS ORIGINALLY PROVIDED IN THE SITE 3 RI
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ORIGINAL SITE 3 ERA

1 The ERA identified risks for ecological receptors exposed to surface water. Chemicals with HQs exceeding 1.0 in filtered surface water samples included aluminum, arsenic, iron, and vanadium. These inorganics were detected infrequently in surface water. Aluminum, arsenic, and iron were detected in 2 of 20 samples and vanadium was detected in 1 of 20 samples.

UPDATED 2008 ERA REVIEW

Table A-2 in the November 1999 Site 3 Feasibility Study clarifies the ecological risk from surface water by calculation of RGOs that would be protective. Table A-2 has been modified and included in this Tech Memo as follows:

- Table 4-3 is based on Table A-2 but adds a column for maximum concentration detected for each of the Preliminary COCs.
- Table 4-4 is based on Table A-2 but adds a column for average concentrations detected for each of the Preliminary COCs.

While Table 4-3 does indicate maximum concentrations of several Preliminary COCs that exceed benchmarks shown, Table 4-4 indicates that no Preliminary COCs have concentrations exceed benchmarks shown.

CONCLUSION:

No unacceptable ecological risk exists in surface water at Site 3 based on review of the original data and assumptions.

DRAWING NO. FIGURE 1 REV. 0

HORSE ISLAND

CAUSEWAY ASPHALT ROAD

HISTORICAL EDGE OF CAUSEWAY

HISTORICAL EDGE OF CAUSEWAY

PAI 03 SD 46

PAI 03 SD 47

PAI 03 SD 48

SEDIMENT AREA 1

PAI 03 SD 49

EDGE OF COVER

PAI 03 SD 41

EDGE OF COVER

PAI 03 SD 50

PAI 03 SD 51

SEDIMENT AREA 2

PAI 03 SD 52

PAI 03 SD 42

CULVERT

MALECON DRIVE

PARRIS ISLAND

POND SIDE

PAI 03 SD 43

PAI 03 SD 44

CULVERT

MARSH SIDE

PAI 03 SD 53

PAI 03 SD 54

PAI 03 SD 55

SEDIMENT AREA 3

PAI 03 SD 45

PAI 03 SD 56

PAI 03 SD 57

SEDIMENT AREA 4

PAI 03 SD 58

PAI 03 SD 59

PAI 03 SD 60

RIBBON CREEK

TEMPORARY ROAD

CAUSEWAY ASPHALT ROAD

LEGEND:

- 1998 SEDIMENT SAMPLE LOCATION
- 1999 SEDIMENT SAMPLE LOCATION
- 2001 SEDIMENT SAMPLE LOCATION
- 2001 EXTENT OF LANDFILL COVER
- TREE LINE 1998
- SEDIMENT COVER AREAS (2001)

0 240 480
SCALE IN FEET

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY HJB	DATE 1/18/02
CHECKED BY ----	DATE ----
REVISED BY ----	DATE ----
SCALE AS NOTED	

POST CONSTRUCTION SEDIMENT SAMPLE LOCATIONS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 3920	
OWNER NO. ----	
APPROVED BY	DATE
DRAWING NO. FIGURE 1	REV. 0

ACAD: 3920CM11.dwg 04/18/02 HJB PIT

APPENDIX A

SUPPORTING INFORMATION FOR HEALTH RISK ASSESSMENT

A.1 RAGS Part D Tables
A.2 Sample Calculations

APPENDIX A.1

RAGS-PART D TABLES

TABLE 2.1
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe:
Medium: Fish Tissue
Exposure Medium: Fish Tissue

Exposure Point	CAS Number	Chemical	Minimum Sediment Concentration[1]	Maximum Sediment Concentration[1]	Units	Sample of Maximum Concentration	Frequency of Detection	Range of Nondetects[2]	BSAF[3]	Estimated Fish Tissue Concentration[4]	Range of Background Concentrations[5]	USEPA Region 3 RBCs for Fish Ingestion (mg/kg)[6]	Potential ARAR/TBC	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
SWMU 3	Semivolatile Organic Compounds															
	83-32-9	Acenaphthene	28 J	28 J	ug/kg	PAI-03-SD-41-01-D	1/9	26 - 70	0.29	8.12	NA	8100 N	NA	NA	No	BSL
	120-12-7	Anthracene	14 J	78 J	ug/kg	PAI-03-SD-41-01-D	2/9	26 - 70	0.29	22.6	NA	41000 N	NA	NA	No	BSL
	56-55-3	Benzo(a)anthracene	12 J	300 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	87.0	NA	4.3 C	NA	NA	Yes	ASL
	50-32-8	Benzo(a)pyrene	11 J	170 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	49.3	NA	0.43 C	NA	NA	Yes	ASL
	205-99-2	Benzo(b)fluoranthene	10 J	230 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	66.7	NA	4.3 C	NA	NA	Yes	ASL
	191-24-2	Benzo(g,h,i)perylene	12 J	71 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	1	71.0	NA	4100 N[8]	NA	NA	No	BSL
	207-08-9	Benzo(k)fluoranthene	7 J	82 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	23.8	NA	43 C	NA	NA	No	BSL
	218-01-9	Chrysene	6 J	190 J	ug/kg	PAI-03-SD-41-01-D	6/9	28 - 70	0.29	55.1	NA	430 C	NA	NA	No	BSL
	53-70-3	Dibenzo(a,h)anthracene	12 J	26 J	ug/kg	PAI-03-SD-41-01-D	2/9	28 - 70	0.29	7.54	NA	0.43 C	NA	NA	Yes	ASL
	206-44-0	Fluoranthene	21 J	470 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	136	NA	5400 N	NA	NA	No	BSL
	86-73-7	Fluorene	8 J	37	ug/kg	PAI-03-SD-41-01-D	2/9	26 - 70	0.29	10.7	NA	5400 N	NA	NA	No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	18 J	120 J	ug/kg	PAI-03-SD-41-01-D	3/9	28 - 70	0.29	34.8	NA	4.3 C	NA	NA	Yes	ASL
	85-01-8	Phenanthrene	7 J	320 J	ug/kg	PAI-03-SD-41-01-D	5/9	28 - 70	1	320	NA	4100 N[8]	NA	NA	No	BSL
	129-00-0	Pyrene	12 J	330 J	ug/kg	PAI-03-SD-41-01-D	8/9	28 - 28	0.29	95.7	NA	4100 N	NA	NA	No	BSL
	Pesticides/PCBs															
	72-54-8	4,4'-DDD	1.4 J	58	ug/kg	PAI-03-SD-59-01	8/16	5.5 - 19	0.28	16.2	NA	13 C	NA	NA	Yes	ASL
	72-55-9	4,4'-DDE	1.2 J	26	ug/kg	PAI-03-SD-59-01	15/16	5.7 - 5.7	7.7	200	NA	9.3 C	NA	NA	Yes	ASL
	50-29-3	4,4'-DDT	1.1 J	12 J	ug/kg	PAI-03-SD-41-01	5/16	4.3 - 19	1.67	20.0	NA	9.3 C	NA	NA	Yes	ASL
	5103-71-9	alpha-Chlordane	2.8 J	6.6	ug/kg	PAI-03-SD-42-01	2/13	2.2 - 9.6	4.77	31.5	NA	9 C[9]	NA	NA	Yes	ASL
	5103-74-2	gamma-Chlordane	2 J	3.4	ug/kg	PAI-03-SD-54-01	2/13	2.2 - 9.6	2.22	7.55	NA	9 C[9]	NA	NA	No	BSL
	Inorganics															
	7440-38-2	Arsenic	0.84	13.6	mg/kg	PAI-03-SD-44-01	23/23	- - -	0.69	0.375	NA	0.0021 C	NA	NA	Yes	ASL
	7440-50-8	Copper	1.1	27.1	mg/kg	PAI-03-SD-44-01	20/20	- - -	5.25	142	NA	5.4 N	NA	NA	Yes	ASL
	7439-92-1	Lead	4.2	44.9 J	mg/kg	PAI-03-SD-60-01	23/23	- - -	0.607	27.3	NA	NA	NA	NA	No	NTX
	7439-97-6	Mercury	0.01	0.2	mg/kg	PAI-03-SD-48-01	20/23	0.2 - 0.2	2.868	0.574	NA	0.041 N[10]	NA	NA	Yes	ASL
	7440-66-6	Zinc	6.7	93.3 J	mg/kg	PAI-03-SD-58-01	20/20	- - -	7.527	702	NA	41 N	NA	NA	Yes	ASL

Footnotes:
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - Sediment to invertebrate biotransfer factors were used for the inorganics without sediment to fish biotransfer factors.
4 - For organics the estimated fish tissue concentration = BSAF x Sediment Concentration x f_l / f_{oc}.
f_l = lipid content (0.01). foc= fraction organic carbon (0.01).
For inorganics the estimated fish tissue concentration = BASF x Sediment Concentration.
5 - No background soil samples were collected
6 - The EPA Region 3 RBC for fish ingestion is presented. Value represents the risk based screening level divided by 10 to correspond to a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag), or an incremental cancer risk of 1.0E-6 for carcinogens (denoted with a "C" flag) (USEPA, April 2006).
5 - The chemical is selected as a COPC if the estimated fish tissue concentration exceeds the risk-based COPC screening level.
8 - Pyrene is used as a surrogate for benzo(g,h,i)perylene and phenanthrene.
9 - Chlordane is used as a surrogate for alpha- and gamma-chlordane.
10 - Value is for methylmercury.
Shaded criterion indicates that the maximum detected concentration exceeds one or more screening criteria. Shaded chemical name indicates that the chemical was retained as a COPC.

Associated Samples

PAI-03-SD-41-01	PAI-03-SD-45-01-D	PAI-03-SD-51-01	PAI-03-SD-57-01
PAI-03-SD-41-01-D	PAI-03-SD-46-01	PAI-03-SD-52-01	PAI-03-SD-58-01
PAI-03-SD-42-01	PAI-03-SD-47-01	PAI-03-SD-53-01	PAI-03-SD-59-01
PAI-03-SD-43-01	PAI-03-SD-48-01	PAI-03-SD-54-01	PAI-03-SD-60-01
PAI-03-SD-44-01	PAI-03-SD-49-01	PAI-03-SD-55-01	
PAI-03-SD-45-01	PAI-03-SD-50-01	PAI-03-SD-56-01	

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirements To Be Considered
BSAF = Biota sediment accumulation factor
C = Carcinogen
COPC = Chemical Of Potential Concern
J = Estimated value
N = Noncarcinogen
NA = Not Applicable/Not Available

Rationale Codes:
For selection as a COPC:
ASL = Above Screening Level and site background.

For elimination as a COPC:
BSL = Below COPC Screening Level
NTX = No toxicity criteria

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RAGS PART D TABLE 4
VALUES USED FOR DAILY INTAKE CALCULATIONS

Table No.

4.1 Usepa Region IV Default Exposure Assumptions
4.2 Site-Specific Exposure Assumptions

TABLE 4.1

VALUES USED FOR DAILY INTAKE CALCULATIONS

USEPA REGION IV DEFAULT EXPOSURE ASSUMPTIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Finfish/Shellfish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational Users	Adult	Site/SWMU 3	CFish	Chemical Concentration in Fish	See Text	mg/kg	See Text	Intake (mg/kg/day) =
				IR	Ingestion Rate of fish/shellfish	0.054	kg/meal	U.S. EPA, 2000	CFish x IR x FI x EF x ED
				FI	Fraction ingested from source	1	unitless	U.S. EPA, 2000	BW x AT
				EF	Exposure Frequency	350	meals/year	U.S. EPA, 2000	
				ED	Exposure Duration	30	years	U.S. EPA, 2000	
				BW	Body Weight	70	kg	U.S. EPA, 1989	
				AT-C	Averaging Time (Cancer)	25550	days	U.S. EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	10950	days	U.S. EPA, 1989	

Sources:

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. U.S. EPA/540/1-86/060.

U.S. EPA Region 4, 2000: Supplement Guidance to RAGS: Region 4 Bulletins.

Unit Intake Calculations

Ingestion Intake = (IR x FI x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 3.17E-04 Noncancer Ingestion Intake = 7.40E-04

TABLE 4.2

VALUES USED FOR DAILY INTAKE CALCULATIONS

SITE-SPECIFIC EXPOSURE ASSUMPTIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Finfish/Shellfish

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational Users	Adult	Site/SWMU 3	CFish	Chemical Concentration in Fish	See Text	mg/kg	See Text	Intake (mg/kg/day) =
				IR	Ingestion Rate of fish/shellfish	0.145	kg/meal	U.S. EPA, 2000	CFish x IR x FI x EF x ED
				FI	Fraction ingested from source	1	unitless	U.S. EPA, 2000	BW x AT
				EF	Exposure Frequency	45	meals/year	(1)	
				ED	Exposure Duration	6	years	(2)	
				BW	Body Weight	70	kg	U.S. EPA, 1989	
				AT-C	Averaging Time (Cancer)	25550	days	U.S. EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3285	days	U.S. EPA, 1989	

Sources:

1 - Assumes approximately one day a week.

2 - Assumes two 3-year tours of duty.

U.S. EPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. U.S. EPA/540/1-86/060.

U.S. EPA Region 4, 2000: Supplement Guidance to RAGS: Region 4 Bulletins.

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RAGS PART D TABLE 5
NON-CANCER TOXICITY DATA

Table No.

