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FEASIBILITY STUDY/CORRECTIVE MEASURES STUDY FOR SITE 3 CAUSEWAY LANDFILL MCRD PARRIS ISLAND SC

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Feasibility Study/ Corrective Measures Study
for
Site/SWMU 3 – Causeway Landfill

Marine Corps Recruit Depot
Parris Island, South Carolina

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888

Contract Task Order 0020

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FEASIBILITY STUDY/ CORRECTIVE MEASURES STUDY FOR SITE/SWMU 3 – CAUSEWAY LANDFILL

MARINE CORPS RECRUIT DEPOT PARRIS ISLAND, SOUTH CAROLINA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYM LIST

ABB-ES	ABB Environmental Services
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criterion
B&R Environmental	Brown & Root Environmental
BEHP	bis(2-Ethylhexyl) phthalate
bgs	below ground surface
BSFA	biota sediment accumulation factor
CAA	Clean Air Act
CAOs	Corrective Action Objectives
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Response, Compensation,
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMS	Corrective Measures Study
COC	Chemical of Concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
CTO	Contract Task Order
CWA	Clean Water Act
DOT	Department of Transportation
E.O.	Executive Order
ERA	ecological risk assessment
ER-L	Effects Range Low
ER-M	Effects Range Medium
ESV	Ecological Screening Value
FDEP	Florida Department of Environmental Protection
FS	Feasibility Study
HHRA	human health risk assessment
HSWA	Hazardous and Solid Waste Amendments of 1984
HQ	Hazard Quotient
IAS	Initial Assessment Study
ILCR	incremental lifetime cancer risk
IR	Installation Restoration
LDR	Land Disposal Restrictions

LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LUC	Land Use Controls
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCRD	Marine Corps Recruit Depot
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHSPE	Ministry of Housing, Spatial Planning, and Environment
MSWLF	Municipal Solid Waste Landfill
NAAQS	National Ambient Air Quality Standards
NACIP	Naval Assessment and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
Navy	United States Navy
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutant
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollution Discharge Elimination System
NSPS	New Source Performance Standards
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PEL	Probable Effects Level
PPE	personal protective equipment
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidelines for Superfund
RAOs	Remedial Action Objectives
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facilities Assessment
RFI	RCRA Facilities Investigation

RGO	Remedial Goal Options
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SOUTHDIV	Southern Division
SOUTHNAVFAC	Southern Division Naval Facilities
SSL	Soil Screening Level
SVOCs	semivolatile organic compounds
SWMU	Solid Waste Management Unit
TBC	To Be Considered
TCE	trichloroethene
TDS	total dissolved solids
TEL	Threshold Effects Level
TSCA	Toxic Substance Control Act
TSD	treatment, storage, and disposal
TtNUS	Tetra Tech NUS, Inc.
µg/kg	micrograms per kilogram
µg/l	micrograms per liter
U.S. EPA	United States Environmental Protection Agency
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
USMC	United States Marine Corps
VOCs	volatile organic compounds
WQC	Water Quality Criterion
WQS	Water Quality Standard

RESPONSES TO REGULATORY COMMENTS TO THE DRAFT FS/CMS FOR SITE/SWMU 3

RESPONSE TO U.S. EPA COMMENTS

Reviewer: **Robert H. Pope**
Federal Facilities Branch
Waste Management Division

General Comments

1. **Comment:** Page ES-3, Bullet 4

   The appropriate RGO should be to eliminate migration of COCs, not just reduce. Revise the text.

   Response:

   The text of report will be changed to reflect the requested language; however, please note this change is being made with the understanding that it is not possible to ever completely eliminate potential migration of COCs.

2. **Comment:** All Alternatives

   All contaminated soils that represent a Human Health Risk must be covered with a minimum of 18 inches of cover and 6 inches of topsoil. 1 foot of cover for any contaminated soils that represent a Human Health risk is unacceptable.

   Response:

   Only one surface soil location (PAI-03-SS-01) contains a detection of a chemical [benzo(a)pyrene] that exceed a site-specific human health RGO corresponding to an ILCR equal to 1.0E-06. In all action alternatives, the PAI-03-SS-01 area will be covered with 18 inches of cover and 6 inches of topsoil as indicated in the FS. Please note that no surface soil locations exceed site-specific human health RGOs corresponding to ILCRs equal to 1.0E-05 or 1.0E-04.

3. **Comment:** Page ES-4, Alternative 2a (and all other presented Alternatives)

   The FS should and the forthcoming Proposed Plan (PP) must be more specific regarding the sampling and reporting. It must be stated that the sampling (surface water, sediment, groundwater) will be done on an annual basis, at a minimum. In addition, it must be stated that the annual sampling results will be reported to the regulatory agencies on an annual basis along with the monitoring results of the Land Use Controls (institutional controls). Also, the PP and Record of Decision must detail the Land Use Controls that will be implemented at Site 3.

   Response:

   The FS report will be modified to add sediment testing in addition to the current language regarding the annual sampling of groundwater. In accordance with discussions during the

February 10-11, 2000 Partnering Team meeting, surface water sampling will not be conducted. Sampling results will be reported to the regulatory agencies on an annual basis. The Proposed Plan and Record of Decision will detail the Land Use Controls that will be implemented at Site 3.

4. **Comment:** Alternatives 3a and 3b:

It should be stated that as part of the Remedial Design, any "hot spot" areas would need to be further and more completely delineated.

Response:

The description of the sediment excavation portions of Alternatives 3a and 3b in Sections 5.1.4 and 5.1.5 contain similar language. No changes are proposed.

5. **Comment:** General

The FS should also state that the entire causeway will be covered down the center by an asphalt road which will help reduce infiltration of water and flushing of contaminants into the sensitive ecosystems of the Pond and Marsh. Also, it should be stated that the slopes of the causeway will be graded in areas where erosion is occurring to enhance surface water runoff and even further reduce infiltration and any resultant flushing.

Response:

The text of the report will be modified to indicate that an asphalt road will run along the length of the causeway. Additionally, to reduce infiltration, drainage ditches will be installed along the side of the road to preferentially drain road runoff to the marsh and pond. Slope stabilization and erosion control measures currently exist in all proposed alternatives.

6. **Comment:** Chapter 2

The text of Section 2.3 and 2.4 provide a brief discussion of the nature and extent of contamination and the results of the human health and ecological risk assessments conducted at the site. However, the text does not provide an adequate summary of the contamination identified during the previous studies that are listed. In addition, the text does not summarize the findings of the human health and ecological risk assessments and instead references the Remedial Investigation/RCRA Facility Investigation (RI/RFI) for this information. In order to present a clear description of the contamination at the site and the risks to potential human health and ecological receptors, additional information should be included in the text. This should briefly state the findings of each of the referenced studies and the baseline risk assessment.

Response:

The requested information is currently discussed in detail and is also summarized in the RI report. Because the RI and FS are being issued at basically the same time, it would not be efficient to repeat this information in the FS. In addition, both documents have been distributed to the Partnering Team and will be available to the public in the information repository. Furthermore, the Proposed Plan and Record of Decision for Site 3 will summarize this information. Due to these reasons, no changes are proposed in the FS.

7. **Comment**: Chapter 3 and Appendix C

It is unclear why the Clean Boundary Determinations for surface soil are presented only for mercury and not for other COCs; arsenic, lead, zinc, and polyaromatic hydrocarbons (PAHs). It should be verified that boundaries are based on all relevant COCs.

Response:

When comparing analytical results to the RGOs that correspond to an ILCR equal to 1.0E-04 and/or high risk to ecological receptors and taking into account South Carolina clean cover requirements, clean soil would be placed over soil southeast of surface soil location PAI-03-SS-08. PAI-03-SS-08 is chosen as a clean boundary point because hand auger borings indicate that less than two feet of clean cover is present southeast of PAI-03-SS-08 (see Table 2-1). Additionally, PAI-03-SS-08 does not exceed ecological or human health RGOs under this scenario. Northwest of PAI-03-SS-08, only one surface soil sample location exceeds an RGO under this scenario. PAI-03-SS-09 contains a detection of mercury that exceeds the RGO that correspond to a high risk to ecological receptors; however, in adjacent surface soil sampling locations, mercury was not detected at a concentration that exceeds the mercury RGO. The calculations provided in Attachment 1 of Appendix C are provided to estimate a boundary of impacted surface soil in the vicinity of the mercury exceedance at PAI-03-SS-09.

Similarly, when comparing analytical results to the RGOs that correspond to an ILCR equal to 1.0E-05 and/or moderate risk to ecological receptors and taking into account South Carolina clean cover requirements, clean soil would be placed over all soil southeast of surface soil location PAI-03-SS-08 as described previously. Northwest of PAI-03-SS-08, only two surface soil sample locations exceed an RGO under this scenario. PAI-03-SS-09 and PAI-03-SS-10 contain detections of mercury that exceed the RGO that correspond to a moderate risk to ecological receptors; however, in adjacent surface soil sampling locations, mercury was not detected at a concentration that exceeds the mercury RGO. The calculations provided in Attachment 1 of Appendix C are provided to estimate a

boundary of impacted surface soil in the vicinity of the mercury exceedances at PAI-03-SS-09 and PAI-03-SS-10.

When comparing analytical results to the RGOs that correspond to an ILCR equal to 1.0E-06 and/or low risk to ecological receptors and taking into account South Carolina clean cover requirements, clean soil would be placed over all the entire causeway. Because all surface soil samples exceed the RGOs under this scenario, no clean boundary calculations are presented.

Specific Comments

8. **Comment**: Page 3-45, Table 3-6.

Footnote 1 indicates that 2 times the "typical facility pesticide concentration" was used as a screen. Although, it seems to have no effect on the screening of the pesticide detections for Site 3, this method is inappropriate. While it is acceptable to conduct a screen of pesticides at the FS stage, using a number twice the average of the "typical facility pesticide concentration" is far from protective. Do not use this methodology in future documents. Pesticides are not to be treated as metals. Pesticides are anthroprogenic contaminants and are not considered to have a natural variation that would justify using twice the facility specific average concentration as a screen.

Response:

The use of two times the mean concentration for the typical facility concentration was intended to mirror the U.S. EPA Region 4 guidance for establishing background concentrations. At MCRD Parris Island, the typical facility concentration was developed to distinguish between site-related contamination and anthropogenic chemicals commonly found in the environment. Pesticides are of particular concern at this site and other similar recreational areas at MCRD Parris Island where these chemicals would normally have been applied to control insect populations.

The Navy will consider other approaches to distinguishing between site-related contamination and commercial application of pesticides using concentration data including the 95% upper tolerance limit, the 95th percentile, and/or a comparison of means (t-test). If the U.S. EPA has successfully used other methods, we can also consider them.

9. **Comment**: Page 3-45, Table 3-6.

   The No Observed Adverse Effect Level (NOAEL) for Aroclor 1254 of 74 ug/kg is based on the raccoon, not the heron. The table should be corrected.

   Response:

   Agreed. The correction will be made.

10. **Comment**: Page 3-48, Table 3-8.

    The table presents a summary of the sediment RGOs. The selenium RGO for low ecological risk is listed at 0.034 mg/kg, but should be 0.93 mg/kg, as listed in Table 3-6. The table should be corrected.

    Response:

    Agreed. The correction will be made.

11. **Comment**: Page 5-29, Section 5.3.4.3.

    If contaminated sediment is consolidated on site, MCRD will be responsible to determine that contaminant concentrations do not exceed levels that will trigger RCRA Land Disposal Restrictions (LDR). If LDR levels are exceeded, some sediment may not be able to be consolidated on-site and will have to be disposed of at an appropriate landfill (Subtitle D or Subtitle C). This is an issue that will have to be addressed in the Remedial Design, but it is important for MCRD to be aware of the issue before the remedy is selected.

    Response:

    Acknowledged.

12. **Comment**: Appendix A, Page A-1 and A-2.

    The appendix provides a comparison of the surface water and groundwater preliminary COCs to the chemical-specific criteria. The text provides a list of various surface water criteria and references Tables A-1 and A-2 for comparison of these values with the surface water concentrations. It appears that the text does not list the South Carolina Water Quality Criteria (SCWQC) for Protection of Human Health (South Carolina Regulation 61-68, Appendix 2) that are provided on Table A-1. This is also the case for the groundwater information provided in this appendix. The text of Page A-2 does not include the SCWQC although they are provided for comparison on Table A-3. The text should include this information.

Response:

Agreed. The text will be modified.

13. **Comment:** Page C-1.

Assumptions are listed near the bottom of the page. The first assumption is that the depth of impacted sediment is 2 feet. The rationale for this assumption is not provided. This information should be included on the table.

Response:

Based on the geometry of the causeway and the maximum water level elevations of the pond (4 feet), a two-foot depth was assumed for estimation purposes. If excavation of sediments is chosen, this depth will be verified during delineation sampling.

14. **Comment:** Page C-15, Table C-4.

This table lists COCs that exceed RGOs for the sediments sampling sites. There are apparently some sites missing from the table. For example, location PA1-03-SD-34-01, for which Aroclor 1254 exceeds the RGO for moderate ecological risk, is shown on Figure C-4 but is not in this table. A review to ensure that all relevant sample locations were used to establish impacted area boundaries should be conducted and additional information included on the table for clarity.

Response:

The delineation round of sediment data was not added to these tables; however, please note that the exceedances observed in the delineation samples were taken into account in the sediment volume calculations. Sediment samples PAI-03-SD-34 and PAI-03-SD-38 will be added to Table C-4.

Please see the response to U.S. EPA comment #16 for further clarification on this comment.

15. **Comment:** Page C-15, Table C-4.

The first note in the legend states that RGOs for arsenic and vanadium at sediment sites 23, 24, and 26 were based on the raccoon. The note continues, "Because this area is not a forage area for the raccoon [as it is in the center of the marsh], the sample location will not be retained as an impacted sediment area." As ecological receptors serve as representatives of groups of ecologically similar species, the relevance of the risk conditions at the above sites should be reviewed for species which might be represented by the raccoon (e.g., mink, otter), and which might not be as restricted by water in accessing forage areas. In addition, raccoon can travel significant distances into salt marshes

during low tide if foraging areas such as tidal ditches are nearby. Additional justification is needed for excluding sites 23, 24 and 26 from this evaluation.

Response:

The footnote 1 of Table C-4 will be revised as follows:

(1) Sediment locations PAI-03-SD-23, PAI-03-SD-24, and PAI-03-SD-25 will not be retained as impacted sediment areas. Concentrations of vanadium at these locations were detected from 56.6 to 63.7 mg/kg, only 13 to 27 percent above background (50 mg/kg). Additionally, the one detection of arsenic was observed at a concentration of 19.8 mg/kg that is within a factor of two of the its background concentration (12 mg/kg). For the raccoon, LOAEL HQs calculated based on exposure to site average arsenic and vanadium concentrations (HQs of 1.1 and 2.97, respectively) only slightly exceeded a HQ of 1. Because published biota sediment accumulation factors (BSAFs) are not available for inorganics, HQs for arsenic and vanadium were calculated assuming a BSAF of 1. This is a conservative assumption since transfer through the food chain does not occur for most metals.

16. **Comment:** Page C-17 and C-18.

The tables on these pages show the Clean Boundary Determinations for surface soil (moderate and high risk) and sediments. Boundary determinations are not provided for impacted areas around soil locations SS-01 and SS-03, though the sites are listed in Table C-3 as posing moderate risk to ecological receptors. Similarly, the table for sediments does not show determinations for sediment locations 20, 22, 28, though these locations are listed in Table C-4 as posing moderate risk to ecological receptors. Further, the sediment table presents Clean Boundary Determinations based on sediment locations 34 and 38, though these two sites are not listed in Table C-4. An explanation of these apparent discrepancies should be provided and, if necessary, the above sites should be incorporated into the calculations on these tables. Verification that all relevant sampling locations were used to establish Clean Boundaries should be provided.

Response:

A clean boundary location was not provided for surface soil locations PAI-03-SS-01 and PAI-03-SS-03. Under all alternatives, these locations would be covered with clean soil in accordance with South Carolina requirements.

Sediment samples collected to delineate PAI-03-SD-20, PAI-03-SD-22, and PAI-03-SD-28 did not contain detections above RGOs. The delineation samples were used as the clean boundary

sampling points; therefore, calculations such as those performed in Attachment 1 of Appendix C were not performed.

- Sediment samples PAI-03-SD-34 and PAI-03-SD-38 will be added to Table 3-4; however, please note that the exceedances observed in the delineation samples were taken into account in the sediment volume calculations. No other changes are proposed.

RESPONSE TO SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL COMMENTS

Reviewer: **J. Stamps, Engineer Associate**
Corrective Action Engineering Section
Division of Hazardous and Infectious Waste Management

1. **Comment:** General

   The RFI for SWMU 3 states that human exposure to surface water is minimal due to the presence of alligators. If so, the maintenance of these alligator postings must be incorporated as an institutional control.

   Response:

   Agreed. Maintenance of existing no swimming/wading signs will be added as an item in the institutional control section of each alternative.

2. **Comment:** General

   Please incorporate Tables and Figures throughout the document as referenced rather than placing them at the end of each section. This will facilitate the review of future documents and result in a more expedited review.

   Response:

   We can discuss, but our current preference is to present the tables and figures at the end of each section. Due to the number of tables and figures included within the report, the tables and figures were placed in the back of each of their respective sections to put them in an easily accessible area. Additionally, because one page of text nestled between several figures/tables can be difficult to find, the tables/figures were placed at the end of each section to alleviate this problem. Lastly, having the tables/figures in this format greatly facilitates the production of the report.

3. **Comment: Page ES-1**

   Please provide documentation that the northeast portion of the causeway landfill was comprised primarily of fill dirt rather than waste material.

   Response:

   The statement was referenced from the September 1986 Initial Assessment Study (IAS) conducted by NEESA for the Parris Island. This statement can be found on page 8-7, second paragraph, third sentence of the IAS.

4. **Comment: Page 3-4, Table 3-1**

Table 3-1 identifies RCRA Subtitle C as an ARAR; however, it seems as though the Hazardous and Solid Waste Amendments to RCRA should also be identified as an ARAR. HSWA is the instrument, which provided RCRA with corrective action authority. Please make this revision or explain why HSWA is not applicable as an ARAR.

Response:

Chapter 3 will be revised to include the 1984 Hazardous and Solid Waste Amendments to RCRA as a potentially applicable ARAR.

5. **Comment:** Table 3-5

Please explain why 4,4-DDT was not retained as a COC since its maximum concentration exceeded the ILCR of 10-6 for fish ingestion. The Department considers a COC to be any constituent contributing to a cumulative risk level of 1E-06 or greater and/or a cumulative hazard index above 1.0, and whose individual ILCR exceeds 1E-06 or whose hazard quotient exceeds 0.1. Additionally, please discuss the source of the "Background Typical Facility Pesticide Concentration". Are the concentrations listed obtained from background sediment locations or were they obtained from background soil locations? If the latter is true, then the background results may not be directly comparable to the sediment sampling results, as the comparison of analytical results from differing media is not appropriate. This may alter the elimination of DDT as an ecological COC as listed in Table 3-6.

Response:

Table 3-5 cities Background/Typical Facility Pesticide Concentrations for various chemicals. The background values are only cited for inorganics and are presented in Table 4-1 of the RI/RFI for Site 3. Typical facility pesticide concentrations are applicable to pesticides and are discussed in a 1999 technical memorandum presented to the Partnering Team. Footnote 1 will be revised to clarify the difference between the nomenclature of these values.

Sediment and surface soil sample locations used to calculate the typical facility pesticide concentrations were collected from locations where pesticides have historically been used to control insect populations. At the request of the Partnering Team, select background locations were also added to this data set even though the background locations are in areas where pesticides were not commonly used. In locations where pesticides were commonly used, low-level detections of pesticides where observed in both surface soil and sediment locations used in the data set.

As indicated in Table 3-5, 4,4'-DDT does not represent a potential risk to human health (1.0E-06) under any of the site-specific scenarios (ingestion of fish and dermal contact by construction/maintenance workers). However, as discussed with SCDHEC on May 1, 2000, 4,4'-DDT will be retained as a COC because 4,4'-DDT breakdown products (4,4'-DDD and 4,4'-DDE) were detected retained as COCs.