5-1 Non-Cancer Toxicity Data - Oral/Dermal

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
NSB-NLON, GROTON, CONNECTICUT

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds										
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticide/PCBs										
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	Chronic	5.0E-04	mg/kg/day	1	5.0E-04	mg/kg/day	Liver	100/1	IRIS	3/19/2007
alpha-Chlordane	Chronic	5.0E-04	mg/kg/day	1	5.0E-04	mg/kg/day	Liver	300/1	IRIS	3/19/2007
Inorganics										
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, CVS	3/1	IRIS	3/19/2007
Copper	Chronic	4.0E-02	mg/kg/day	1	4.0E-02	mg/kg/day	GS	NA	HEAST	7/1997
Mercury	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Autoimmune	1000/1	IRIS	3/19/2007
Zinc	Chronic	3.0E-01	mg/kg/day	1	3.0E-01	mg/kg/day	Blood	3/1	IRIS	3/19/2007

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005.
2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.
3 - Values are for cadmium water.
4 - Values are for mercuric chloride.
5 - Weight adjustment of the IRIS value.

Definitions:
CVS = Cardiovascular system
GS = Gastrointestinal
IRIS = Integrated Risk Information System
NA = Not Applicable
HEAST = Health Effects Assessment Summary Table

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CANCER TOXICITY DATA

Table No.

6-1 Cancer Toxicity Data - Oral/Dermal

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
NSB-NLON, GROTON, CONNECTICUT

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds								
Benzo(a)pyrene	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	3/19/2007
Pesticide/PCBs								
4,4'-DDD	2.4E-01	$(mg/kg/day)^{-1}$	1	2.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	3/19/2007
4,4'-DDE	3.4E-01	$(mg/kg/day)^{-1}$	1	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	3/19/2007
4,4'-DDT	3.4E-01	$(mg/kg/day)^{-1}$	1	3.4E-01	$(mg/kg/day)^{-1}$	B2	IRIS	3/19/2007
alpha-Chlordane	3.5E-01	$(mg/kg/day)^{-1}$	1	3.5E-01	$(mg/kg/day)^{-1}$	B2	IRIS	3/19/2007
Inorganics								
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	3/19/2007
Copper	NA	NA	NA	NA	NA	D	IRIS	3/19/2007
Mercury	NA	NA	NA	NA	NA	C	IRIS	3/19/2007
Zinc	NA	NA	NA	NA	NA	D	IRIS	3/19/2007

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.

EPA Group:
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.
E - Evidence of noncarcinogenicity.

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CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

Table No.

7.1 USEPA Region IV Default Exposure Assumptions - Maximum Fish Tissue Concentrations
7.2 Site-Specific Exposure Assumptions - Maximum Fish Tissue Concentrations
7.3 USEPA Region IV Default Exposure Assumptions - Average Fish Tissue Concentrations
7.4 Site-Specific Exposure Assumptions - Average Fish Tissue Concentrations

TABLE 7.1

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

USEPA REGION IV DEFAULT EXPOSURE ASSUMPTIONS AND MAXIMUM FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Finfish/Shellfish	Site/SWMU 3	Ingestion	Benzo(a)pyrene Equivalents	0.076	mg/kg	2.4E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.8E-04	5.6E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDD	0.016	mg/kg	5.1E-06	(mg/kg/day)	2.4E-01	$(mg/kg/day)^{-1}$	1.2E-06	1.2E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDE	0.200	mg/kg	6.3E-05	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	2.2E-05	1.5E-04	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDT	0.020	mg/kg	6.4E-06	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	2.2E-06	1.5E-05	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.03
				alpha-Chlordane	0.031	mg/kg	1.0E-05	(mg/kg/day)	3.5E-01	$(mg/kg/day)^{-1}$	3.5E-06	2.3E-05	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.05
				Arsenic	0.375	mg/kg	1.2E-04	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.8E-04	2.8E-04	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.9
				Copper	142.3	mg/kg	4.5E-02	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-01	(mg/kg/day)	4.0E-02	(mg/kg/day)	2.6
				Mercury	0.574	mg/kg	1.8E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.2E-04	(mg/kg/day)	3.0E-04	(mg/kg/day)	1.4
				Zinc	702.3	mg/kg	2.2E-01	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	5.2E-01	(mg/kg/day)	3.0E-01	(mg/kg/day)	1.7
			Exp. Route Total								3.8E-04					6.8
		Exposure Point Total									3.8E-04					6.8
	Exposure Medium Total										3.8E-04					6.8
Medium Total											3.8E-04					6.8
										Total of Receptor Risks Across All Media	3.8E-04				Total of Receptor Hazards Across All Media	6.8

TABLE 7.2

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

SITE-SPECIFIC EXPOSURE ASSUMPTIONS AND MAXIMUM FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Finfish/Shellfish	Site/SWMU 3	Ingestion	Benzo(a)pyrene Equivalents	0.076	mg/kg	1.7E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.2E-05	1.3E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDD	0.016	mg/kg	3.6E-07	(mg/kg/day)	2.4E-01	$(mg/kg/day)^{-1}$	8.5E-08	2.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDE	0.200	mg/kg	4.4E-06	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	1.5E-06	3.4E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDT	0.020	mg/kg	4.4E-07	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	1.5E-07	3.4E-06	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.007
				alpha-Chlordane	0.031	mg/kg	6.9E-07	(mg/kg/day)	3.5E-01	$(mg/kg/day)^{-1}$	2.4E-07	5.4E-06	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.011
				Arsenic	0.375	mg/kg	8.2E-06	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.2E-05	6.4E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.2
				Copper	142.3	mg/kg	3.1E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.4E-02	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.6
				Mercury	0.574	mg/kg	1.3E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.8E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.3
				Zinc	702.3	mg/kg	1.5E-02	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-01	(mg/kg/day)	3.0E-01	(mg/kg/day)	0.4
			Exp. Route Total								2.6E-05					1.6
		Exposure Point Total									2.6E-05					1.6
	Exposure Medium Total										2.6E-05					1.6
Medium Total											2.6E-05					1.6
										Total of Receptor Risks Across All Media	2.6E-05				Total of Receptor Hazards Across All Media	1.6

TABLE 7.3

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

USEPA REGION IV DEFAULT EXPOSURE ASSUMPTIONS AND AVERAGE FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Finfish/Shellfish	Site/SWMU 3	Ingestion	Benzo(a)pyrene Equivalents	0.017	mg/kg	5.3E-06	(mg/kg/day)	7.3E+00	(mg/kg/day)$^{-1}$	3.8E-05	1.2E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDD	0.003	mg/kg	8.5E-07	(mg/kg/day)	2.4E-01	(mg/kg/day)$^{-1}$	2.0E-07	2.0E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDE	0.034	mg/kg	1.1E-05	(mg/kg/day)	3.4E-01	(mg/kg/day)$^{-1}$	3.7E-06	2.5E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDT	0.012	mg/kg	3.9E-06	(mg/kg/day)	3.4E-01	(mg/kg/day)$^{-1}$	1.3E-06	9.0E-06	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.02
				alpha-Chlordane	0.019	mg/kg	6.0E-06	(mg/kg/day)	3.5E-01	(mg/kg/day)$^{-1}$	2.1E-06	1.4E-05	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.03
				Arsenic	0.028	mg/kg	8.8E-06	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	1.3E-05	2.0E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.07
				Copper	14.2	mg/kg	4.5E-03	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	1.0E-02	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.3
				Mercury	0.116	mg/kg	3.7E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	8.5E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.3
				Zinc	78.5	mg/kg	2.5E-02	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	--	5.8E-02	(mg/kg/day)	3.0E-01	(mg/kg/day)	0.2
			Exp. Route Total								5.9E-05					0.9
		Exposure Point Total									5.9E-05					0.9
	Exposure Medium Total										5.9E-05					0.9
Medium Total											5.9E-05					0.9
Total of Receptor Risks Across All Media											5.9E-05	Total of Receptor Hazards Across All Media				0.9

TABLE 7.4

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

SITE-SPECIFIC EXPOSURE ASSUMPTIONS AND AVERAGE FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Finfish/Shellfish	Site/SWMU 3	Ingestion	Benzo(a)pyrene Equivalents	0.017	mg/kg	3.6E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.7E-06	2.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDD	0.003	mg/kg	5.9E-08	(mg/kg/day)	2.4E-01	$(mg/kg/day)^{-1}$	1.4E-08	4.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDE	0.034	mg/kg	7.5E-07	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	2.5E-07	5.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				4,4'-DDT	0.012	mg/kg	2.7E-07	(mg/kg/day)	3.4E-01	$(mg/kg/day)^{-1}$	9.1E-08	2.1E-06	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.004
				alpha-Chlordane	0.019	mg/kg	4.1E-07	(mg/kg/day)	3.5E-01	$(mg/kg/day)^{-1}$	1.4E-07	3.2E-06	(mg/kg/day)	5.0E-04	(mg/kg/day)	0.006
				Arsenic	0.028	mg/kg	6.0E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	9.1E-07	4.7E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.02
				Copper	14.2	mg/kg	3.1E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	--	2.4E-03	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.06
				Mercury	0.116	mg/kg	2.5E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	--	2.0E-05	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.07
				Zinc	78.5	mg/kg	1.7E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	--	1.3E-02	(mg/kg/day)	3.0E-01	(mg/kg/day)	0.04
			Exp. Route Total								4.1E-06					0.2
		Exposure Point Total									4.1E-06					0.2
	Exposure Medium Total										4.1E-06					0.2
Medium Total											4.1E-06					0.2
										Total of Receptor Risks Across All Media	4.1E-06				Total of Receptor Hazards Across All Media	0.2

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9.2 Site-Specific Exposure Assumptions - Maximum Fish Tissue Concentrations
9.3 USEPA Region IV Default Exposure Assumptions - Average Fish Tissue Concentrations
9.4 Site-Specific Exposure Assumptions - Average Fish Tissue Concentrations

TABLE 9.1

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

USEPA REGION IV DEFAULT EXPOSURE ASSUMPTIONS AND MAXIMUM FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Finfish/Shellfish	Site/SWMU 3	Benzo(a)pyrene Equivalents	2E-04	--	- -	--	2E-04	NA	--	- -	- -	--
			4,4'-DDD	1E-06	--	- -	--	1E-06	NA	--	- -	- -	--
			4,4'-DDE	2E-05	--	- -	--	2E-05	NA	--	- -	- -	--
			4,4'-DDT	2E-06	--	- -	--	2E-06	Liver	0.03	- -	- -	0.03
			alpha-Chlordane	3E-06	--	- -	--	3E-06	Liver	0.05	- -	- -	0.05
			Arsenic	2E-04	--	- -	--	2E-04	Skin, CVS	0.9	- -	- -	0.9
			Copper	- -	--	- -	--	- -	GS	3	- -	- -	3
			Mercury	- -	--	- -	--	- -	Autoimmune	1	- -	- -	1
			Zinc	- -	--	- -	--	- -	Blood	2	- -	- -	2
			Chemical Total	4E-04	--	- -	--	4E-04		7	- -	- -	7
		Exposure Point Total						4E-04					7
	Exposure Medium Total							4E-04					7
Medium Total								4E-04					7
Receptor Total							Receptor Risk Total	4E-04				Receptor HI Total	7

Total Blood HI	2
Total Autoimmune HI	1
Total CVS HI	0.9
Total GS HI	3
Total Liver HI	0.08
Total Skin HI	0.9

TABLE 9.2

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

SITE-SPECIFIC EXPOSURE ASSUMPTIONS AND MAXIMUM FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Finfish/Shellfish	Site/SWMU 3	Benzo(a)pyrene Equivalents	1E-05	--	- -	--	1E-05	NA	--	- -	- -	--
			4,4'-DDD	9E-08	--	- -	--	9E-08	NA	--	- -	- -	--
			4,4'-DDE	1E-06	--	- -	--	1E-06	NA	--	- -	- -	--
			4,4'-DDT	1E-07	--	- -	--	1E-07	Liver	0.007	- -	- -	0.007
			alpha-Chlordane	2E-07	--	- -	--	2E-07	Liver	0.01	- -	- -	0.01
			Arsenic	1E-05	--	- -	--	1E-05	Skin, CVS	0.2	- -	- -	0.2
			Copper	- -	--	- -	--	- -	GS	0.6	- -	- -	0.6
			Mercury	- -	--	- -	--	- -	Autoimmune	0.3	- -	- -	0.3
			Zinc	- -	--	- -	--	- -	Blood	0.4	- -	- -	0.4
			Chemical Total	3E-05	--	- -	--	3E-05		2	- -	- -	2
		Exposure Point Total						3E-05					2
	Exposure Medium Total							3E-05					2
Medium Total								3E-05					2
Receptor Total							Receptor Risk Total	3E-05				Receptor HI Total	2

Total Blood HI	0.4
Total Autoimmune HI	0.3
Total CVS HI	0.2
Total GS HI	0.6
Total Liver HI	0.02
Total Skin HI	0.2