6. **Comment:** Table 3-6

Aluminum must be retained as an ecological COC. The food chain modeling presented in Tables 7-9 through 7-14 of the RFI indicate HQs much greater than 1.0. Consequently, aluminum appears to be a risk driver and as such must be retained as an ECOC. Additionally, for those constituents not selected as ECOCs, please indicate the basis for that determination. Please do the same for the sediment COCs listed in Table 3-5.

Response:

The requested discussion is presented on page 3-25 of the FS/CMS report and in the footnotes to Tables 3-5 and 3-6. In addition, a footnote will be added to Tables 3-4 and 3-6 listing 33,000 mg/kg as a typical eastern United States background soil value for aluminum. Maximum aluminum concentrations in were 10,800 mg/kg in Site 3 soil and 29,700 mg/kg in Site 3 sediment. Furthermore, a statement will be added to the text indicating that aluminum is not readily bio-available to ecological receptors (Venugopal and Luckey, 1978).

7. **Comment:** Table 3-8

Please explain why the RGO values corresponding to 10^{-5} and 10^{-6} risk do not simply differ by an order of magnitude. Were the inherent assumptions utilized in calculating these RGOs different?

Response:

Conservative fish ingestion assumptions were used to comprise the RGOs equal to an ILCR = 1.0E-06 and *site-specific* fish ingestion assumptions were used to comprise the RGOs equal to an ILCR = 1.0E-06. Benzo(a)pyrene will be used as an example to illustrate why RGOs value do not differ by an order of magnitude.

As discussed on page 3-29, Section 3.6.2.1, the RGO used as the RGO corresponding to a human health ILCR = 1.0E-06 is the lower of the two calculated values:

- The chemical concentration in sediment protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-06. This value was calculated to be 220 ug/kg

- The chemical concentration in sediment that corresponds to an ILCR of 1.0E-06 to the adult recreational user through consumption of fish. *Conservative ingestion* rates by the adult recreational user are assumed. This value was calculated to be 2.09 ug/kg.

Thus, 2.09 ug/kg was used as the RGO corresponding to a human health ILCR = 1.0E-06.

The RGO used as the RGO corresponding to a human health ILCR = 1.0E-05 is the lower of the two calculated values:

- The chemical concentration in sediment protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-05. This value was calculated to be 2,200 ug/kg

- The chemical concentration in sediment that corresponds to an ILCR of 1.0E-05 to the adult recreational user through ingestion of fish. *Site-specific* ingestion rates by the adult recreational user are assumed. This value was calculated to be 303 ug/kg.

Thus, 303 ug/kg was used as the RGO corresponding to a human health ILCR = 1.0E-06

8. **Comment**: Section 4

It is stated that the institutional controls are to be incorporated into the master work plan. However, page 4-15 references the use of "deed restrictions". Is there truly a deed for the Parris Island property? Are these two methods to be used in conjunction as a means of documenting ICs? Furthermore, it seems as though a LUCAP/LUCIP must be developed as a mechanism for documenting and enforcing the ICs.

Response:

In accordance with discussions during the February 10 – 11, 2000 MCRD Parris Island Partnering Team meeting, references to deed restrictions and the base master plan will be changed to reference the land use control implementation plan (LUCIP) and land use control assurance plan (LUCAP) as well as the MCRD Parris Island Master Plan. The LUCIP will be incorporated into the record of decision as an appendix.

9. **Comment**: Figures 4-1 and 4-2

   These figures should address the incidental excavation of sediments and the management of said sediments for alternatives 2a and 2b.

   Response:

   Agreed. Figures 4-1 and 4-2 will be revised accordingly.

10. **Comment:** Section 5

    As stated, all trees and shrubbery that will penetrate or obstruct the installation of the cover must be removed from the causeway landfill.

    Response:

    Agreed. The existing statement in the FS,

    > "Existing trees would be removed from the site to facilitate cover placement where required and to minimize root growth through the cover."

    will be revised to

    > "Existing trees and shrubbery that would penetrate or obstruct the installation of the cover would be removed from the site."

11. **Comment:** General

    Please ensure that all necessary permits are obtained prior to excavating the wetland areas, if applicable.

    Response:

    Acknowledged.

12. **Comment:** Figure 5-5

    The Department believes that the causeway landfill is one contiguous unit and must be closed as such. Consequently, a 2-foot cover consisting of clean fill must be applied to the entire length and width of the landfill. Additionally, measures must be implemented to maintain the integrity of the cover including, but not limited to, preventing erosion of the cover.

Response:

It is the Navy's position that the causeway was historically covered with clean cover material. Therefore, where the surface soil meets the definition of clean material (i.e., 1.0E-06 residential) and adequate thickness is present (i.e., 2 feet), then additional soil cover is not required.

Hand-auger soil borings were advanced at each location where a surface soil sample was collected (16 locations). Observations made in northwest portion of the landfill area during the advancement of hand auger soil borings indicate that no wastes were present in the first two feet of the borings. The results of the soil boring observations are presented in Table 2-1.

Additionally, based the surface soil sample analytical results from the 16 surface soil samples collected during the investigation, surface soil sample analytical results did not exceed residential U.S. EPA Region 3 RBCs (1.0E-06 residential) in the northwest portion of the causeway. Therefore, the existing cover in the northwest half of the causeway is suitable clean cover material and an additional 2-foot cover over the entire causeway is not necessary.

As discussed in each alternative, slope stabilization and erosion control measures will be implemented to maintain the integrity of the cover. These actions are proposed to minimize the potential for failure of the causeway's slideslopes and to reduce the erosion rate of cover due to surface water runoff, waves, and/or wind.

No changes are proposed.

13. **Comment:** General

Given the plans to construct a road on top of an approved corrective measure, the Department must review and accept the work plan outlining the construction details prior to the construction of the road. This is necessary so that the Department can ensure that the integrity of the corrective measure is maintained during and after construction activities.

Response:

In accordance with discussions during the February 10 – 11, 2000 MCRD Parris Island Partnering Team meeting, the design will be provided to the state for review.

14. **Comment:** General

The existing monitoring wells must be extended to the new elevation resulting from the installation of the cover. Alternately, the wells may be abandoned in accordance with R.61-71: South Carolina Well Standards and Regulations and reinstalled at adjacent locations.

Response:
Acknowledged.

15. **Comment: Page 5-7, 2nd paragraph**
The Department has reservations about placing contaminated sediment back onto the landfill as part of the soil cover or otherwise. The Department would like to discuss this issue in the February Tier I meeting.

Response:
In accordance with discussions during the February 10 – 11, 2000 MCRD Parris Island Partnering Team meeting, there is precedent at other sites to consolidate contaminated sediments within a landfill.

Excavated sediment that is consolidated on-site would not be used as the top one foot of cover material assuming that the consolidated sediment does not contain COCs at concentrations in excess of the soil RGOs that represent an ILCR greater than 1.0E-06. If the sediment does exceed these RGO values, the sediment would not be used as the top two feet of cover material.

16. **Comment:** General
Page 5-7, Institutional Controls and Long Term Monitoring: LTM must include monitoring of sediment, surface water, and groundwater, rather than solely groundwater monitoring. Please revise accordingly. A detailed LTM plan should be incorporated into the CMS including sampling frequency and a list of analytes to be monitored. The location of the surface water and sediment samples should be determined prior to each sampling event. Additionally, a contingency plan should be included to address what actions will be taken should the LTM reveal additional contamination resulting from further releases. These actions should include further investigation to determine if the landfill is truly the source of this contamination.

Response:

The FS report will be modified to add sediment testing in addition to the current language regarding the annual sampling of groundwater. In accordance with discussions during the February 10 – 11, 2000 Partnering Team meeting, surface water sampling will not be conducted. Sampling results will be reported to the regulatory agencies on an annual basis. The Proposed Plan and Record of Decision will detail the Land Use Controls that will be implemented at Site 3.

The long-term monitoring contingency plan will be addressed in the proposed plan and record of decision.

17. **Comment:** General

As outlined in OSWER Directive 9902.3-2A (RCRA Corrective Action Plan), dated May 31, 1994, the Corrective Measure Study should recommend a proposed remedy. Please revise accordingly

Response:

In the spirit of partnering, the Draft FS/CMS report for Site 3 did not propose a remedy. The intention was for the MCRD Parris Partnering Team to initially review the material presented in the Draft Report and then discuss and come to a consensus as a team regarding the most appropriate remedial action/corrective measures implementation for Site 3.

As discussed during the February 10 MCRD Parris Island Partnering Team meeting, the transmittal letter of future FS/CMS reports will contain a recommended alternative.

Reviewer: **Donald C. Hargrove, Hydrogeologist**
Hazardous Waste Section
Division of Hydrogeology
Bureau of Land and Waste Management

1. **Comment:** Section 4.2.3, Containment:

   This section should specify the requirement that risk from both chemical and physical exposure to the waste must be minimized. Please revise the text.

   Response:

   The first sentence of Section 4.2.3 will be revised accordingly. "Containment involves the application of physical measure to reduce the potential for contaminant migration and thereby reduce the risk ***from both chemical and physical exposure*** to the public and the environment"

2. **Comment:** Section 4.7, Identification of Remedial Actions/Corrective Measure Alternatives for Site 3:

   a) The descriptions of alternatives 2a and 3a are deceptive. They both claim to "...protect humans from exposure to contaminated soil and the contents of the landfill." However, both of these alternatives propose only half of the waste be covered with two (2) feet of clean soil cover. The purpose of the clean soil cover is to protect human health and the environment by limiting exposure to both physical and chemical hazards. The two foot clean soil cover must be installed over the entire area of landfill waste. This has already been shown in the figures to encompass the entire length of the causeway landfill (SWMU 3). As such, the only alternatives that should be considered, are those that include one of the following activities:

   i) An in-depth investigation of the existing cover material to assess physical and chemical risk, with specifications for adding clean cover to any portion of the existing cover that poses unacceptable risk due clean cover thicknesses less than two (2) feet.

   ii) An assumption that the existing cover would not pass the criteria in item i, with the proposal to install two (2) feet of clean cover over the entire landfill. This activity appears to be included in alternatives 2b and 3b already.

   If alternatives 2a and 3a are to remain part of this FS/CMS, then the statement that they are protective of human health should be removed.

Response:

It is the Navy's position that the causeway was historically covered with clean cover material. Therefore, where the surface soil meets the definition of clean material (i.e., 1.0E-06 residential) and adequate thickness is present (i.e., 2 feet), then additional soil cover is not required.

Hand-auger soil borings were advanced at each location where a surface soil sample was collected (16 locations). Observations made in northwest portion of the landfill area during the advancement of hand auger soil borings indicate that no wastes were present in the first two feet of the borings. The results of the soil boring observations are presented in Table 2-1.

Additionally, based the surface soil sample analytical results from the 16 surface soil samples collected during the investigation, surface soil sample analytical results did not exceed residential U.S. EPA Region 3 RBCs (1.0E-06 residential) in the northwest portion of the causeway. Therefore, the existing cover in the northwest half of the causeway is suitable clean cover material and an additional 2-foot cover over the entire causeway is not necessary.

Comment:

b) The subsections for each of the listed alternatives are mislabeled (4.3.1, 4.3.2, 4.3.3, etc) when they should be labeled as 4.7.1, 4.7.2, 4.7.3, etc. Please revise the text.

Response:

The numbers of the subsections will be revise.

3. **Comment:** Figure 4-1, Block Flow Diagram, Site 3-Alternative 2a:

The notes on this figure are confusing. Note #1 specifies that 2 feet of clean soil will be present over landfill contents (previously shown as the entire causeway). Note #2 specifies that some areas will only have 1 foot of clean soil over the landfill contents. These notes should be revised to incorporate Comment #2 (above).

Response:

As stated in comment response 2, observations made in the northwest portion of the landfill area during the advancement of hand auger soil borings indicate that no wastes were present in the first two feet of the borings and chemical testing found the soil to meet the definition of clean cover. Therefore, the existing cover in the northwest half of the causeway is suitable cover material. In those areas where less than 2 feet of cover material was observed but where the surface soil is clean, Alternative 2a proposes supplementing the existing cover so that a total of 2 feet of cover

material exists. For instance, at PAI-03-SS-07, hand-auger borings indicated that waste was detected at a depth of 1.6 bgs. Under this alternative, approximately 6 inches of cover soil would be added to the existing cover to bring the total cover to 2 feet. Footnote 1 implies this action.

For those areas where surface soil analytical results exceed the RGOs that represent a potentially high risk to ecological receptors, Alternative 2a proposes and additional 1 foot of cover on top of existing soil (i.e., up to 3 feet of clean cover soil over wastes) to be protective of ecological receptors. The upper 1 foot of soil represents the depth at which most soil macroinvertebrates live and vegetation roots extend. The area (where surface soil concentrations exceed high risk RGOs) corresponds to the area in the vicinity of surface soil location PAI-03-SS-09 as shown on Figure 5-1. Footnote 2 of Figure 4-2 implies this action.

No changes to the footnotes of Figure 4-1 are proposed.

4. **Comment:** Figure 4-2
Same as comment 3.

Response:
Regarding the justification of footnote 1, please see comment response 3.

For those areas where surface soil analytical results exceed the RGOs that represent a potentially low risk to ecological receptors, Alternative 2b proposes and additional 1 foot of cover on top of existing soil (i.e., up to 3 feet of clean cover soil over wastes) to be protective of ecological receptors. The upper 1 foot of soil represents the depth at which most soil macroinvertebrates live and vegetation roots extend. The area where concentrations in surface soil exceed the low risk RGOs protective of ecological receptors corresponds to the entire length of the causeway. However, under this alternative, more than 1 foot of cover material would be placed in certain locations in the lower half of the causeway for human health reasons and compliance with South Carolina regulations.

No changes to the notes of Figure 4-2 are proposed.

5. **Comment:** Figure 4-3
Same as comment 3.

Response:
No changes to the notes of Figure 4-3 are proposed. Please see the response to comment 3.

6. **Comment:** Figure 4-4

   Same as comment 3.

   Response:

   No changes to the notes of Figure 4-4 are proposed. Please see the response to comment 4.

7. **Comment:** Section 5.1.2, Alternative 2a-Partial Containment:

   The bullet stating that this alternative will be consistent with federal and South Carolina regulations should be removed. If only half of the causeway is proposed for a 2 foot clean soil cover, then this alternative is not consistent with South Carolina regulations.

   Response:

   The Navy believes that the existing cover in the northwest half of the causeway is suitable cover material and a 2-foot cover over the entire causeway is not necessary. Please see comment response 2a.

8. **Comment:** Section 5.1.4, Alternative 3a-Partial Containment with Sediment Excavation:

   Same as Comment #7 (above).

   Response:

   The Navy believes that the existing cover in the northwest half of the causeway is suitable cover material and a 2-foot cover over the entire causeway is not necessary. Please see comment response 2a.

9. **Comment:** Section 6.1, Introduction:

   The description for alternative 3a is incomplete (top of Page 6-2). Please revise accordingly.

   Response:

   Agreed. The description for alternative 3a will be revised accordingly.

RESPONSE TO SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES COMMENTS

Reviewer: **Robert E. Duncan**
Environmental Programs Director

General Comments

1. **Comment:**

The SCDNR believes that the "partial cover" alternatives (2a and 3a) should be modified to include a minimum of 1 foot of soil cover over surface soils that exceed a *moderate* (rather than *high*) risk to terrestrial ecological receptors. This modification would result in the coverage of soils over approximately the southeastern *two-thirds* (rather than the southeastern *half*) of the causeway. Unlike the proposed "partial cover" alternatives, this modification would protect small omnivorous birds (represented by the robin in the ecological risk assessment) from exposure to mercury concentrations (0.18 mg/kg at Station SS-10) that are more than 6 times greater than the LOAEL for this species.

Response:

The Navy agrees. The preferred alternative to be presented in the Proposed Plan will be a modified Alternative 3a that includes covering of surface soils to the moderate risk level.

2. **Comment:** All Alternatives

Please provide figures that show the approximate extent of soil cover and sediment excavation under each alternative. Although this information can be generally inferred from Figures 3-1 through 3-4, it is not immediately apparent to the reader. It is also unclear whether the intent is for the "partial cover" alternatives (2a and 3a) to include a *continuous* cover of soil which would span the gaps between areas determined to represent an unacceptable risk to terrestrial ecological receptors, or whether the cover would be discontinuous. This should be clarified in the text and in the additional figures requested above.

Response:

Additional figures will be presented to more clearly identify the contaminated sediments to be addressed and the extent of the bank stabilization.

The partial cover, as presented in the FS, would be discontinuous, consisting of two sections. From surface soil location PAI-03-SS08 to the southern eastern edge of the causeway, the soil cover would be continuous. The purpose of this section is to comply with South Carolina landfill requirements (2 feet of soil cover atop waste material). Incidentally, this section also provides 2 feet of soil cover atop

the only surface soil location (PAI-03-SS-01) that exceeds the site-specific human health ILCR greater than 1.0E-06.

The second section is located within the vicinity of surface soil location PAI-03-SS-09. This location is the only surface soil location that contains a detection of a chemical (mercury) that exceeds an RGO corresponding to a high risk to ecological receptors.

3. **Comment:** Page ES-4, Alternative 2a (and all other presented Alternatives)
The SCDNR believes that sediments adjacent to the causeway with contaminant levels that exceed the "moderate risk" criterion for higher level trophic groups should also be targeted for excavation as part of Alternatives 3a and 3b. This would include mercury-contaminated sediments at Stations SD-14, SD-15 and SD-28, as well as lead-contaminated sediments at Station SD-17. According to the footnotes at the bottom of Table C-4, the levels of mercury and lead at these sites "do not significantly impact food-chain receptors"; however, the lead concentration at Station SD-17 clearly exceeds the less conservative ("moderate risk") LOAEL for the great blue heron, and the mercury concentrations at Stations SD-14, SD-15 and SD-28 (0.14 – 0.35 mg/kg) exceed the LOAEL for the raccoon (see Table 3-6). The conclusion that there is no significant impact is apparently based on the large home range for each of these species compared to the area of impact; however, it should be noted that both the raccoon and the great blue heron were chosen as representative receptors for ecologically similar species, many of which may have substantially smaller home ranges. Since sediments at Stations SD-14 and SD-28 are already targeted for excavation under Alternatives 3a and 3b due to pesticide contamination, our proposed modification would only add "hot spot" removal in the vicinity of Stations SD-15 and SD-17 to these two remedial alternatives.

Response:
As proposed under the bank stabilization measures, the referenced sediment locations will be mostly covered and/or excavated. However, based on technical reasons, we do not believe that these additional locations and constituents require separate consideration under Alternatives 3a and 3b.

Several conservative assumptions used in the food chain modeling for lead result in considerable overestimates of risk. First, most toxicity studies of dietary exposure use a highly bioavailable form of lead. The mammal and avian NOAELs and LOAELs that are used as TRVs for Site 3 were based on laboratory studies in which lead acetate was administered in the diet (Sample et al, 1996). Lead acetate is considered to be 100 percent bioavailable (Wixon and Davies, 1993). The bioavailability (i.e., the portion that is absorbed) of environmental lead after ingestion depends upon a variety of factors, including the chemical form of lead, the species of organism, as well as the age, sex, and

nutritional status of the individual (Eisler, 1988). The absorption of oral lead in newborn rats can be up to 90 percent, but decreases to 15 percent within 20 to 30 days of age (Ma, 1996). In general, absorption rates of environmental forms of lead in mammals varies from 2 to 20 percent (Ma, 1996). Absorption rates for environmental lead in birds were not available, but are probably less than 100 percent. Thus, the TRVs used in the food chain model overestimate the potential risks of lead ingestion under field conditions. The extent of any overestimation, however, is uncertain.

A second factor that contributes to the overestimation of risk via the food chain is the assumption that concentrations of lead in prey items are equal to sediment concentrations. This assumption was used since BSAFs do not exist for inorganic compounds. Although the ratio of lead concentrations in aquatic prey items to concentrations in sediment is variable, available data indicate that such ratios (i.e., BSAFs) are usually much less than 1.0 (Eisler, 1988).

Furthermore, upper level receptors (mammals, birds) will be exposed to lead concentrations throughout the site, not just at the location of the maximum concentration and the mean concentration probably better represents the actual exposure term better than the maximum concentration. Therefore, with the above considerations in mind, the HQs in Table 7-12 of the RI (NOAEL HQs of 4.76 for lead and 1.57 for mercury) are not significantly elevated.

Lastly, please note that the referenced locations and constituents do not exceed effects range - median values.