TABLE 9.3

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

USEPA REGION IV DEFAULT EXPOSURE ASSUMPTIONS AND AVERAGE FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Finfish/Shellfish	Site/SWMU 3	Benzo(a)pyrene Equivalents	4E-05	--	- -	--	4E-05	NA	--	- -	- -	--
			4,4'-DDD	2E-07	--	- -	--	2E-07	NA	--	- -	- -	--
			4,4'-DDE	4E-06	--	- -	--	4E-06	NA	--	- -	- -	--
			4,4'-DDT	1E-06	--	- -	--	1E-06	Liver	0.02	- -	- -	0.02
			alpha-Chlordane	2E-06	--	- -	--	2E-06	Liver	0.03	- -	- -	0.03
			Arsenic	1E-05	--	- -	--	1E-05	Skin, CVS	0.07	- -	- -	0.07
			Copper	- -	--	- -	--	- -	GS	0.3	- -	- -	0.3
			Mercury	- -	--	- -	--	- -	Autoimmune	0.3	- -	- -	0.3
			Zinc	- -	--	- -	--	- -	Blood	0.2	- -	- -	0.2
			Chemical Total	6E-05	--	- -	--	6E-05		0.9	- -	- -	0.9
		Exposure Point Total						6E-05					0.9
	Exposure Medium Total							6E-05					0.9
Medium Total								6E-05					0.9
Receptor Total							Receptor Risk Total	6E-05				Receptor HI Total	0.9

Total Blood HI	0.2
Total Autoimmune HI	0.3
Total CVS HI	0.07
Total GS HI	0.3
Total Liver HI	0.05
Total Skin HI	0.07

TABLE 9.4

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

SITE-SPECIFIC EXPOSURE ASSUMPTIONS AND AVERAGE FISH TISSUE CONCENTRATIONS

MCRD PARRIS ISLAND, SOUTH CAROLINA

Scenario Timeframe: Current/Future
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Finfish/Shellfish	Site/SWMU 3	Benzo(a)pyrene Equivalents	3E-06	--	- -	--	3E-06	NA	--	- -	- -	--
			4,4'-DDD	1E-08	--	- -	--	1E-08	NA	--	- -	- -	--
			4,4'-DDE	3E-07	--	- -	--	3E-07	NA	--	- -	- -	--
			4,4'-DDT	9E-08	--	- -	--	9E-08	Liver	0.004	- -	- -	0.004
			alpha-Chlordane	1E-07	--	- -	--	1E-07	Liver	0.006	- -	- -	0.006
			Arsenic	9E-07	--	- -	--	9E-07	Skin, CVS	0.02	- -	- -	0.02
			Copper	- -	--	- -	--	- -	GS	0.06	- -	- -	0.06
			Mercury	- -	--	- -	--	- -	Autoimmune	0.07	- -	- -	0.07
			Zinc	- -	--	- -	--	- -	Blood	0.04	- -	- -	0.04
			Chemical Total	4E-06	--	- -	--	4E-06		0.2	- -	- -	0.2
		Exposure Point Total						4E-06					0.2
	Exposure Medium Total							4E-06					0.2
Medium Total								4E-06					0.2
Receptor Total							Receptor Risk Total	4E-06				Receptor HI Total	0.2

Total Blood HI	0.04
Total Autoimmune HI	0.07
Total CVS HI	0.02
Total GS HI	0.06
Total Liver HI	0.01
Total Skin HI	0.02

APPENDIX A.2

SAMPLE CALCULATIONS

CALCULATION WORKSHEET

CLIENT: MCRD PARRIS ISLAND, SOUTH CAROLINA		**JOB NUMBER:** 5260
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF FISH/SHELLFISH CURRENT/FUTURE ADULT RECREATIONAL USER		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 03/19/2007

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from incidental ingestion of fish/shellfish.

EQUATION:

$$IEX = \frac{CF_{fish} \times IR \times EF \times ED \times FI}{BW \times AT}$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
CF_{fish}	=	exposure point concentration in fish tissue(mg/kg)
IR	=	incidental soil ingestion rate (kg/meal)
EF	=	exposure frequency (meals/year)
ED	=	exposure duration (years)
FI	=	fraction ingested from contaminated source (unitless)
BW	=	body weight (kg)
AT	=	averaging time (days)
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)
RfDo	=	oral noncarcinogenic reference dose (mg/kg/day)

RISKS:

ICLR (Carcinogens) = Intake (mg/kg/day) x CSFo $(mg/kg/day)^{-1}$
HQ (Noncarcinogens) = Intake (mg/kg/day) / RFDo (mg/kg/day)

ASSUMPTIONS:

CFfish	=	0.38	mg/kg	Chemical: Arsenic
IR	=	0.054	kg/meal	
EF	=	350	meals/year	
ED	=	30	years	
FI	=	1	unitless	
BW	=	70	kg	
ATc	=	25550	days	
ATnc	=	10950	days	
CSFo	=	1.5E+00	$(mg/kg/day)^{-1}$	
RfDo	=	3.0E-04	(mg/kg/day)	

CLIENT: MCRD PARRIS ISLAND, SOUTH CAROLINA		JOB NUMBER: 5260
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF FISH/SHELLFISH CURRENT/FUTURE ADULT RECREATIONAL USER		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: L. Jackson	DATE: 03/19/2007

EXAMPLE CARCINOGENIC CALCULATION

$$IEXc = \frac{0.38 \text{ mg/kg} \times 0.054 \text{ kg/meal} \times 350 \text{ meals/year} \times 30 \text{ years} \times 1}{70 \text{ kg} \times 25550 \text{ days}}$$

IEXc = 1.20E-04 mg/kg/day

ICLR = 1.20E-04 mg/kg/day x 1.50E+00 (mg/kg/day)-1 = Incremental Lifetime Cancer Risk

ICLR = 1.81E-04

EXAMPLE NONCARCINOGENIC CALCULATION

$$IEXnc = \frac{0.38 \text{ mg/kg} \times 0.054 \text{ kg/meal} \times 350 \text{ meals/year} \times 30 \text{ years} \times 1 \text{ unitless}}{70 \text{ kg} \times 10950 \text{ days}}$$

IEXnc = 2.81E-04 mg/kg/day

HQ = 2.81E-04 mg/kg/day / 3.00E-04 (mg/kg/day) = Hazard Quotient

HQ = 9.37E-01

APPENDIX B

May 2002 Technical Memorandum
Post-Interim Construction Risk Assessment
for
Site/SWMU 3 – Causeway Landfill

REVISION 0
MAY 2002

TECHNICAL MEMORANDUM
POST-INTERIM CONSTRUCTION RISK ASSESSMENT
SITE/SWMU 3 - CAUSEWAY LANDFILL

MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

U.S. EPA IDENTIFICATION NUMBER
SC6 170 022 762

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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TECHNICAL MEMORANDUM
POST-INTERIM CONSTRUCTION RISK ASSESSMENT
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

1.0 OBJECTIVE

The objective of this technical memorandum is to present the data that were collected at Site/SWMU 3 (Site 3) to determine whether environmentally significant concentrations of contaminants remain in exposed sediments. From August 2000 to June 2001, an interim remedy was implemented at the site that covered and stabilized waste materials within the causeway and covered the most contaminated sediments. Additional adjacent, but less contaminated, sediments were also covered during this interim remedy.

The sediment sampling was to be conducted 90 days after the end of the interim remedy to allow site conditions to stabilize. The interim construction was completed on July 10, 2001, and sediment samples were collected along the sides of the causeway on October 15 and 16, 2001.

2.0 BACKGROUND

Environmental investigations at Site 3 were conducted from 1988 to 1999. In September 2000, an Interim Record of Decision was signed that addressed waste materials and the most significantly impacted sediments at the site. Historical sediment testing is summarized as follows.

In 1988, eight sediment samples were collected at the site. The results were compared to the United States Environmental Protection Agency (U.S. EPA) Region 4 ecological screening values. The sediment testing found elevated concentrations of several metals, including lead and mercury. Environmentally significant concentrations of organic compounds were not detected in the 1988 testing. In 1998, 21 sediment samples were collected at the site and evaluated. This evaluation identified arsenic, copper, lead, mercury, zinc, polychlorinated biphenyls (PCBs), several pesticides, and polycyclic aromatic hydrocarbons (PAHs) in one or more sediment sample locations at levels that exceeded background values and human health and/or ecological screening values. Generally, the metal exceedances were relatively minor, with a maximum Hazard Quotient (HQ), relative to U.S. EPA Region 4 ecological screening values, of only 3.5. Evaluation of data for PCBs, several pesticides, and PAHs indicated a more significant concern; maximum HQs, relative to U.S. EPA Region 4 ecological screening values, were 11.6, 237.7, and 31, respectively.

Ecological food-chain modeling was conducted. The results indicated that, at that time, the maximum and mean levels of several pesticides (DDT, DDE, and DDD) in the sediment represented a potentially significant threat to the heron and eagle in the area [lowest-observed-adverse-effect level (LOAEL) HQs greater than 1.0]. Also, some sediments with elevated concentrations of aluminum, arsenic, iron, lead, mercury, thallium, and vanadium represented potential threats to aquatic food chain receptors (LOAEL HQ greater than 1.0). However, as discussed in the RI Report, thallium, aluminum, iron, and vanadium concentrations were similar to background levels, and the presence of these metals was likely to be of natural origin.

In 1999, 12 additional sediment samples were collected to better define distribution of sediment contamination. The results were used to establish sediment cover areas for the interim remedy. The highest concentration of each of the site contaminants was identified along the toe of the landfill and generally corresponded to areas where eroded waste was visible. Many of the sediment contaminants were also identified in fish samples collected at Site 3 in 1991. Estimated risks attributable to fish consumption were generally within acceptable levels for human consumption, assuming fish consumption typical of harvesting practices at MCRD Parris Island.

Based on these findings, four sediment areas were identified as representing a potentially significant environmental risk that warranted environmental action; these areas were covered as part of the interim remedy at Site 3. Contaminant concentrations within the areas also generally exceeded ecological effect range - median values. Detected chemical concentrations near the edges of the areas were generally similar to background or ecological screening values. Each of the areas was on the pond side of the causeway. The contaminants associated with the four areas, Areas 1, 2, 3, and 4 were PAHs, PCBs, pesticides, and pesticides, respectively.

As part of the Site 3 interim remedy bank stabilization, sediments along the toe of the site were covered to a distance of 10 to 30 feet from the pre-interim remedy bank (see Figure 1). Based on localized site conditions, most or all of the pre-2001 sediment sample locations on the pond side of the causeway were covered. However, the majority of the pre-2001 marsh side sediment sample locations remain.

3.0 SAMPLING ACTIVITIES

As was decided during the December 2000 and February 2001 MCRD Parris Island partnering team meetings, 20 post-interim construction sediment samples (plus two duplicates) were collected at the site. Fifteen samples were collected on the pond side of the causeway, and five samples were collected on the marsh side. The samples were collected at a distance of 2 to 15 feet from the toe of the recently built slope, in depressions just beyond the edge of the newly installed rip-rap and cover fabric. The samples were scoped from the sediment using a stainless-steel spoon, mixed in a stainless-steel bowl, and

transferred to the sample jars for analysis. Decontamination of the sampling equipment between locations consisted of an alconox wash and rinse, isopropyl alcohol rinse, and de-ionized water rinse. The locations of the sampling points are shown on Figure 1 (PAI-03-SD-41-01 through PAI-03-SD-60-01).

Analytical testing differed by location, as shown on Table 1, and was based on contaminant findings during the pre-interim remedy sediment results. The marsh-side samples were analyzed for PAHs, select metals (arsenic, copper, lead, mercury, and zinc), and select pesticides (DDT, DDE, DDD, alpha chlordane, and gamma chlordane) (five samples, PAI-03-SD-41 through -45). The selected marsh-side locations correspond to 1998 sample locations (see Figure 1). Area 1 samples were analyzed for PAHs and select metals (four samples, PAI-03-SD-46 through -49). Area 2 samples were analyzed for PCBs and select metals (three samples, PAI-03-SD-50 through -52). Areas 3 (three samples, PAI-03-SD-53 through -55) and Area 4 (five samples, PAI-03-SD-56 through -60) samples were analyzed for select pesticides (DDT, DDE, DDD, alpha chlordane, and gamma chlordane) and select metals.

4.0 ANALYTICAL RESULTS

Table 2 presents the positive detections for the sediment samples collected at Site 3. Appendix A presents all analytical results. Fourteen PAHs, five pesticides, and five inorganics were detected in the sediment samples. PCBs were not detected in the 2001 samples.

Table 3 presents the frequency of detection, range of positive detections, range of nondetect values, the location where the maximum positive detection was found, and the average of the results for all sediment samples. PAHs were detected in eight of nine samples; the maximum concentration, 330 µg/kg (pyrene), was in the duplicate sample collected at PAI-03-SD-41. PAHs were also detected in the non-duplicate sample at this location, but at a concentration approximately 10 times lower than in the duplicate sample (e.g., pyrene at 22 µg/kg). This type of variation can occur in solid samples when chemical detections are low and contaminants are concentrated in isolated particles. For evaluation purposes, the average of the duplicate and non-duplicate samples was used as the representative concentration for this location.

4,4'-DDT was detected in five of 13 samples; the maximum concentration, 12 µg/kg, was at sample location PAI-03-SD-41. 4,4'-DDD and 4,4-DDE were detected in six of 13 samples and 12 of 13 samples at maximum concentrations of 58 and 26 µg/kg, respectively, from location PAI-03-SD-59. Alpha-chlordane and gamma-chlordane were detected in two of 13 samples at maximum concentrations of 6.6 µg/kg (PAI-03-SD-42) and 3.4 µg/kg (PAI-03-SD-54), respectively.

Arsenic, copper, lead, mercury, and zinc were detected in all 20 sediment samples. Arsenic and copper were detected at maximum concentrations of 13.6 and 27.1 mg/kg, respectively, from location PAI-03-SD-44. Lead was detected at a maximum of 44.9 mg/kg at location PAI-03-SD-60. Mercury was

detected at a maximum of 0.2 mg/kg at location PAI-03-SD-48, and zinc was detected at a maximum of 93.3 mg/kg at location PAI-03-SD-58.