4. **Comment:** Alternatives 3a and 3b:

For Alternatives 3a and 3b, please provide greater detail regarding the proposed method for containing and consolidating excavated sediments beneath the soil cover on the upland portion of the causeway. In order for either of these alternatives to be acceptable to the SCDNR, we would need to have reasonable assurance that the excavated sediments would be permanently isolated from the aquatic environment, and not be subject to run-back during excavation or erosion after placement on the causeway.

Response:

The original plan for excavating contaminated sediments in the pond area called for the pond level to be dropped by 1 to 3 feet to expose and dewater the contaminated sediments. Damp but largely water-free sediments would then be excavated and mixed in with existing causeway soils to stabilize the blend, covered with additional soil as needed, and then vegetated. However, upon further review of potentially significant environmental damage from this plan, we are re-considering lowering the

pond level as an option. However, there are only a few other options available, and all of these options cause short-term damage to the environment. Under these other options, sediment removal would occur while the sediments are under water.

For excavation near the bank where the water is relatively shallow, silt barriers could be installed in one to two feet of water and would be relatively efficient in controlling migration of contaminants. Also, the material nearest the bank is predominately coarser grained material and could be excavated with only small quantities of free water and then handed as originally planned.

However, for sediments further away from the bank, which are in deeper water, the excavated sediments would be diluted with much larger quantities of water. As a result, washout and sediment migration would be more prominent and difficult to control. Therefore, the concern raised with contaminated sediments re-entering the pond becomes very significant. Silt fences/curtains would be used to reduce migration in all cases. However, because of the water depth, these fences/curtains would only have a limited effectiveness. The geology of the areas to be addressed and depth of water in the pond also limit the effectiveness of other options such as cofferdams and hydraulic dredging.

Regarding estimated impacted sediment boundaries as shown in Figure 3-4 of the FS, the areas of PAH- and PCB-impacted sediment are conservatively shown as the maximum possible extent of sediment contamination. The PAH and PCB delineation samples are used as the clean boundary point with this conservative estimate because there were no PAHs or PCBs detected in these samples above the moderate risk levels. However, because the delineation samples are clean, the actual clean boundary of sediment contamination for these areas lies between the delineation samples and the bank of the causeway.

Based on these reasons, planned actions at each of the hot spot areas were further evaluated. This discussion is preliminary and is currently being refined. Specific hot spot areas are discussed as follows.

Based on revised calculations, PAH concentrations exceeding moderate risk levels extend outward a calculated distance of 10 to 30 feet. The planned excavation/cover in this area would extend outward approximately 6 to 10 feet.

Similarly, for the PCB hotspot area, PCB concentrations exceeding moderate risk levels extend outward a recalculated distance of 10 to 30 feet. The planned excavation/cover in this area would extend outward approximately 10 to 15 feet.

A footnote will be inserted onto Figure 3-4 of the FS noting that estimated PAH- and PCB-impacted sediment boundaries are based on the maximum possible extent of contamination.

For the two pesticide hot spot areas, the cover would extent outward approximately 3 to 6 feet. Pesticides in these areas were found at concentrations exceeding moderate risk levels at distances of 20 feet in one case and 75 feet out in the second case. We are still working on resolving an approach for the pesticide exceedances further out in the pond area, but are focusing on covering and/or monitoring biodegradation rates. Also, we may recalculate anthropogenic concentrations of pesticides to distinguish those associated with Site 3 from normal historic applications.

To address these concerns, a revised approach for addressing sediments was developed as follows. Excavate/cover the contaminated sediments only as needed for bank stabilization. After bank stabilization is complete, sample the sediments to determine if sediment contamination remains beyond the extent of the excavation/cover. This approach has the added advantage of addressing contaminants that might have migrated during implementation of the bank stabilization. Based on the volume, extent, concentration, and biodegradation rates, excavate the sediments (high concentration - low volume), monitor and remaining allow contamination to naturally attenuate (low concentration), and/or cover marsh type soils.

Once the source of contaminants is stopped via either preventing additional waste migration into the pond or the historical pesticide bans, natural attenuation of the contaminants will occur, although slowly. Referenced biodegradation rates of the primary contaminants are provided in the following table and indicate that moderate risk levels may be achieved in the pond sediments over reasonable time periods without creating short-term damage to the wetlands as discussed above. Note that under the proposed remedy, the majority of the most contaminated areas (areas closest to the causeway) will be excavated or covered during bank stabilization.

Site 3 Sediment COCs	Range of Detections 1998-1999 RI/RFI (µg/kg)	Site-Specific Clean-up Level (µg/kg)	Maximum Half Life (years)[1]	Estimated Maximum Time for Cleanup (years)
Anthracene	3.7 – 770	245	5.04	8.3
Benzo(a)anthracene	5.1 – 1200	303	7.45	15
Benzo(a)pyrene	8.1 – 1200	693	5.8	4.6
Chrysene	3.2 – 1900	846	11	13
Fluoranthene	15 – 3500	1494	4.82	5.9
Phenanthrene	5.8 – 2400	544	2.19	4.7
Pyrene	11 – 2700	1398	20.8	20
Aroclor-1254	65 – 250	178	NA	NA
Alpha-Chlordane	28	13.9	3.8[2]	3.8
DDD	40 – 290	33.6	15.6	49
DDE	45	31.6	15.6	8.0
Gamma-Chlordane	28	13.2	3.8[2]	4.1

1. Referenced from Howard, et. al, 1991. The slowest half-life value in the reference is presented in this table. Actual rates may be faster. Since the site sediments are in a marsh, anaerobic biodegradation half lives are assumed. Aerobic biodegradation rates for these chemicals are faster.
2. Because the aerobic rate is much slower than the anaerobic rate for this chemical, the aerobic rate was used.

NA: Not available or not applicable.

5. **Comment:** General

In summary, the SCDNR does not believe that Alternatives 1, 2a or 2b are adequately protective of aquatic ecological receptors, since "limited/incidental sediment excavation" in areas which exceed moderate risk for aquatic species may or may not occur during side slope stabilization. The SCDNR further believes that Alternatives 2a and 3a, as currently proposed, are not sufficiently protective of terrestrial ecological receptors because both alternatives would leave exposed soils with mercury concentrations that are more than 6 times greater than the LOAEL for small omnivorous birds. The SCDNR also recommends that Alternatives 3a and 3b be modified as described above (see comment #3) to include the excavation of sediments adjacent to the causeway which pose a "moderate risk" to higher level trophic groups (i.e., piscivorous birds and mammals). Provided the revisions suggested above are incorporated into the FS, the SCDNR would consider both Alternatives 3a and 3b to be sufficiently protective of aquatic and terrestrial ecological receptor species.

Response:

Acknowledged. In the Proposed Plan, the Navy has revised the proposed alternative to a modified Alternative 3a that includes soil cover to the moderate risk level. However, as discussed under the response to Comment 4, the Navy is concerned that excavating contaminated sediments in the pond area may cause more short-term environmental damage than is protected in the long term, especially when natural biodegradation of site contaminants is considered. The modified Alternative 3a would include the provisions for reassessing the sediment contamination after the bank stabilization is in place, and then either excavating, covering, or monitoring the contaminated sediments.

REFERENCES

Eisler, R., 1988, *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, U.S. Fish and Wildlife Service Biological Report 85 (1.14).

Howard, Phillip, H., et al., 1991. Handbook of Environmental Degradation Rates. Lewis Publishers Inc, Chelsea, Michigan.

Ma, W., 1996. "Lead in Mammals" in Beyer, W. N., G. H. Heinz, and A. W. Redmond-Norwood, 1996. *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations,* CRC Press, Boca Raton, Florida, 494 pp.

Wixson, B. G. and B. E. Davies. 1993. *Bioavailability of Lead for Animals*, Lead in Soil Task Force Recommended Guidelines, Society for Environmental Geochemistry and Health. Science Reviews, 132 pp.

EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) has prepared this Feasibility Study (FS)/Corrective Measures Study (CMS) report for the Causeway Landfill [Site 3/Solid Waste Management Unit (SWMU) 3], located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina. This report was prepared for the United States Navy (Navy) Southern Division (SOUTHDIV) Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0020, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888. The objective of this FS/CMS report is to develop and evaluate potential remedial alternatives/corrective measures for addressing risks to human health and the environment found within Site/SWMU 3 (Site 3).

SITE DESCRIPTION

Site 3 is an integral part of a causeway connecting Horse Island and Parris Island, in the north section of MCRD Parris Island. The causeway is a gravel, two-lane road consisting of alternate layers of solid waste and fill dirt constructed along a tidal marsh of the Broad River (across Ribbon Creek). At two locations along the causeway, three concrete pipes are buried beneath the causeway to allow tidal movement between the surface water bodies separated by the unit.

Site 3 functioned as the major disposal area for trash and other materials discarded in dumpsters around the MCRD during most of the period between 1960 and 1972. Between 1960 and 1965, this landfill received approximately 75 percent of the solid waste generated by the Depot. The site was inactive between 1966 and 1968. Between 1969 and 1972, the site received all of the Depot's solid waste. The solid waste reportedly disposed at the site included empty pesticide containers, oily rags, spent absorbent, petroleum and chlorinated solvent sludge, perchloroethylene (PCE) still bottoms, mercury amalgam and beryllium waste, polychlorinated-biphenyl (PCB)-contaminated oil, and metal shavings. In 1972, landfilling operations ceased at Site 3.

The causeway was constructed in two separate sections across a tidal marsh of the Broad River. One section began from the northeast edge of Horse Island and was built primarily with fill dirt taken from the borrow pits on Horse Island. Some solid wastes were also reportedly placed in this section of the causeway. The other section started near the southern end of Talasesa Street on Parris Island and was built with the solid waste mentioned in the previous paragraph and with fill dirt. Aerial photos taken in 1951, 1965, and 1972 illustrate that the two sections of causeway gradually extended into the marsh until they met in 1972. At its completion in 1972, the causeway was approximately 10 acres in size, 4,000 feet long, 100 feet wide, and 10 feet high (above the water surface), with a gravel road surface and rip-rap sides overgrown with vegetation. No landfill activity has taken place at Site 3 since 1972.

MEDIA OF CONCERN

During the remedial investigation, surface soils and sediment were found to contain several polynuclear aromatic hydrocarbons (PAHs), PCBs, pesticides, and inorganics at concentrations greater than present in background soils/sediment and in exceedance of the most stringent human health RBCs (residential) or ecological screening values. Surface soil and sediment are retained as media of concern in this FS/CMS.

Surface water is also retained as a medium of concern in this FS/CMS due to detections of PAHs and arsenic observed above applicable or relevant and appropriate requirements (ARARs), to be considered (TBC) criteria, and site-specific remedial goal options (RGOs). However, because these surface water detections are located near elevated surface soil concentrations of PAHs and arsenic, surface water will be addressed through the management of surface soil.

Based on a screening of groundwater analytical results against ARARs, TBCs, and site-specific RGOs, groundwater is not retained in this FS/CMS as a medium of concern. The total dissolved solids content of the groundwater precludes its use as a drinking water source. Also, data indicate that groundwater may not pose a concern to ecological receptors.

REMEDIAL ACTION OBJECTIVES/CORRECTIVE ACTION OBJECTIVES

Remedial action objectives/corrective action objectives (RAOs/CAOs) are developed as medium-specific and chemical-specific objectives for protecting human health and the environment. RGOs are the chemical-specific portion of the RAO/CAO and have been developed to illustrate a range of cleanup alternatives at Site 3. For both surface soil and sediment, three sets of RGOs are established for identified chemicals of concern (COCs). In each RGO set, a value protective of human health and ecological receptors is selected. RGOs for the selected COCs are summarized in Tables 3-7 and 3-8 of this report.

The following RAOs/CAOs have been developed for Site/SWMU 3.

- Control human exposure (the existing maintenance worker, the future construction worker, and the adult recreational user) to COCs in surface soil and sediment at concentrations in excess of RGOs. RGOs take into consideration an incremental lifetime cancer risk (ILCR) range of 1.0E-06 to 1.0E-04. Additionally, RGOs take into consideration a HQ of 1 where noncarcinogenic effects would be expected. The COCs and range of RGOs for surface soil and sediment are presented in Tables 3-7 and 3-8, respectively.

- Protect adult recreational users from consumption of fish and shellfish containing COCs at concentrations in excess of sediment-based RGOs. Protection would be achieved by controlling sediment COC concentrations to prevent the bioaccumulation of sediment COCs into fish. Sediment-based RGOs take into consideration an ILCR range of 1.0E-06 to 1.0E-04. Additionally, RGOs take into consideration a HQ of 1 where noncarcinogenic effects would be expected. The COCs and range of RGOs are presented in Table 3-8.

- Control exposure of ecological receptors to COCs in surface soil and sediment at concentrations greater than RGOs. The RGOs take into account direct contact of COCs by macroinvertebrates and ingestion and bioaccumulation of COCs by site-specific food chain receptors. RGOs address a range of risks where "low effects" to "high effects" may be anticipated by ecological receptors. The COCs and range of RGOs for surface soil and sediment are presented in Tables 3-7 and 3-8, respectively.

- Eliminate the migration of COCs from the fill material to sediment, surface water, and groundwater.

- Comply with chemical-specific, location-specific, and action-specific federal and state ARARs.

REMEDIAL ACTION/CORRECTIVE MEASURES ALTERNATIVE DEVELOPMENT

Remedial action/corrective measures alternatives were developed that address the COCs and exposure pathways in order to achieve the RAOs/CAOs. The following alternatives have been developed for Site 3:

- Alternative 1 - No Action: This alternative is developed per the NCP to provide a baseline for comparison to other alternatives.

  Alternative 2a – Partial Containment: This alternative is developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection would be achieved by assuring that a minimum of two feet of clean soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. In addition, in areas where a concern to only terrestrial ecological receptors is present under the *high*-risk scenario, a minimum of 1 foot of soil cover would be placed. The soil cover described in this alternative would be placed over the southeast half of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway). Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

Alternative 2b – Full Containment: This alternative is also developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection is achieved by assuring that a minimum of two feet of soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. Alternative 2b provides equal protection to human health as Alternative 2a; however, Alternative 2b is more protective of terrestrial ecological receptors. In areas where a concern to only terrestrial ecological receptors is present under the *low*-risk scenario, a minimum of 1 foot of soil cover would be placed. As a result of the evaluation, the soil cover described in this alternative would be placed over the entire length of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway). Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

Alternative 3a – Partial Containment with Further Sediment Evaluation: Alternative 3a consists of all the components of Alternative 2a; however, Alternative 3a also contains components for the intentional delineation and potential excavating/covering of the more contaminated sediment found on the pond side of the causeway. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

Alternative 3b – Full Containment with Further Sediment Evaluation: Alternative 3b consists of all the components of Alternative 2b; however, Alternative 3b also contains components for the intentional delineation and potential excavating/covering of the more contaminated sediment found on the pond side of the causeway. The sediment component would be the same as proposed in Alternative 3a. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

These alternatives are further described as follows.

Alternative 1 - No Action

The no-action alternative maintains the site at status quo. This alternative is retained to provide a baseline for comparison to other alternatives and, therefore, does not address the wastes present or impacted surface soil and sediment.

Alternative 2a – Partial Containment

Alternative 2a consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring.

A soil cover would be placed over the southeastern half of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and high risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. Limited/incidental sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. These controls would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates. Existing "No Swimming/Wading" signs would be maintained. Sediment and groundwater sampling and inspections of the soil cover would be performed to determine the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

Alternative 2b – Full Containment

Alternative 2b consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring. Alternative 2b is similar to Alternative 2a; however, with Alternative 2b, the soil cover is placed over the entire length of the causeway instead of the causeway's southeastern half. This action has the additional benefit of protecting terrestrial ecological receptors from surface soil COC concentrations that exceed the most stringent ecological criteria.

The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. Limited/incidental sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. These controls would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates. Existing "No Swimming/Wading" signs would be maintained. Sediment and groundwater sampling and inspections of the soil cover would be performed to determine the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

Alternative 3a – Partial Containment with Further Sediment Evaluation

Alternative 3a consists of four components: 1) Soil Cover, 2) Slope Stabilization, and Erosion Control 3) Further Sediment Evaluation, and 4) Land Use Controls and Long-term Monitoring. Alternative 3a is similar to Alternative 2a; however, Alternative 3a addresses sediment as a remedial component.

A soil cover would be placed over the southeastern half of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and high risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration,

drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind.

After the soil cover and slope stabilization and erosion control measures are installed, sediment on the pond side of the causeway would be further delineated. Sediment in excess of clean-up goals would be either covered, excavated and consolidated on site, or allowed to naturally biodegrade in place. Additional biota testing may also be conducted to refine the clean-up goals.

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. These controls would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates. Existing "No Swimming/Wading" signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

Alternative 3b – Full Containment with Further Sediment Evaluation

Alternative 3b consists of four components: 1) Soil Cover, 2) Slope Stabilization, and Erosion Control 3) Further Sediment Evaluation, and 4) Land Use Controls and Long-term Monitoring. Alternative 3b is similar to Alternative 2b; however, Alternative 3b addresses sediment as a remedial component.

A soil cover would be placed over the entire length of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind.

After the soil cover and slope stabilization and erosion control measures are installed, sediment on the pond side of the causeway would be further delineated. Sediment in excess of clean-up goals would be either covered, excavated and consolidated on site, or allowed to naturally biodegrade in place. Additional biota testing may also be conducted to refine the clean-up goals.

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. These controls would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates. Existing "No Swimming/Wading" signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

EVALUATION OF ALTERNATIVES

Each alternative was evaluated using criteria specified in the U.S. Environmental Protection Agency (U.S. EPA) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988) and RCRA Corrective Action Plan (Final) (U.S. EPA, 1994). These criteria include protection of human health and the environment; media clean-up standards; source control; waste management standards; long-term reliability and effectiveness; reduction in toxicity, mobility, and/or volume; short-term effectiveness; implementability; and cost. Section 5.0 of this report presents the results of this evaluation process.

A comparative analysis of alternatives was completed. This comparative analysis was performed with respect to specific factors for each of the above-mentioned criteria and differences among the alternatives were identified. The results of this analysis are presented in Section 6.0 and summarized in Table 6-1. The estimated cost for each alternative are as follows:

Alternative	Capital ($)	Operating ($/year)	30-Year Present Worth ($)
1	0	0	0
2a	4,090,000	58,700 to 74,700	4,880,000
2b	4,530,000	58,700 to 74,700	5,310,000
3a	4,700,000	58,700 to 74,700	5,480,000
3b	5,130,000	58,700 to 74,700	5,910,000

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

Tetra Tech NUS, Inc. (TtNUS) has prepared this Feasibility Study (FS)/Corrective Measures Study (CMS) report for the Causeway Landfill [Site 3/Solid Waste Management Unit (SWMU) 3], located at the Marine Corps Recruit Depot (MCRD) Parris Island, South Carolina (as shown in Figure 1-1). This report was prepared for the United States Navy (Navy) Southern Division (SOUTHDIV) Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0020, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888.

The objective of the remedial investigation/RCRA facility investigation (RI/RFI) and FS/CMS process is to gather and evaluate information sufficient to select an appropriate remedy for a given site based on an informed risk management decision-making process. An RI/RFI (TtNUS, 1999) was performed at MCRD Parris Island between May 1998 and August 1999 that included sampling of soils, surface water, and sediment, as well as an overall investigation of site groundwater and establishment of background conditions. The purpose of these activities was to characterize the nature and extent of contamination at Site 3 where the potential for off-site migration exists. Both human health and ecological risk assessments were included in the report to support site decisions.

This FS/CMS report uses the results of the RI/RFI report to develop and evaluate potential remedial alternatives/corrective measures for addressing risks to human health and the environment found within these areas.

1.2 REGULATORY SETTING

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act of 1986 (SARA) established a program for the clean-up of hazardous waste disposal and spill sites nationwide. This program contains provisions for the clean-up of contamination from past hazardous waste operations and past hazardous material spills and is the framework for Installation Restoration (IR) Programs at Navy and Marine Corps installations. The Resource Conservation and Recovery Act (RCRA), as amended, also establishes a clean-up program that provides for current and future hazardous waste management practices, as well as clean-up of past disposal sites at permitted or interim status Navy/Marine Corps installations. SOUTHNAVFAC has the responsibility for implementing the Navy's IR Program at MCRD Parris Island.