During an initial evaluation of the data, the sediment data were compared to background and typical facility concentrations for metals and pesticides, Region 9 residential soil preliminary remediation goals (PRGs), and U.S. EPA Region 4 ecological screening values (ESVs) (see Table 3, Table 4, and Figure 2). A more detailed ecological evaluation of the data, presented in Section 5.0, provides an initial evaluation of the data using U.S. EPA Region 4 ecological effects values (EEV).

Because PAHs represent a complex class of chemicals, benzo(a)pyrene (BAP) equivalent values for human health comparison and total PAH values for ecological comparison were calculated for the sediment samples (see Appendix B). Based on this evaluation, BAP equivalent results do not exceed human health criteria. Although several individual PAHs exceed U.S. EPA Region 4 ESVs in two samples, total PAHs do not exceed the ESVs.

With the exception of arsenic, the maximum detected concentrations of pesticides and metals do not exceed U.S. EPA Region 9 Soil RGOs (for residential development), indicating that these chemicals do not represent a potential threat to human health even under an unrestricted use scenario. Because the samples represent sediment locations, site-specific risk estimates would be even lower. For arsenic, the average and maximum detected concentrations at Site 3 were 4.7 mg/kg and 13.6 mg/kg, respectively, compared to an U.S. EPA Region 9 RGO of 0.39 mg/kg. However, arsenic is a common naturally occurring metal, and the average and maximum concentrations of arsenic detected in the background data set for MCRD Parris Island were 6.1 mg/kg and 12.2 mg/kg, respectively (see Table 4). Based on this comparison, the arsenic present in the site sediments is equivalent to background levels and therefore does not represent a significant incremental risk to human health.

4,4' DDD, arsenic, copper, lead, and mercury were detected in one or more samples at concentrations that exceed typical facility/background sediment concentrations and U.S. EPA Region 4 ESVs, indicating potential risk to ecological receptors. To further evaluate the sediment results relative to background/typical facility sediment concentrations, a comparison was conducted of the average concentrations of these five chemicals in Site 3 sediments to one-half the background/typical facility concentrations for MCRD Parris Island (see Table 4). One-half the background/typical facility concentration is equal to the average concentration in the background data set. Based on this comparison of averages, 4,4'-DDD and arsenic sediment concentrations are equal to or less than the concentration of those chemicals found in the background/typical facility data set. Copper (9.1 mg/kg versus 6.1 mg/kg), lead (18 mg/kg versus 10.3 mg/kg), and mercury (0.087 versus 0.045 mg/kg) are slightly elevated in sediment concentrations at Site 3.

These results are discussed individually for the marsh-side samples and the four cover areas below.

The 2001 sediment samples on the marsh side were analyzed for PAHs, pesticides, and inorganics (see Table 5 and Figure 2). Since the marsh-side sediment sample locations from 1998 were not covered during the interim remediation, the 1998 marsh-side sediment data are also presented in Table 5. The average concentrations for the 1998 and 2001 samples were calculated (see Appendix C). Also presented in Table 5 are the background/typical facility concentration concentrations, EPA Region 9 residential soil PRGs, and the EPA Region 4 ESVs.

Measured total PAH, pesticide, mercury, and zinc concentrations did not exceed background and ESV concentrations in the marsh-side samples. Lead was found to exceed criterion in one of five samples collected in 1998 but not in any samples collected in 2001. Arsenic and copper were found at slightly elevated concentrations. Arsenic concentrations exceeded background and ESVs in one of five samples collected in 2001 but not in any of the samples collected in 1998. Copper was found to exceed criterion in one in five samples collected in 1998 and two of five samples collected in 2001. Overall, the 1998 and 2001 sediment sample results are similar.

The Area 1 sediment samples (pond side) were analyzed for PAHs and metals. Only mercury (0.2 mg/kg) in one of four samples exceeded background (0.09 mg/kg) and ESVs (0.13 mg/kg) at sample location PAI-03-SD-48.

The Area 2 sediment samples (pond side) were analyzed for PCBs, pesticides, and metals. Copper (22.5 mg/kg) in one of four samples and lead (35.8 mg/kg) in one of four samples exceeded background concentrations (10.1 mg/kg and 20.6 mg/kg, respectively) and ESVs (18.7 and 30.2 mg/kg, respectively) at sample location PAI-03-SD-50.

The Area 3 sediment samples (pond side) were analyzed for pesticides and metals. Background/typical facility concentrations and ESVs were not exceeded in these samples.

The Area 4 sediment samples (pond side) were analyzed for pesticides and metals. 4,4- DDD exceeded typical facility concentrations (33.6 µg/kg) and ESVs (1.22 µg/kg) at one sample location PAI-03-SD-59 (58 µg/kg). Mercury exceeded background (0.09 mg/kg) and ESVs (0.13 mg/kg) at sample locations PAI-03-SD-57 (0.16 mg/kg), PAI-03-SD-58 (0.16 mg/kg), PAI-03-SD-59 (0.15 mg/kg), and PAI-03-SD-60 (0.14 mg/kg). Lead exceeded background (20.6 mg/kg) and ESVs (30.2 mg/kg) at sample locations PAI-03-SD-59 (36.4 mg/kg) and PAI-03-SD-60 (44.9 mg/kg).

5.0 ECOLOGICAL RISK ASSESSMENT

Sediment data from samples collected in October 2001 from five areas along the Site 3 causeway landfill were used to assess the potential risks of site contamination on aquatic and semi-aquatic ecological receptors. The assessment followed the guidance described by U.S. EPA (EPA, 1997; 2000a) and the Navy (DON, 1998) for Steps 1 through 3a of ecological risk assessments:

Step 1	Screening-Level Problem Formulation and Ecological Effects Evaluation
Step 2	Screening-Level Exposure Estimate and Risk Calculation
Step 3a	Refinement of Preliminary Contaminants of Concern

Details regarding the above three steps and the ecological risk assessment process can be found in the references cited above, as well as in the original ecological risk assessment for Site 3 (TtNUS, 1999).

5.1 Screening-Level Problem Formulation And Ecological Effects Evaluation

5.1.1 Habitat Types and Ecological Receptors

Site 3 consists of a causeway constructed across a tidal marsh in the northern portion of MCRD Parris Island. The marsh south of the causeway is a vast expanse of thickly vegetated cordgrass (*Spartina alterniflora*), intersected by several tidal channels. The marsh on the northern side of the causeway is essentially a ponded area of open water, with scattered areas of cordgrass.

The ponded area north of the site occasionally receives tidal inflow via two sets of three culverts beneath the causeway. This tidal flow results in saline conditions in the pond, thereby limiting aquatic organisms in the pond to marine species. Fish such as red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentatus*), whiting (*Menticirrhus americanus*), and striped mullet (*Mugil cephalus)* are known to occur in the marsh on both sides of the causeway. Small, schooling fish species such as mud minnows (*Umbra pygmaea*) and mummichogs (*Fundulus heteroclitus*) and a variety of mollusks and crustaceans also occur there.

Several species of animals prey upon the fish, mollusks, and crustaceans in the marsh and pond. These include ospreys (*Pandion haliaetus*), wading birds such as the tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), green heron (*Butorides striatus)*, and snowy egret (*Egretta thula*). Various shorebirds and wintering waterfowl forage in the marsh. Mammals that are known or expected to forage along the edge of the marsh include the raccoon *(Procyon lotor*), mink (*Mustela vison*), river otter (*Lutra canadensis*), opossum (*Didelphis virginiana*), marsh rabbit (*Sylvilagus palustris*), and rice rat (*Oryzomys palustris*).

Endangered and threatened species that utilize the aquatic habitats along the causeway include the bald eagle (*Haliaeetus leucocephalus*), wood stork (*Mycteria americana*), and American alligator (*Alligator mississippiensis*). An active bald eagle nest is located near the southeastern end of the causeway, and the associated pair of eagles is known to frequently forage in the vicinity of the site. The bald eagle is state and federally listed as threatened. Wood storks (state and federally listed as endangered) forage in various locations throughout the Depot, and they are often observed in the ponded marsh north of the causeway. Two alligators are frequently observed in the ponded area. Although common in some parts of its range, the alligator is federally listed as threatened due to its similarity in appearance to the endangered American crocodile (*Crocodylus acutus*).

5.1.2 Contaminant Sources and Migration Pathways

The contaminant source at Site 3 is buried material from historical landfilling activities at the site. Recent remediation activities have eliminated the surface-soil-to-terrestrial receptors pathway and have greatly reduced the possibility of contaminant migration from the landfill into the adjacent aquatic habitats. However, residual contaminant migration from the landfill into adjacent surface water and sediment might exist in some portions of the causeway. Therefore, post-remediation sediment sampling activities were conducted in October 2001, as requested by the MCRD Parris Island Partnering Team.

5.1.3 Exposure Routes

Aquatic organisms and wildlife that forage in the aquatic habitats along the causeway could be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Birds and mammals could incidentally ingest sediment while grooming fur, preening feathers, digging, or feeding on items to which sediment has adhered (such as roots and tubers). Some animals could also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors (Sample et al., 1996). In addition, the salinity of the surface water in the marsh precludes its use as drinking water.

Exposure to contaminants in the sediment through dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons probably minimize transfer of contaminants across dermal tissue. In addition, little information is available (e.g., absorption factors) to evaluate dermal exposures to wildlife.

5.1.4 Selection of Analytes to be Investigated

The chemicals selected for laboratory analyses varied depending on the location of the sample (Table 1) and were approved by the MCRD Parris Island partnering team. All analytes detected in sediment samples collected in October 2001 were included for quantitative analysis in this report. Profiles describing the environmental fate, transport, and toxicity of these chemicals are presented in Appendix F of the Site 3 RFI/RI Report (TtNUS, 1999).

5.1.5 Preliminary Assessment and Measurement Endpoints

An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (U.S. EPA, 1997). The preliminary assessment endpoints were the protection of aquatic biota from adverse effects of site-related chemicals on growth, survival, and reproduction.

Measurement endpoints are often used to make inferences about risks to the assessment endpoints, since they are more easily quantified or observed than assessment endpoints. The preliminary measurement endpoints were chemical concentrations in sediment that are associated with adverse effects on growth, survival, and reproduction of benthic organisms (sediment ecological screening values). Toxicity data, including food chain doses are discussed in more detail in the Site 3 RI Addendum.

5.2 SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

5.2.1 Approach

Maximum concentrations of chemicals detected in sediment were compared to EPA Region 4 ecological screening values for sediment (U.S. EPA, 2000a and 2000b). A Hazard Quotient (HQ) is presented for each detected chemical and is defined as the ratio of the maximum chemical concentration to the ecological screening value (referred to as a "screening HQ"). If the maximum concentration did not exceed the ecological screening value (i.e., HQ less than 1.0), the chemical was eliminated from further consideration. If the maximum concentration exceeded the ecological screening value or if an ecological screening value was not available, the chemical was considered to be an ecological chemical of potential concern (COPC) and was retained for further evaluation.

In accordance with U.S. EPA Region 4 guidance, sediment PAH data were assessed primarily by evaluating total PAH concentrations. Total PAH concentrations were calculated as the sum of concentrations of acenaphthene, acenapththylene, anthracene, fluorene, 2-methylnaphthalene,

All concentrations of metals were less than their respective ecological screening values (Table 9).

In summary, concentrations of pesticides and metals in marsh samples were low relative to ecological screening values, alternate sediment guidelines, and/or background/typical facility concentrations. Concentrations of gamma-chlordane could pose potential risk to benthic receptors in the vicinity of one sample, but concentrations of this pesticide do not appear to be site related. Otherwise, concentrations of pesticides and metals pose negligible risk to benthic invertebrates and upper level receptors.

5.3.2.5 Sediment Area 4

Pesticide concentrations were elevated in some sediment samples collected in the vicinity of Area 4 prior to remediation (TtNUS, 1999). DDD, DDE, DDT, alpha-chlordane, gamma-chlordane, lead, and mercury were present at concentrations greater than their respective ecological screening values in Area 4 samples collected in October 2001 (Table 10).

The maximum site-wide concentrations of DDD and DDE were measured in sample SD-59, and maximum screening HQs for DDD and DDE were 47.5 and 12.6, respectively (Table 10). Maximum screening HQs for the other three pesticides ranged from 3.2 to 5.6 (Table 10), and concentrations of these three pesticides were less than most alternate guidelines (Table 11). The DDD concentration in SD-59 was elevated relative to all alternate guidelines, and the DDE concentration in this sample exceeded some alternate guidelines. With the exception of DDD in sample SD-59, all pesticide concentrations were less than typical facility pesticide concentrations at MCRD Parris Island (Table 10).

The maximum concentrations of DDT, alpha-chlordane, and gamma-chlordane in Area 4 were similar to the site-wide average, and thus, the food-chain HQs for the maximum concentrations in Area 4 would be approximately those shown in Table 13, indicating negligible risk to piscivorous birds and mammals. Based on the concentration of DDE in SD-59, maximum food-chain HQs were elevated for the heron (HQ = 47.2) and osprey (HQ = 15.0) (Table 12). These HQs, especially that for the heron, suggest that piscivorous birds would be at risk if foraging occurred exclusively in the vicinity of this sample. This possibility is essentially nonexistent. The Area 4 average concentrations would more realistically represent potential exposure concentrations for upper-level receptors. The average DDD and DDE concentrations (14.6 and 10.0 µg/kg, respectively) are approximately twice the average site-wide concentrations for these compounds. Thus, average food-chain HQs for DDD and DDE would be approximately twice the values shown in Table 13, indicating negligible risk to piscivorous receptors from DDD. Potential food-chain risk from DDE to receptors represented by the heron is indicated to the extent that these receptors forage in the vicinity of Area 4. As stated above, however, concentrations of DDE were less than typical facility pesticide concentrations at MCRD Parris Island.

Concentrations of lead and mercury exceeded ecological screening values, but maximum HQs were relatively low (lead HQ = 1.5; mercury HQ = 1.2) (Table 10). Concentrations of these two metals were not elevated relative to most alternate guidelines shown in Table 11. Since the maximum site-wide lead concentration was measured in sample SD-60, the maximum food-chain HQs for lead in this sample are those shown in Table 12. The maximum mercury concentration in Area 4 results in food-chain HQs slightly less than those in Table 12. For reasons discussed earlier regarding the food-chain model, the food-chain HQs for lead and mercury are considered to be relatively low.

In summary, metals, as well as the pesticides DDT, alpha-chlordane, and gamma-chlordane in Area 4 sediments, pose negligible risk to benthic and upper-level receptors. The DDE concentration in sample SD-59 poses potential risk benthic receptors but the concentration was less than typical facility-wide DDE concentrations at MCRD Parris Island. The DDD concentration in SD-59 poses potential risk to benthic receptors and was greater than typical facility-wide DDD concentrations at MCRD Parris Island. Concentrations of these pesticides pose potential risk to piscivorous birds only if such receptors forage exclusively in Area 4; this seems highly unlikely.

5.2.3.6 Screening-Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ecological risk assessment process. General uncertainties involved in this ecological risk assessment were discussed in the previous ecological risk assessment (TtNUS, 1999) and will not be repeated here. Areas of uncertainty specific to this risk assessment are discussed below.

Mercury is known to biomagnify in aquatic systems, but the food-chain modeling assumed that concentrations in prey items of representative ecological receptors were equal to sediment concentrations. This assumption was incorporated since biota-to-sediment accumulation factors (BSAFs) do no exist for mercury compounds in salt water environments. The assumption could underestimate risk via the food chain. Mercury concentrations in samples analyzed for this risk assessment were relatively low, however. Thus, the uncertainty associated with this issue is probably minimal in this assessment.

Species used in the food-chain modeling included species with home ranges much larger than aquatic habitats at Site 3. However, the resulting over-estimate of potential risks was partially mitigated by applying area-use factors. Nevertheless, area-use factors for piscivorous mammals and birds vary considerably by species, seasonal prey availability, and habitat conditions.

Few dietary NOAELs and LOAELs for fish were available and, thus, the investigation of dietary exposure and related risks to the mummichog and red drum could not be evaluated for pesticides, lead, or copper.

As a result, direct conclusions about the potential risks to fish through ingestion of these chemicals cannot be made, and only qualitative inferences can be drawn.

Data on food ingestion rates for mink (used herein to represent piscivorous mammals) were sparse. The Wildlife Exposures Factors Handbook (U.S. EPA, 1993) contains the following ingestion rates for mink: 0.13 g/g bw/d for captive mink, 0.12 and 0.16 g/g bw/d for farm raised mink, and 0.22 g/g bw/day estimated using Nagy's (1987) equation. These values may not adequately represent actual food ingestion rates for wild mink. The mink food ingestion rate used herein was 0.22 g/g bw/day and is only slightly greater than rates estimated using Nagy's (1987) equation for two other piscivorous mammals (raccoon: 0.21 g/g bw/day; otter: 0.19 g/g bw/day). Thus, although the food ingestion rate of the mink is uncertain, the value used in this assessment is probably an adequately conservative estimate of food ingestion for piscivorous mammals.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations for the Site 3 Confirmatory Sampling event are summarized below.

1.0 PAHs and zinc were detected in Site 3 post-interim construction sediment samples at concentrations exceeding MCRD Parris Island background concentrations. However, based on a comparison of these data with human health and ecological screening values, no adverse effects from these chemicals would be anticipated.

2.0 Copper, lead, and mercury were detected in Site 3 post-interim construction sediment samples at concentrations exceeding MCRD Parris Island background concentrations. Based on a comparison of these data with human health screening values, no adverse impacts on human health would be anticipated. A comparison of these data with ecological criteria concludes the following:

- Based on U.S. EPA Region 4 ESVs, potential minor impacts to the benthic community may occur in localized areas. The corresponding maximum screening HQ's are copper, 1.4; lead, 1.5; and mercury, 1.5. Based on average site metal concentrations, each of the HQs would be less than 1.0.

- Modeling calculations did not find potential impacts to upper food-chain receptors associated with copper in the sediments (NOAEL HQs less than 1.0).

- Based on food-chain modeling calculations for lead, the maximum NOAEL HQ is 8.35 for the osprey. This value indicates a potential adverse impact. However, when mean

concentrations and home range factors are considered, NOAEL HQs for all receptors are less than 1.0, indicating that adverse impacts are unlikely.

- Based on food-chain modeling calculations for mercury, the maximum NOAEL HQ is 6.57 for the osprey. When mean concentrations and home range factors are considered, only the mink would be potentially impacted (Avg. NOAEL HQ = 1.47). All other NOAEL HQs are less than 1.0.

3.0 Arsenic and pesticides were detected in Site 3 sediments at concentrations below background and typical facility concentrations, respectively. Based on a comparison of these data with human health screening values, no adverse impacts on human health would be anticipated. A comparison of these data with ecological criteria concludes the following:

- For arsenic, based on U.S. EPA Region 4 ESVs, potential minor impacts to the benthic community may occur in localized areas. The maximum screening HQ is 1.9. Based on average site arsenic concentrations, the HQ would be less than 1.0.

- Based on food-chain modeling for arsenic, the maximum NOAEL HQ is 23.7 for the mink. When mean concentrations and home range factors are considered, only the mink would be potentially impacted (Avg. NOAEL HQ = 8.21). All other NOAEL HQs are less than 1.0.

- For pesticides, based on U.S. EPA Region 4 ESVs, potentially significant impacts to the benthic community may occur in localized areas. The corresponding screening HQs range from 6.8 (gamma-chlordane) to 48 (DDD). Based on average site pesticide concentrations, the screening HQs range from 2.4 (DDE) to 7.1 (DDD).

- Based on food-chain modeling for pesticides, the maximum NOAEL HQ is 47.2 for the Heron. When mean concentrations and home range factors are considered, only the heron would be potentially impacted (Avg. NOAEL HQ = 1.45). All other NOAEL HQs are less than 1.0.

4.0 The interim construction activities conducted at the Site 3 causeway landfill, which consisted of encapsulating waste materials and covering the most contaminated sediments, were effective in addressing the most significant human health and ecological concerns with the site. Some pesticides remain in site sediments, but the concentrations are such that remaining human health and ecological risks are within an acceptable risk range given the extenuating risk management factors described above. In addition, since there is no longer an active source, pesticide concentrations will continue to decline through natural recovery processes (biodegradation).

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TABLE 1

POST INTERIM CONSTRUCTION SAMPLING
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Sample location	Sample designation	Sample Depth (feet Below ground surface)	Sample Analysis			
			TCL PAHS	Select metals[1]	Select pesticides[1]	TCL PCBS
MARSH SIDE						
PAI-03-SD-41	PAI-03-SD-41-01	0 - 0.5	X	X	X	X
PAI-03-SD-42	PAI-03-SD-42-01	0 - 0.5	X	X	X	X
PAI-03-SD-43	PAI-03-SD-43-01	0 - 0.5	X	X	X	X
PAI-03-SD-44	PAI-03-SD-44-01	0 - 0.5	X	X	X	X
PAI-03-SD-45	PAI-03-SD-45-01	0 - 0.5	X	X	X	X
POND SIDE						
PAI-03-SD-46	PAI-03-SD-46-01	0 - 0.5	X	X		
PAI-03-SD-47	PAI-03-SD-47-01	0 - 0.5	X	X		
PAI-03-SD-48	PAI-03-SD-48-01	0 - 0.5	X	X		
PAI-03-SD-49	PAI-03-SD-49-01	0 - 0.5	X	X		
PAI-03-SD-50	PAI-03-SD-50-01	0 - 0.5		X		X
PAI-03-SD-51	PAI-03-SD-51-01	0 - 0.5		X		X
PAI-03-SD-52	PAI-03-SD-52-01	0 - 0.5		X		X
PAI-03-SD-53	PAI-03-SD-53-01	0 - 0.5		X	X	
PAI-03-SD-54	PAI-03-SD-54-01	0 - 0.5		X	X	
PAI-03-SD-55	PAI-03-SD-55-01	0 - 0.5		X	X	
PAI-03-SD-56	PAI-03-SD-56-01	0 - 0.5		X	X	
PAI-03-SD-57	PAI-03-SD-57-01	0 - 0.5		X	X	
PAI-03-SD-58	PAI-03-SD-58-01	0 - 0.5		X	X	
PAI-03-SD-59	PAI-03-SD-59-01	0 - 0.5		X	X	
PAI-03-SD-60	PAI-03-SD-60-01	0 - 0.5		X	X	

(1) Metal analysis consisted of arsenic, copper, lead, mercury, and zinc.
Pesticide analysis consisted of DDT, DDE, DDD, alpha chlordane, and gamma chlordane. Analytical methods consisted of the current SW-846 methods for PCBs, pesticides, and metals and EPA 8270C (SIM) or SW846 8310 for PAHs.
X indicates that the sample was analyzed for that parameter.

TABLE 2

SUMMARY OF POSITIVE SEDIMENT ANALYTICAL RESULTS
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

SAMPLE NUMBER FIELD DUPLICATE OF: SAMPLE DATE	PAI-03-SD-41-01 PAI-03-SD-41-01-D 10/16/01	PAI-03-SD-41-01-AVG 10/16/01	PAI-03-SD-41-01-D PAI-03-SD-41-01 10/16/01	PAI-03-SD-42-01 10/16/01	PAI-03-SD-43-01 10/16/01	PAI-03-SD-44-01 10/16/01	PAI-03-SD-45-01 PAI-03-SD-45-01-D 10/16/01	PAI-03-SD-45-01-AVG 10/16/01
Semivolatile Organics (ug/kg)								
ACENAPHTHENE	28 U	28 J	28 J	26 U	70 UJ	56 U	42 UJ	42 UJ
ANTHRACENE	28 UJ	46 J	78 J	26 U	70 UJ	56 U	42 UJ	14 J
BENZO(A)ANTHRACENE	24 J	162 J	300 J	66	29 J	12 J	30 J	48.5 J
BENZO(A)PYRENE	11 J	90.5 J	170 J	48	70 UJ	56 U	14 J	22 J
BENZO(B)FLUORANTHENE	19 J	124.5 J	230 J	59	25 J	13 J	25 J	35 J
BENZO(G,H,I)PERYLENE	28 UJ	42.5 J	71 J	30	70 UJ	56 U	12 J	12 J
BENZO(K)FLUORANTHENE	7 J	44.5 J	82 J	24 J	70 UJ	56 U	42 UJ	14 J
CHRYSENE	12 J	101 J	190 J	34	70 UJ	56 U	17 J	24 J
DIBENZO(A,H)ANTHRACENE	28 U	26 J	26 J	12 J	70 UJ	56 U	42 UJ	42 UJ
FLUORANTHENE	42 J	256 J	470 J	91	34 J	21 J	58 J	89 J
FLUORENE	28 U	25.5	37	26 U	70 UJ	56 U	42 UJ	8 J
INDENO(1,2,3-CD)PYRENE	28 UJ	67 J	120 J	46	70 UJ	56 U	42 UJ	18 J
PHENANTHRENE	7 J	163.5 J	320 J	23 J	70 UJ	56 U	23 J	54.5 J
PYRENE	22 J	176 J	330 J	53	21 J	12 J	33 J	45 J
Pesticides/PCBs (ug/kg)								
4,4'-DDD	3.8 J	3.3 J	2.8 J	1.4 J	12 UJ	9.2 U	7.1 U	7.05 U
4,4'-DDE	1.8 J	1.6 J	1.4 J	1.5 J	2.9 J	1.7 J	1.6 J	1.65 J
4,4'-DDT	12 J	6.55 J	1.1 J	1.5 J	12 UJ	9.2 U	7.1 U	7.05 U
ALPHA-CHLORDANE	2.4 U	2.4 U	2.4 U	6.6	6.0 UJ	4.7 U	3.6 U	3.6 U
GAMMA-CHLORDANE	2.4 U	2.4 U	2.4 U	2.2 U	6.0 UJ	4.7 U	3.6 U	3.6 U
Inorganics (mg/kg)								
ARSENIC	2	1.9	1.8	2.2	9.5 J	13.6	3.8	4.2
COPPER	4.5	4	3.5	5	19.7 J	27.1	9.9	10.55
LEAD	7	6.15	5.3	13.2	19.0 J	27.3	12.6	13.4
MERCURY	0.01	0.01	0.01	0.04	0.06 J	0.06	0.05	0.05
ZINC	12.7	11.2	9.7	20.3	50.3 J	67.7	32.0 J	49.8 J
Miscellaneous Parameters (%)								
TOTAL SOLIDS	69.9 %	70.65 %	71.4 %	76.0 %	28.3 %	35.8 %	46.6 %	46.7 %