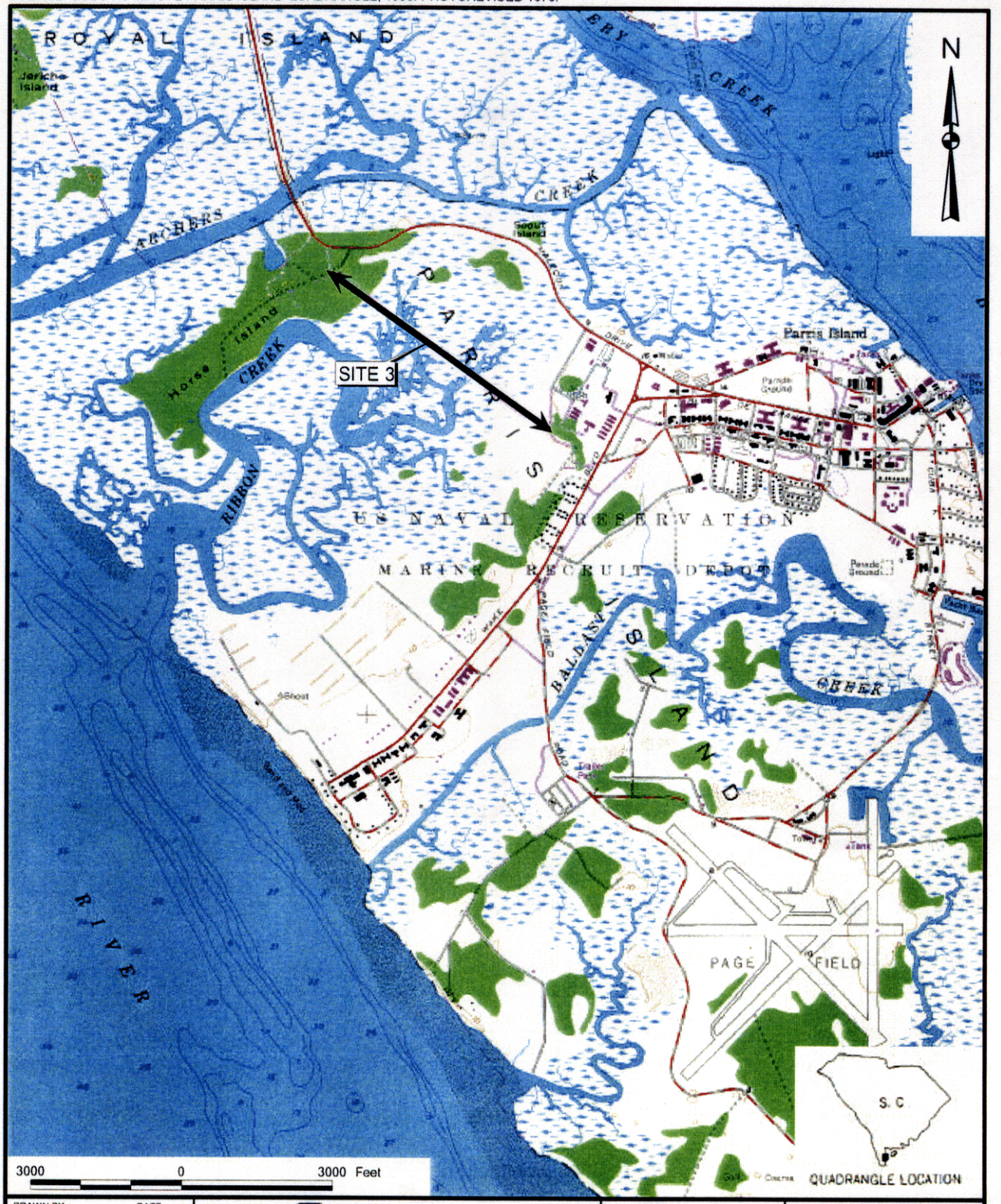
Because of the past hazardous waste activities conducted at the MCRD Parris Island, South Carolina, the MCRD meets criteria for conducting IR activities under the CERCLA regulatory framework. To date, the MCRD has completed steps equivalent to the RI phase of the CERCLA remedial action process at Site/SWMU 3. The MCRD also meets the criteria for conducting IR activities under the authority of RCRA because, in the late 1980s, the MCRD submitted a RCRA Part A application. Per RCRA, this action required the MCRD to conduct corrective action for the release of hazardous waste or hazardous constituents from SWMUs. An interim RCRA Facility Assessment (RFA) was conducted in 1990 as part of this requirement. The MCRD has since withdrawn its Part A application.

Because of the circumstances surrounding the MCRD's IR program history, discussions have been held among representatives from the U.S. Marine Corps, U.S. Navy, South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Environmental Protection Agency (U.S. EPA) Region IV to determine the appropriate regulatory framework for conducting IR activities at the MCRD. From these discussions, it has been decided that this report will encompass both CERCLA and RCRA requirements and the title, FS/CMS, reflects this decision. For ease of reading and clarity, Site/SWMU 3 will be referred to as Site 3 for the remainder of this document.

1.3 REPORT ORGANIZATION

This report is divided into six sections. Section 1.0 presents the purpose of the report and the regulatory setting at MCRD Parris Island. Section 2.0 provides background information regarding Site 3. Section 3.0 presents the development of remedial action objectives/corrective measures objectives. Section 4.0 describes the identification, screening, and development of remedial action/corrective measures alternatives. Section 5.0 presents a detailed evaluation of the remedial action/corrective measure alternatives. Section 6.0 provides a comparative analysis of the alternatives. Appendices A through E provide support documentation for this report.

SOURCE: USGS 7.5 MINUTE PARRIS ISLAND QUADRANGLE, 1956. PHOTOREVISED 1979.



DRAWN BY D. PERRY	DATE 25-JAN-99	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0020 / OWNER NO. —
CHECKED BY —	DATE —		APPROVED BY — / DATE —
COST/SCHEDULE-AREA		DEPOT LOCATION MAP MCRD, PARRIS ISLAND, SOUTH CAROLINA	APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 / REV 0

P:\GIS\MCRD_PARRISISLAND\PARRIS.APR 16-MAR-99 DNP DEPOT LOCATION - SITE 3 LAYOUT

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TABLE 3-7

SURFACE SOIL RGOS SUMMARY TABLE
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

COC	Human Health ILCR = 1.0E-06	Ref.	Low Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-05	Ref.	Moderate Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-04	Ref.	High Risk to Ecological Receptors*	Ref.
SVOCs (µg/kg)												
ACENAPHTHYLENE	-	-	100	h	-	-	5,000	i	-	-	50,000	g
ANTHRACENE	-	-	100	h, j	-	-	10,000	i	-	-	100,000	g
BENZO(A)ANTHRACENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(A)PYRENE	890	b	100	h, j	8,900	c	1,000	i	89,000	d	10,000	g
BENZO(B)FLUORANTHENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(G,H,I)PERYLENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(K)FLUORANTHENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
CHRYSENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
FLUORANTHENE	-	-	100	h	-	-	10,000	i	-	-	100,000	g
INDENO(1,2,3-CD)PYRENE	-	-	100	h, j	-	-	1,000	i	-	-	10,000	g
PHENANTHRENE	-	-	100	h, j	-	-	5,000	i	-	-	50,000	g
PYRENE	-	-	100	h, j	-	-	10,000	i	-	-	100,000	g
PCBs (µg/kg)												
AROCLOR-1254	-	-	20.0	j	-	-	238	f	-	-	2,380	g
AROCLOR-1260	-	-	20.0	j	-	-	238	f	-	-	2,380	g
Inorganics (mg/kg)												
ARSENIC	-	-	1.4	a	-	-	7.79	f	-	-	78.0	k
LEAD	-	-	12.5	a	-	-	61.9	f	-	-	619	k
MERCURY	-	-	0.11	a	-	-	0.11	a	-	-	0.29	k
VANADIUM	-	-	9.5	a	-	-	28.9	f	-	-	289	k
ZINC	-	-	10.6	e	-	-	95.5	f	-	-	955	k

References:
a. Inorganic background
b. Site-Specific Human Health RGOs - ILCR = 1.E-06
c. Site-Specific Human Health RGOs - ILCR = 1.E-05
d. Site-Specific Human Health RGOs - ILCR = 1.E-04
e. NOAEL, HQ = 1
f. LOAEL, HQ = 1
g. The moderate risk ecological RGO multiplied by 10
"-" = Not Applicable
* Values may be revised upward based on site-specific ecological studes.
h. Dutch Soil Clean-up Act "a" Values
i. Dutch Soil Clean-up Act "b" Values
j. U.S. EPA Region IV Ecological Screening Values for Soils
k. LOAEL, HQ = 10

TABLE 3-8

SEDIMENT RGOS SUMMARY TABLE
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

COC	Human Health ILCR = 1.0E-06	Ref.	Low Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-05	Ref.	Moderate Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-04	Ref.	High Risk to Ecological Receptors*	Ref.
PAHs (µg/kg)												
ANTHRACENE	-	-	46.9	k,l	-	-	245	n	-	-	2,450	p
BENZO(A)PYRENE	2.09	c	88.8	k,l	303	f	763	n	3,030	g	7,630	p
BENZO(A)ANTHRACENE	20.9	c	74.8	k,l	3,030	f	693	n	30,300	g	6,930	p
BENZO(B)FLUORANTHENE	20.9	c	655	l	3,030	f	6,550	o	30,300	g	65,500	p
CARBAZOLE	219	c	-	-	31,700	f	-	-	317,000	g	-	p
CHRYSENE	-	-	108	k,l	-	-	846	n	-	-	8,460	p
FLUORANTHENE	-	-	113	k,l	-	-	1,494	n	-	-	14,900	
INDENO(1,2,3-CD)PYRENE	20.9	c	655	l	3,030	f	6,550	o	30,300	g	65,500	p
PHENANTHRENE	-	-	86.7	k,l	-	-	544	n	-	-	5,440	p
PYRENE	-	-	153	k,l	-	-	1,398	n	-	-	14,000	p
PCBs (µg/kg)												
AROCLOR-1254	1.19	c	21.6	k,l	178	f	180	m	1,780	g	1,800	p
AROCLOR-1260	1.19	c	21.6	k,l	175	f	180	m	1,750	g	1,800	p
Pesticides (µg/kg)												
ALPHA-CHLORDANE	13.9	b	13.9	b	382	f	13.9	b	3,820	g	139	p
4,4'-DDD	65.9	c	33.6	b	9,670	f	33.6	b	96,700	g	336	p
4,4'-DDE	31.6	b	31.6	b	251	f	31.6	b	2,510	g	316	p
GAMMA-CHLORDANE	13.2	b	13.2	b	824	f	13.2	b	8,240	g	132	p
Inorganics (mg/kg)												
ARSENIC	16.8	d	12.0	a	59.7	e	12.0	a	489	h	59	q
COBALT	-	-	4.66	i	-	-	46.6	j	-	-	466	q
COPPER	-	-	18.7	l	-	-	108	m	-		1,080	q
LEAD	-	-	21.0	a	-	-	62.8	j	-	-	628	q
MERCURY	-	-	0.09	a	-	-	0.117	j	-	-	1.17	q
SELENIUM	-	-	0.93	i	-	-	1.54	j	-	-	15.4	q
THALLIUM	-	-	0.41	a	-	-	0.41	a	-	-	3.4	q
VANADIUM	-	-	50.0	a	-	-	50.0	a	-	-	98	q
ZINC	-	-	80.6	i	-	-	271	m	-	-	2,710	q