TABLE 2

SUMMARY OF POSITIVE SEDIMENT ANALYTICAL RESULTS
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

SAMPLE NUMBER FIELD DUPLICATE OF: SAMPLE DATE	PAI-03-SD-45-01-D PAI-03-SD-45-01 10/16/01	PAI-03-SD-46-01 10/16/01	PAI-03-SD-47-01 10/16/01	PAI-03-SD-48-01 10/16/01	PAI-03-SD-49-01 10/16/01	PAI-03-SD-50-01 10/15/01	PAI-03-SD-51-01 10/15/01	PAI-03-SD-52-01 10/15/01
Semivolatile Organics (ug/kg)								
ACENAPHTHENE	42 U	28 U	50 U	34 U	28 U			
ANTHRACENE	14 J	28 U	50 U	34 U	28 U			
BENZO(A)ANTHRACENE	67	28 U	18 J	13 J	13 J			
BENZO(A)PYRENE	30 J	28 U	50 U	34 U	28 U			
BENZO(B)FLUORANTHENE	45	28 U	15 J	10 J	10 J			
BENZO(G,H,I)PERYLENE	42 U	28 U	50 U	34 U	28 U			
BENZO(K)FLUORANTHENE	14 J	28 U	50 U	34 U	28 U			
CHRYSENE	31 J	28 U	11 J	9 J	6 J			
DIBENZO(A,H)ANTHRACENE	42 U	28 U	50 U	34 U	28 U			
FLUORANTHENE	120	28 U	25 J	28 J	27 J			
FLUORENE	8 J	28 U	50 U	34 U	28 U			
INDENO(1,2,3-CD)PYRENE	18 J	28 U	50 U	34 U	28 U			
PHENANTHRENE	86	28 U	50 U	10 J	12 J			
PYRENE	57	28 U	17 J	17 J	14 J			
Pesticides/PCBs (ug/kg)								
4,4'-DDD	7.0 U							
4,4'-DDE	1.7 J							
4,4'-DDT	7.0 U							
ALPHA-CHLORDANE	3.6 U							
GAMMA-CHLORDANE	3.6 U							
Inorganics (mg/kg)								
ARSENIC	4.6	0.84	7.7	3.5	1	10.5	5.2	9.3
COPPER	11.2	1.9	10.2	6.2	1.1	22.5	7.7	13.8
LEAD	14.2	4.7	17.7	11.2	4.2	35.8	13.3	26.8
MERCURY	0.05	0.05	0.08	0.2	0.04	0.12	0.07	0.13
ZINC	67.6 J	7.3	36.1	28.6	6.7	72.5	25.4	48.4
Miscellaneous Parameters (%)								
TOTAL SOLIDS	46.8 %	71.2 %	40.0 %	57.3 %	71.3 %	35.8 %	51.2 %	38.9 %

TABLE 2

SUMMARY OF POSITIVE SEDIMENT ANALYTICAL RESULTS
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

SAMPLE NUMBER	PAI-03-SD-53-01	PAI-03-SD-54-01	PAI-03-SD-55-01	PAI-03-SD-56-01	PAI-03-SD-57-01	PAI-03-SD-58-01	PAI-03-SD-59-01	PAI-03-SD-60-01
FIELD DUPLICATE OF:								
SAMPLE DATE	10/15/01	10/15/01	10/15/01	10/16/01	10/16/01	10/16/01	10/16/01	10/16/01
Semivolatile Organics (ug/kg)								
ACENAPHTHENE								
ANTHRACENE								
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
CHRYSENE								
DIBENZO(A,H)ANTHRACENE								
FLUORANTHENE								
FLUORENE								
INDENO(1,2,3-CD)PYRENE								
PHENANTHRENE								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	5.7 U	5.5 U	2.7 J	2.1 J	7.8 U	19 U	58	12 J
4,4'-DDE	5.7 U	1.2 J	1.7 J	2.8 J	4.2 J	4.8 J	26	12 J
4,4'-DDT	5.7 U	5.5 U	1.3 J	4.3 U	7.8 U	19 U	3.8 J	3.8 J
ALPHA-CHLORDANE	2.9 U	2.8 U	3.2 U	2.2 U	4.0 U	9.6 U	2.8 J	5.8 UJ
GAMMA-CHLORDANE	2.9 U	3.4	3.2 U	2.2 U	2.0 J	9.6 U	3.8 U	5.8 UJ
Inorganics (mg/kg)								
ARSENIC	2.1	3.6	5.1	1.9	1.6	4.5 J	2.3	3.5 J
COPPER	3.2	4.1	5.6	4.2	6.8	7.6 J	7.6	13.2 J
LEAD	9.9	10	13.7	23.2	14.6	17.2 J	36.4	44.9 J
MERCURY	0.09	0.04	0.05	0.04	0.16	0.16 J	0.15	0.14 J
ZINC	16.5	20.4	25.9	49.4	65.4	93.3 J	38.1	78.0 J
Miscellaneous Parameters (%)								
TOTAL SOLIDS	58.2 %	60.1 %	53.6 %	76.3 %	42.2 %	17.7 %	44.2 %	29.0 %

TABLE 3

FREQUENCY OF DETECTION
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

PARAMETER	FREQUENCY OF DETECTION	MINIMUM QUALIFIER	MAXIMUM QUALIFIER	RANGE OF POSITIVE DETECTIONS	RANGE OF NONDETECTS	LOCATION OF MAXIMUM POSITIVE DETECTION	AVERAGE OF POSITIVE RESULTS	AVERAGE OF ALL RESULTS
Semivolatile Organics (ug/kg)								
Acenaphthene	1/9	J	J	28	26 - 70	PAI-03-SD-41	28	22
Anthracene	2/9	J	J	14 - 78	26 - 70	PAI-03-SD-41	30	23
Benzo(a)anthracene	8/9	J	J	12 - 300	28	PAI-03-SD-41	45	42
Benzo(a)pyrene	3/9	J	J	11 - 170	28 - 70	PAI-03-SD-41	54	33
Benzo(b)fluoranthene	8/9	J	J	10 - 230	28	PAI-03-SD-41	36	34
Benzo(g,h,i)perylene	3/9	J	J	12 - 71	28 - 70	PAI-03-SD-41	28	24
Benzo(k)fluoranthene	3/9	J	J	7 - 82	28 - 70	PAI-03-SD-41	28	24
Chrysene	6/9	J	J	6 - 190	28 - 70	PAI-03-SD-41	31	29
Dibenzo(a,h)anthracene	2/9	J	J	12 - 26	28 - 70	PAI-03-SD-41	19	21
Fluoranthene	8/9	J	J	21 - 470	28	PAI-03-SD-41	71	65
Fluorene	2/9	J		8 - 37	26 - 70	PAI-03-SD-41	17	20
Indeno(1,2,3-cd)pyrene	3/9	J	J	18 - 120	28 - 70	PAI-03-SD-41	44	29
Phenanthrene	5/9	J	J	7 - 320	28 - 70	PAI-03-SD-41	53	41
Pyrene	8/9	J	J	12 - 330	28	PAI-03-SD-41	44	41
Pesticides/PCBs (ug/kg)								
4,4'-DDD	6/13	J		1.4 - 58	5.5 - 19	PAI-03-SD-59	13	8.7
4,4'-DDE	12/13	J		1.2 - 26	5.7	PAI-03-SD-59	5.2	5.0
4,4'-DDT	5/13	J	J	1.1 - 12	4.3 - 19	PAI-03-SD-41	3.4	4.0
Alpha-Chlordane	2/13	J		2.8 - 6.6	2.2 - 9.6	PAI-03-SD-42	4.7	2.5
Gamma-Chlordane	2/13	J		2 - 3.4	2.2 - 9.6	PAI-03-SD-54	2.7	2.2
Inorganics (mg/kg)								
Arsenic	20/20			0.84 - 13.6	0	PAI-03-SD-44-01	4.7	4.7
Copper	20/20			1.1 - 27.1	0	PAI-03-SD-44-01	9.1	9.1
Lead	20/20		J	4.2 - 44.9	0	PAI-03-SD-60-01	18	18
Mercury	20/20			0.01 - 0.2	0	PAI-03-SD-48-01	0.09	0.09
Zinc	20/20		J	6.7 - 93.3	0	PAI-03-SD-58-01	41	41
Miscellaneous Parameters (%)								
Total Solids	20/20			17.7 - 76.3	0	PAI-03-SD-56-01	50	50

Associated Samples:

PAI-03-SD-41-01	PAI-03-SD-45-01-D	PAI-03-SD-53-01
PAI-03-SD-41-01-AVG	PAI-03-SD-46-01	PAI-03-SD-54-01
PAI-03-SD-41-01-D	PAI-03-SD-47-01	PAI-03-SD-55-01
PAI-03-SD-42-01	PAI-03-SD-48-01	PAI-03-SD-56-01
PAI-03-SD-43-01	PAI-03-SD-49-01	PAI-03-SD-57-01
PAI-03-SD-44-01	PAI-03-SD-50-01	PAI-03-SD-58-01
PAI-03-SD-45-01	PAI-03-SD-51-01	PAI-03-SD-59-01
PAI-03-SD-45-01-AVG	PAI-03-SD-52-01	PAI-03-SD-60-01

TABLE 4

COMPARISON OF MAXIMUM CONCENTRATIONS
SITE/SWMU3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

SEDIMENT COCs	AVERAGE CONCENTRATION IN SEDIMENT	MAXIMUM CONCENTRATION IN SEDIMENT	1/2 OF BACKGROUND/ TYPICAL FACILITY SEDIMENT CONCENTRATION (1)	BACKGROUND/ TYPICAL FACILITY SEDIMENT CONCENTRATION (1)	REGION 9 RESIDENTIAL SOIL RGO (2)	REGION 4 ESV (3)
PAHs (ug/kg)						
BAP Equivalents (4)	65	152	NA	NA	434 (6)	NA
Total PAHs (5)	413	1117	NA	NA	NA	1684
PESTICIDES (ug/kg)						
4,4'-DDD	8.7	**58**	**16.8**	**33.6**	2400	**1.22**
4,4'-DDE	5	26	**15.8**	31.6	1700	2.07
4,4'-DDT	4	12	**17.3**	34.5	1700	1.19
Alpha-Chlordane	2.5	6.6	**7.0**	13.9	1600 (7)	0.5 (7)
Gamma-Chlordane	2.2	3.4	**6.6**	13.2	1600 (7)	0.5 (7)
INORGANICS (mg/kg)						
Arsenic	4.7	**13.6**	**6.1**	**12.2**	**0.39**	**7.24**
Copper	9.1	**27.1**	**5.1**	**10.1**	2900	**18.7**
Lead	18	**44.9**	**10.3**	**20.6**	400 (8)	**30.2**
Mercury	0.087	**0.2**	**0.045**	**0.09**	23	**0.13**
Zinc	41	93.3	**23**	45	23000	124

1. Background/typical facility sediment concentrations taken from Site 1 RI/RFI (TtNUS, 2001). Pesticide values are typical facility concentrations.
2. U.S. EPA Region 9 PRG Residential Soil Table (U.S. EPA, 2000).
3. U.S. EPA Region 4 Ecological Screening Table (U.S. EPA, 1998).
4. BAP Equivalents = benzo(a)anthracene (0.1) + benzo(a)pyrene (1.0) + benzo(b)fluoranthene (0.1) + benzo(k)fluoranthene (0.01) + chrysene (0.001) + dibenzo(a,h)anthracene (1.0) + indeno(1,2,3-cd)pyrene (0.1).
5. Total PAHs = Low Molecular Weight PAHs + High Molecular Weight PAHs.
   * Low Molecular Weight = 2-methylnaphthalene + acenaphthene + acenaphthylene + anthracene + fluorene + naphthalene + phenanthrene
   * High Molecular Weight PAHs = benzo(a)anthracene + benzo(a)pyrene + chrysene + dibenzo(a,h)anthracene + fluoranthene + pyrene.
   * If a PAH is detected. One-half the detection limit should be used for nondetected PAHs to calculate total PAHs and BAP Equivalents.
6. Calculated as 7 x benzo(a)pyrene Region 9 PRG.
7. Based on total chlordane.
8. OSWER Soil Screening Level for Residential land Use (U.S. EPA, 1994).

NA = Not available.
PAH = Polynuclear aromatic hydrocarbon.
BAP = Benzo(a)pyrene.

TABLE 5

COMPARISON OF 2001 AND 1998 FREQUENCY OF DETECTION - MARSH SIDE
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

PARAMETER	FREQUENCY OF DETECTION 2001	FREQUENCY OF DETECTION 1998	RANGE OF POSITIVE DETECTIONS 2001	RANGE OF POSITIVE DETECTIONS 1998	AVERAGE OF ALL RESULTS (1) 2001	AVERAGE OF ALL RESULTS (2) 1998	BACKGROUND/ TYPICAL FACILITY CONCENTRATIONS	REGION 9 SOIL RGOS (4) RESIDENTIAL	REGION 4 ESV (5)
Semivolatile Organic (ug/kg)									
BAP - equivalents	5/5	-	62-152	-	85	-	-	434	-
Total PAHs	5/5	-	325-1117	-	538	-	-	-	1684
Pesticides/PCBs (ug/kg)									
4,4'-DDD	2/5	0/5	1.4 - 3.8	-	1.5	NA	33.6	2400	1.22
4,4'-DDE	5/5	0/5	1.4 - 2.9	-	1.9	NA	31.6	1700	2.07
4,4'-DDT	2/5	1/5	1.1 - 12	34	2.1	12.4	34.5	1700	1.19
Alpha-Chlordane	1/5	0/5	6.6	-	1.7	NA	13.9	1600 (6)	1.7 (6)
Arochlor-1254	0/5	1/5	-	97	NA	25.5	-	220	NA
Arochlor-1260	0/5	1/5	-	45	NA	13.1	-	220	NA
Gamma-Chlordane	0/5	0/5	-	-	NA	NA	13.2	1600 (6)	0.5 (6)
Inorganics (mg/kg)									
Arsenic	5/5	5/5	1.8 - 13.6	2.6 - 8.4	6.3	5.5	12.2	0.39	7.24
Copper	5/5	5/5	3.5 - 27.1	3 - 20.5	13.3	11.9	10.1	2900	18.7
Lead	5/5	5/5	5.3 - 27.3	10.6 - 44.0	15.8	22.2	20.6	400 (7)	30.2
Mercury	5/5	0/5	0.01 - 0.06	-	0.04	NA	0.09	23	0.13
Zinc	5/5	5/5	9.7 - 67.7	18.2 - 54.1	39.9	32.1	45	23000	124

Associated Samples:

2001

PAI-03-SD-41-01
PAI-03-SD-41-01-AVG
PAI-03-SD-41-01-D
PAI-03-SD-42-01
PAI-03-SD-43-01
PAI-03-SD-44-01
PAI-03-SD-45-01
PAI-03-SD-45-01-AVG
PAI-03-SD-45-01-D

1998

PAI-03-SD-09-01
PAI-03-SD-11-01
PAI-03-SD-12-01
PAI-03-SD-13-01
PAI-03-SD-21-01

(1) Katahdin Analytical Services, Inc. soil MDLs were used to calculate detection limits for pesticides and PCBs, which were not detected in sediment. If a pesticide or PCB was not detected, one-half the laboratory MDL, adjusting for moisture, was used.
(2) RECRA LABNET soil MDLs were used to calculate detection limits for pesticides and PCBs, which were not detected in sediment. If a pesticide or PCB was not detected, one-half the laboratory MDL, adjusting for moisture, was used. A 5:1 dilution factor was accounted for on pesticide results from samples PAI-03-SD-09, -11, -12, -13, and -21.
(3) Background/typical facility sediment concentrations are taken from Site 1 RI/RFI (TtNUS, 2001). Pesticide values are typical facility concentrations.
(4) U.S. EPA Region 9 PRG Residential Soil Table (U.S. EPA, 2000).
(5) U.S. EPA Region 4 Ecological Screening Table (U.S. EPA, 1998).
(6) Based on total chlordane.
(7) OSWER Soil Screening Level for Residential Land Use (U.S. EPA, 1994).
NA: Not applicable because all samples in the area did not detect this chemical.

TABLE 6

CHEMICALS OF POTENTIAL CONCERN (COPC)
MARSH SEDIMENT SAMPLES
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ANALYTE	FREQUENCY OF DETECTION	RANGE OF DETECTED VALUES	LOCATION OF MAXIMUM DETECTION	AVERAGE CONCENTRATION	EPA REGION 4 ESV	MAXIMUM HAZARD QUOTIENT	AVERAGE HAZARD QUOTIENT	# OF SAMPLES EXCEEDED ESV	RANGE OF DETECTION LIMITS IN NON-DETECT SAMPLES(1)	BACKGROUND/ TYPICAL FACILITY CONCENTRATION (2)	RETAINED AS A COPC IN SEDIMENT
PAHs (µg/kg)											
Benzo(b)fluoranthene	5/5	13 - 230	PAI-03-SD-41-01-D	51	NA	NA	NA	NA	0	<2 to <1200	No[abc]
Benzo(g,h,i)perylene	3/5	12 - 71	PAI-03-SD-41-01-D	30	NA	NA	NA	NA	28 - 70	<8.1 to <1200	No[abc]
Benzo(k)fluoranthene	3/5	7 - 82	PAI-03-SD-41-01-D	29	NA	NA	NA	NA	42 - 70	<2 to <1200	No[abc]
Indeno(1,2,3-cd)pyrene	3/5	18 - 120	PAI-03-SD-41-01-D	39	NA	NA	NA	NA	28 - 70	518	No[abc]
Total PAHs[3]	5/5	216 - 1991	PAI-03-SD-41-01-D	538	1684	1.2	0.32	0	28 - 70[4]	see note 5	No[ad]
Pesticides (µg/kg)											
4,4'-DDD	2/5	1.4 - 3.8	PAI-03-SD-41-01	1.5	1.22	3.1	1.2	2	7.0-12 (0.8-2.2)	33.6	No[de]
4,4'-DDE	5/5	1.4 - 2.9	PAI-03-SD-43-01	1.9	2.07	1.4	0.9	1	0	31.6	No[de]
4,4'-DDT	2/5	1.5 - 12.0	PAI-03-SD-41-01	2.1	1.19	10.1	1.8	2	7.0-12 (1.2-2.0)	34.5	No[ef]
Alpha-Chlordane	1/5	6.6	PAI-03-SD-42-01	1.7	0.5[3]	13.2	3.4	1	2.4-6.0 (0.5-1.3)	13.9	No[ef]
Gamma-Chlordane	0/5	-	-	-	0.5[3]	-	-	0	2.2-6.0 (1.2-3.2)	13.2	No[ef]
Inorganics (mg/kg)											
Arsenic	5/5	1.8 - 13.6	PAI-03-SD-44-01	6.3	7.24	1.9	0.9	2	0	12.2	No[d]
Copper	5/5	3.5 - 27.1	PAI-03-SD-44-01	13.3	18.7	1.4	0.7	2	0	10.1	No[d]
Lead	5/5	5.3 - 27.3	PAI-03-SD-44-01	15.8	30.2	0.9	0.5	0	0	20.6	No[g]
Mercury	5/5	0.01 - 0.06	PAI-03-SD-43/44-01	0.04	0.13	0.5	0.3	0	0	0.09	No[g]
Zinc	5/5	9.7 - 67.7	PAI-03-SD-44-01	39.9	124	0.5	0.3	0	0	45	No[g]

Notes:
Marsh samples consisted of SD-41, SD-42, SD-43, SD-44, and SD-45. PCBs were not detected in these samples.
COPC = Chemical of potential concern.
ESV = U.S. EPA Region 4 ecological screening value.
Hazard quotient = chemical concentration ÷ ESV.
PAHs = Polycyclic aromatic hydrocarbons.
NA = EPA Region 4 ESV not available.

1 Detection limits for PAHs are sample-specific practical quantitation limits (PQLs). The initial values shown for pesticides are sample-specific practical quantitation limits (PQLs). The values in parentheses represent the sample-specific method detection limits (MDLs), adjusted for moisture content (calculated as laboratory MDL ÷ solid content of sample).
2 The range of detection limits (PQLs) is shown for PAHs that were not detected in MCRD Parris Island Background samples (TtNUS, 1999). The value for indeno(1,2,3-cd)pyrene is twice the average concentrationconcentration calculated using one-half the detection limit (PQL) in non-detected samples. Values for pesticides represent MCRD Parris Island Typical Facility Pesticide Concentrations (TtNUS, 1999). Values for inorganics represent MCRDParris Island Background Values (TtNUS, 1999).
3 Total PAH concentrations were calculated as the sum of concentrations of 2-methylnaphthalene, acenaphthene, acenapthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene. One-half the sample specific PQL was used to represent non-detected PAHs.
4 Range of PQLs for individual PAHs.
5 Indeno(1,2,3-cd)pyrene was the only PAH detected in background sediments; its background concentration is provided above.
a This chemical does not biomagnify in the food chain.
b No screening values were identified for this chemical.
c Maximum concentration is similar to background concentration and/or the detection limits in"non-detect" samples were less than or similar to background concentration.
d Maximum concentration only slightly exceeds the ESV and is less than alternate screening values.
e Maximum detected concentration and/or detection limits in "non-detect" samples is/are less than the MCRD Parris Island Typical Facility Pesticide Concentration.
f Maximum detected concentration and detection limits in "non-detect" samples are less than alternate screening values.
g Maximum concentration is less than the ESV.

TABLE 7

CHEMICALS OF POTENTIAL CONCERN (COPC)
SEDIMENT AREA 1
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ANALYTE	FREQUENCY OF DETECTION	RANGE OF DETECTED VALUES	LOCATION OF MAXIMUM DETECTION	AVERAGE CONCENTRATION	EPA REGION 4 ESV	MAXIMUM HAZARD QUOTIENT	AVERAGE HAZARD QUOTIENT	# OF SAMPLES EXCEEDED ESV	RANGE OF DETECTION LIMITS IN NON-DETECT SAMPLES(1)	BACKGROUND/ TYPICAL FACILITY CONCENTRATION (2)	RETAINED AS A COPC IN SEDIMENT
PAHs (µg/kg)											
Benzo(b)fluoranthene	3/4	10 - 15	PAI-03-SD-47-01	12.2	NA	NA	NA	NA	28	<2 to <1200	No[abc]
Benzo(g,h,i)perylene	0/4	-	-	-	NA	NA	NA	NA	28 - 50	<8.1 to <1200	No[abc]
Benzo(k)fluoranthene	0/4	-	-	-	NA	NA	NA	NA	28 - 50	<2 to <1200	No[abc]
Indeno(1,2,3-cd)pyrene	0/4	-	-	-	NA	NA	NA	NA	28 - 50	518	No[abc]
Total PAHs[3]	3/4	213 - 340	PAI-03-SD-49-01	258.0	1684	0.2	0.15	0	28 - 50[4]	see note 5	No[acd]
Inorganics (mg/kg)											
Arsenic	4/4	0.84 - 7.7	PAI-03-SD-47-01	3.3	7.24	1.1	0.5	1	0	12.2	No[e]
Copper	4/4	1.1 - 10.2	PAI-03-SD-47-01	4.9	18.7	0.5	0.3	0	0	10.1	No[d]
Lead	4/4	4.2 - 17.7	PAI-03-SD-47-01	9.5	30.2	0.6	0.3	0	0	20.6	No[d]
Mercury	4/4	0.04 - 0.2	PAI-03-SD-48-01	0.09	0.13	1.5	0.7	1	0	0.09	No[f]
Zinc	4/4	6.7 - 36.1	PAI-03-SD-47-01	19.7	124	0.3	0.2	0	0	45	No[d]

Notes:
Area 1 consisted of samples SD-46, SD-47, SD-48, and SD-49. These samples were not analyzed for pesticides or PCBs.
COPC = Chemical of potential concern.
ESV = U.S. EPA Region 4 ecological screening value.
Hazard quotient = chemical concentration ÷ ESV.
PAHs = Polycyclic aromatic hydrocarbons.
NA = EPA Region 4 ESV not available.
1 Detection limits for PAHs are sample-specific practical quantitation limits (PQLs).
2 The range of detection limits (PQLs) is shown for PAHs that were not detected in MCRD Parris Island Background/Typical Facility samples (TtNUS, 1999). The value for indeno(1,2,3-cd)pyrene is twice the average concentration calculated using one-half the detection limit (PQL) in non-detected samples. Values for inorganics represent MCRD Parris Island Background Values (TtNUS, 1999).
3 Total PAH concentrations were calculated as the sum of concentrations of 2-methylnaphthalene, acenaphthene, acenapthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene. One-half the sample specific PQL was used to represent non-detected PAHs.
4 Range of PQLs for individual PAHs.
5 Indeno(1,2,3-cd)pyrene was the only PAH detected in background sediments; its background concentration is provided above.
a This chemical does not biomagnify in the food chain.
b No screening values were identified for this chemical.
c Maximum concentration is similar to background concentration and/or the detection limits in"non-detect" samples were less than or similar to background concentration.
d Maximum concentration is less than the ESV.
e Maximum concentration is less than background concentration.
f Maximum concentration only slightly exceeds the ESV and is less than alternate screening values.

TABLE 8

CHEMICALS OF POTENTIAL CONCERN (COPC)
SEDIMENT AREA 2
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ANALYTE	FREQUENCY OF DETECTION	RANGE OF DETECTED VALUES	LOCATION OF MAXIMUM DETECTION	AVERAGE CONCENTRATION	EPA REGION 4 ESV	MAXIMUM HAZARD QUOTIENT	AVERAGE HAZARD QUOTIENT	# OF SAMPLES EXCEEDED ESV	BACKGROUND/ TYPICAL FACILITY CONCENTRATION (1)	RETAINED AS A COPC IN SEDIMENT
Inorganics (mg/kg)										
Arsenic	3/3	5.2 - 10.5	PAI-03-SD-50-01	8.3	7.24	1.5	1.1	2	12.2	No[ab]
Copper	3/3	7.7 - 22.5	PAI-03-SD-50-01	14.7	18.7	1.2	0.8	1	10.1	No[b]
Lead	3/3	13.3 - 35.8	PAI-03-SD-50-01	25.3	30.2	1.2	0.8	1	20.6	No[b]
Mercury	3/3	0.07 - 0.13	PAI-03-SD-52-01	0.11	0.13	1.0	0.8	0	0.09	No[b]
Zinc	3/3	25.4 - 72.5	PAI-03-SD-50-01	48.8	124	0.6	0.4	0	45	No[c]

Notes:
Area 2 consisted of samples SD-50, SD-51, and SD-52. These samples were not analyzed for PAHs or pesticides, and PCBs were not detected.
COPC = Chemical of potential concern.
ESV = U.S. EPA Region 4 ecological screening value.
Hazard quotient = chemical concentration ÷ ESV.
1 MCRD Parris Island Background Background Value (TtNUS, 1999).
a Maximum concentration is less than MCRD Parris Island Background Background Value.
b Maximum concentration only slightly exceeds the ESV and is less than alternate screening values.
c Maximum concentration is less than the ESV.

TABLE 9

CHEMICALS OF POTENTIAL CONCERN (COPC)
SEDIMENT AREA 3
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ANALYTE	FREQUENCY OF DETECTION	RANGE OF DETECTED VALUES	LOCATION OF MAXIMUM DETECTION	AVERAGE CONCENTRATION	EPA REGION 4 ESV	MAXIMUM HAZARD QUOTIENT	AVERAGE HAZARD QUOTIENT	# OF SAMPLES EXCEEDED ESV	RANGE OF DETECTION LIMITS IN NON-DETECT SAMPLES(1)	BACKGROUND/ TYPICAL FACILITY CONCENTRATION (2)	RETAINED AS A COPC IN SEDIMENT
Pesticides (µg/kg)											
4,4'-DDD	1/3	2.7	PAI-03-SD-55-01	1.2	1.22	2.2	1.0	1	5.5-5.7 (0.8-1.0)	33.6	No[ab]
4,4'-DDE	2/3	1.2 -1.7	PAI-03-SD-55-01	1.1	2.07	0.8	0.5	0	5.7 (0.5)	31.6	No[bc]
4,4'-DDT	1/3	1.3	PAI-03-SD-55-01	0.7	1.19	1.1	0.6	1	5.5-5.7 (0.7-0.9)	34.5	No[ab]
Alpha-Chlordane	0/3	-	-	-	0.5 [3]	-	-	0	2.8-3.2 (0.5-0.6)	13.9	No[d]
Gamma-Chlordane	1/3	3.4	PAI-03-SD-54-01	1.7	0.5 [3]	6.8	3.4	1	2.9-3.2 (1.5-1.6)	13.2	No[be]
Inorganics (mg/kg)											
Arsenic	3/3	2.1 -5.1	PAI-03-SD-55-01	3.6	7.24	0.7	0.5	0	0	12.2	No[cf]
Copper	3/3	3.2 -5.6	PAI-03-SD-55-01	4.3	18.7	0.3	0.2	0	0	10.1	No[cf]
Lead	3/3	9.9 -13.7	PAI-03-SD-55-01	11.2	30.2	0.5	0.4	0	0	20.6	No[cf]
Mercury	3/3	0.04 -0.09	PAI-03-SD-53-01	0.06	0.13	0.7	0.5	0	0	0.09	No[cg]
Zinc	3/3	16.5 -25.9	PAI-03-SD-55-01	20.9	124	0.2	0.2	0	0	45	No[cf]

Notes:
Area 3 consisted of samples SD-53, SD-54, and SD-55. These samples were not analyzed for PAHs or PCBs.
COPC = Chemical of potential concern.
ESV = U.S. EPA Region 4 ecological screening value.
Hazard quotient = chemical concentration ÷ ESV.
1 The initial values shown represent the sample-specific practical quantitation limits (PQLs). The values in parentheses represent the sample-specific method detection limits (MDLs), adjusted for moisture content (calculated as laboratory MDL ÷ solid content of sample).
2 Values for pesticides represent MCRD Parris Island Typical Facility Pesticide Concentrations (TtNUS, 1999). Values for inorganics represent MCRD Parris Island Background Values (TtNUS, 1999).
3 ESV for chlordane.
a Maximum concentration only slightly exceeds the ESV and is less than alternate screening values.
b The maximum detected concentration and detection limits in "non-detect" samples were less than MCRD Parris Island Typical Facility Pesticide Concentration.
c Maximum concentration is less than the ESV.
d Chemical not detected and detection limits were less MCRD Parris Island Typical Facility Pesticide Concentration.
e Maximum concentration is less than alternate screening values.
f Maximum concentration is less than the MCRD Parris Island Background concentration.
g Maximum concentration does not exceed the MCRD Parris Island Background concentration.

TABLE 10

CHEMICALS OF POTENTIAL CONCERN (COPC)
SEDIMENT AREA 4
SITE/SWMU 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

ANALYTE	FREQUENCY OF DETECTION	RANGE OF DETECTED VALUES	LOCATION OF MAXIMUM DETECTION	AVERAGE CONCENTRATION	EPA REGION 4 ESV	MAXIMUM HAZARD QUOTIENT	AVERAGE HAZARD QUOTIENT	# OF SAMPLES EXCEEDED ESV	RANGE OF DETECTION LIMITS IN NON-DETECT SAMPLES(1)	BACKGROUND/ TYPICAL FACILITY CONCENTRATION (2)	RETAINED AS A COPC IN SEDIMENT
Pesticides (µg/kg)											
4,4'-DDD	3/5	2.1 - 58	PAI-03-SD-59-01	14.6	1.22	47.5	12.0	3	7.8-19 (0.7-1.4)	33.6	Yes[abc]
4,4'-DDE	5/5	2.8 - 26	PAI-03-SD-59-01	10.0	2.07	12.6	4.8	5	0	31.6	No[d]
4,4'-DDT	2/5	3.8	PAI-03-SD-59/60-01	1.8	1.19	3.2	1.5	2	4.3-19 (0.6-1.3)	34.5	No[ef]
Alpha-Chlordane	1/5	2.8	PAI-03-SD-59-01	0.9	0.5 [3]	5.6	1.8	1	2.2-9.6 (0.4-1.2)	13.9	No[ef]
Gamma-Chlordane	1/5	2	PAI-03-SD-57-01	1.1	0.5 [3]	4.0	2.2	1	2.2-9.6 (1.0-3.0)	13.2	No[ef]
Inorganics (mg/kg)											
Arsenic	5/5	1.6 -4.5	PAI-03-SD-58-01	2.8	7.24	0.6	0.4	0	0	12.2	No[gh]
Copper	5/5	4.2 -13.2	PAI-03-SD-60-01	7.9	18.7	0.7	0.4	0	0	10.1	No[g]
Lead	5/5	14.6 -44.9	PAI-03-SD-60-01	27.3	30.2	1.5	0.9	2	0	20.6	No[i]
Mercury	5/5	0.04 -0.16	PAI-03-SD-57/58-01	0.13	0.13	1.2	1.0	4	0	0.09	No[i]
Zinc	5/5	38.1 -93.3	PAI-03-SD-60-01	64.8	124	0.8	0.5	0	0	45	No[g]

Notes:
Area 4 consisted of samples SD-56, SD-57, SD-58, SD-59, and SD-60. These samples were not analyzed for PAHs or PCBs.
COPC = Chemical of potential concern.
ESV = U.S. EPA Region 4 ecological screening value.
Hazard quotient = chemical concentration ÷ ESV.

1 The initial values shown represent the sample-specific practical quantitation limits (PQLs). The values in parentheses represent the sample-specific method detection limits (MDLs), adjusted for moisture content (calculated as laboratory MDL ÷ solid content of sample).
2 Values for pesticides represent MCRD Parris Island Typical Facility Pesticide Concentrations (TtNUS, 1999). Values for inorganics represent MCRD Parris Island Background Values (TtNUS, 1999).
3 ESV for chlordane.
a Potential risk to benthic receptors via direct toxicity.
b This chemical can potentially biomagnify in the food chain.
c Maximum concentration is greater than MCRD Parris Island Typical Facility Pesticide Concentration.
d Maximum detected concentration is less than MCRD Parris Island Typical Facility Pesticide Concentration.
e Maximum detected concentration and detection limits in "non-detect" samples were less MCRD Parris Island Typical Facility Pesticide Concentration.
f Maximum concentration is less than alternate screening values.
g Maximum concentration is less than the ESV.
h Maximum concentration is less than the MCRD Parris Island Background concentration.
i Maximum concentration only slightly exceeds the ESV and is less than alternate screening values.

TABLE 11

COMPARISON OF SEDIMENT ANALYTICAL RESULTS TO VARIOUS GUIDELINES
SITE 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CHEMICAL	MAXIMUM	MEAN	EPA REGION 4 ESV	ER-M	PEL	PEC	AET	ONTARIO MOE
PAHs (µg/kg)								
Benzo(b)fluoranthene	230	33.9	NA	NA	NA	NA	1800	NA
Benzo(g,h,i)perylene	71	24.2	NA	NA	NA	6300	670	170/3200
Benzo(k)fluoranthene	82	23.9	NA	NA	NA	NA	1800	240/13400
Indeno(1,2,3-cd)pyrene	120	29.3	NA	NA	NA	836.7	600	200/3200
Total PAHs			1684	44792	16770	13660	NA	4000/100000
Pesticides (µg/kg)								
4,4'-DDD	58	8.7	1.22	NA	7.81	NA	16	8/60
4,4'-DDE	26	5.0	2.07	27	374	NA	9	5/190
4,4'-DDT	12	4.0	1.19	46.1[a]	4.77	NA	12	8/710
alpha-Chlordane	6.6	2.5	0.5[b]	NA	4.79[b]	NA	2.8[b]	7/60[b]
gamma-Chlordane	3.4	2.2	0.5[b]	NA	4.79[b]	NA	2.8[b]	7/60[b]
Metals (mg/kg)								
Arsenic	13.6	4.7	7.24	70	41.6	57	35	6/33
Copper	27.1	9.1	18.7	270	108	77.7	390	16/110
Lead	44.9	18.1	30.2	218	112	396	400	31/250
Mercury	0.2	0.1	0.13	0.71	0.696	NA	0.410	0.2/2
Zinc	93.3	40.6	124	410	271	1532	410	120/820

NA Not available.
ESV U. S. EPA Region 4 ecological screening value.
ER-M Effects Range Median (Long et al., 1995).
PEL Probable Effects Level (MacDonald, 1994).
PEC Probable Effects Concentration, Assessment and Remediation of Contaminated Sediments Program (U.S. EPA 1996d).
AET Apparent Effects Threshold (Buchman, 1999).
MOE Ontario Ministry of the Environment: Lowest effect level / Severe effect level (Jones et al., 1997).
a ER-M for total DDT
b Value for total chlordane

TABLE 12

RESULTS OF FOOD CHAIN MODELING
MAXIMUM CONCENTRATIONS
SITE 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Mink		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
PESTICIDES/PCBs										
4,4'-DDD	1.57E-02	3.13E-03	**3.83E+00**	3.83E-01	NA	NA	NA	NA	**1.22E+00**	1.22E-01
4,4'-DDE	1.75E-01	3.51E-02	**4.72E+01**	**4.72E+00**	NA	NA	NA	NA	**1.50E+01**	**1.50E+00**
4,4'-DDT	1.78E-02	3.56E-03	**4.73E+00**	4.73E-01	NA	NA	NA	NA	**1.50E+00**	1.50E-01
Alpha-Chlordane	4.80E-03	2.40E-03	9.71E-03	1.94E-03	NA	NA	NA	NA	3.09E-03	6.19E-04
Gamma-Chlordane	1.16E-03	5.80E-04	2.33E-03	4.66E-04	NA	NA	NA	NA	7.42E-04	1.48E-04
INORGANICS										
Arsenic	**2.37E+01**	**2.37E+00**	**1.04E+00**	3.48E-01	**1.38E+00**	1.15E-01	4.61E-01	3.83E-02	**1.16E+00**	3.87E-01
Copper	5.10E-01	3.94E-01	1.09E-01	8.29E-02	NA	NA	NA	NA	1.21E-01	9.24E-02
Lead	**1.23E+00**	1.23E-01	**7.50E+00**	7.50E-01	NA	NA	NA	NA	**8.35E+00**	8.35E-01
Mercury	**2.93E+00**	**1.76E+00**	**5.90E+00**	5.90E-01	**1.50E+00**	1.28E-02	5.00E-01	4.26E-03	**6.57E+00**	6.57E-01

NA = NOAEL and LOAEL not available.

HQ = Hazard Quotient.

TABLE 13

RESULTS OF FOOD CHAIN MODELING
MEAN CONCENTRATIONS
SITE 3 CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological Contaminant of Potential Concern	Mink		Heron		Mummichog		Red Drum		Osprey	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
PESTICIDES/PCBs										
4,4'-DDD	2.35E-03	4.70E-04	5.75E-01	5.75E-02	NA	NA	NA	NA	1.83E-01	1.83E-02
4,4'-DDE	3.37E-02	6.74E-03	**9.08E+00**	9.08E-01	NA	NA	NA	NA	**2.89E+00**	2.89E-01
4,4'-DDT	5.93E-03	1.19E-03	**1.58E+00**	1.58E-01	NA	NA	NA	NA	5.02E-01	5.02E-02
Alpha-Chlordane	1.82E-03	9.10E-04	3.68E-03	7.36E-04	NA	NA	NA	NA	1.17E-03	2.34E-04
Gamma-Chlordane	7.51E-04	3.75E-04	1.51E-03	3.01E-04	NA	NA	NA	NA	4.80E-04	9.60E-05
INORGANICS										
Arsenic	**8.21E+00**	8.21E-01	3.60E-01	1.20E-01	4.78E-01	3.97E-02	1.59E-01	1.32E-02	4.02E-01	1.34E-01
Copper	1.71E-01	1.32E-01	3.65E-02	2.78E-02	NA	NA	NA	NA	4.07E-02	3.10E-02
Lead	4.98E-01	4.98E-02	**3.02E+00**	3.02E-01	NA	NA	NA	NA	**3.37E+00**	3.37E-01
Mercury	**1.47E+00**	8.80E-01	**2.95E+00**	2.95E-01	7.50E-01	6.38E-03	2.50E-01	2.13E-03	**3.29E+00**	3.29E-01

NA = NOAEL and LOAEL not available.
HQ = Hazard Quotient.