References:
a. Inorganic background
b. Typical Facility Pesticide Concentrations
c. Human health RGOs based on ingestion of fish (conservative inputs) - ILCR = 1.0E-06
d. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-06
e. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-05
f. Human health RGOs based on ingestion of fish (site-specific inputs) - ILCR = 1.0E-05
g. Human health RGOs based on ingestion of fish (site-specific inputs) - ILCR = 1.0E-04
h. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-04
i. NOAEL, HQ = 1
j. LOAEL, HQ = 1
k. ER-L
l. U.S. EPA Region IV Effects Value
m. ER-M
n. PEL
o. 10 times the ecological low risk RGO.
p. 10 times the ecological moderate risk RGO.
q. LOAEL, HQ = 10
"-" = Not Applicable
* Values may be revised upward based on site-specific ecological studies.

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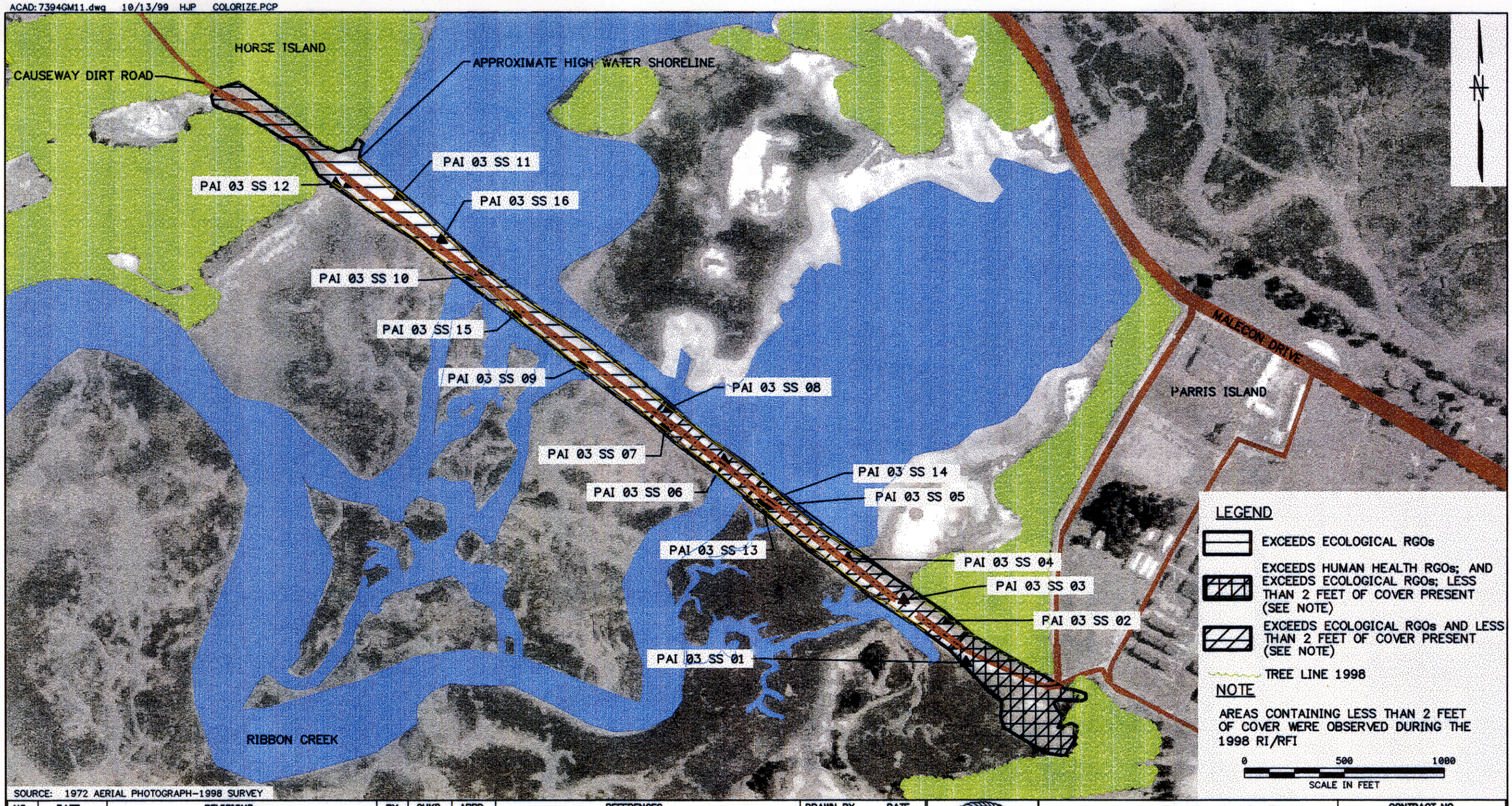

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/29/99
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COST/SCHED-AREA
SCALE AS NOTED

EXTENT OF IMPACTED SOIL BASED ON RGOs REPRESENTING A HUMAN HEALTH ILCR EQUAL TO 1.0E-06 AND LOW RISK TO ECOLOGICAL RECEPTORS
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
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DRAWING NO. FIGURE 3-1 REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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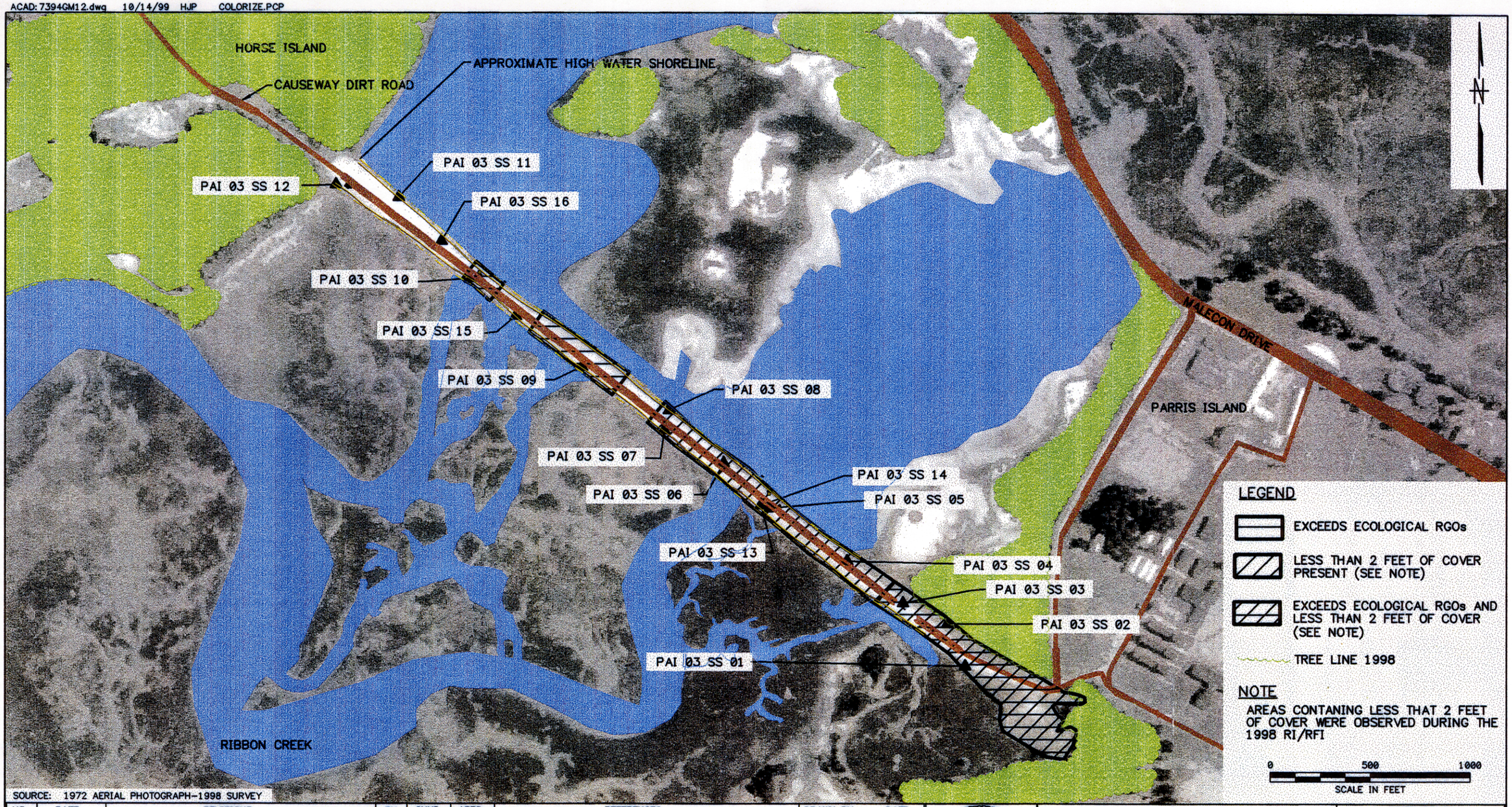
ACAD: 7394GM12.dwg 10/14/99 HJP COLORIZE.PCP



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/29/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

EXTENT OF IMPACTED SOIL BASED ON RGOs REPRESENTING A HUMAN HEALTH ILCR OF 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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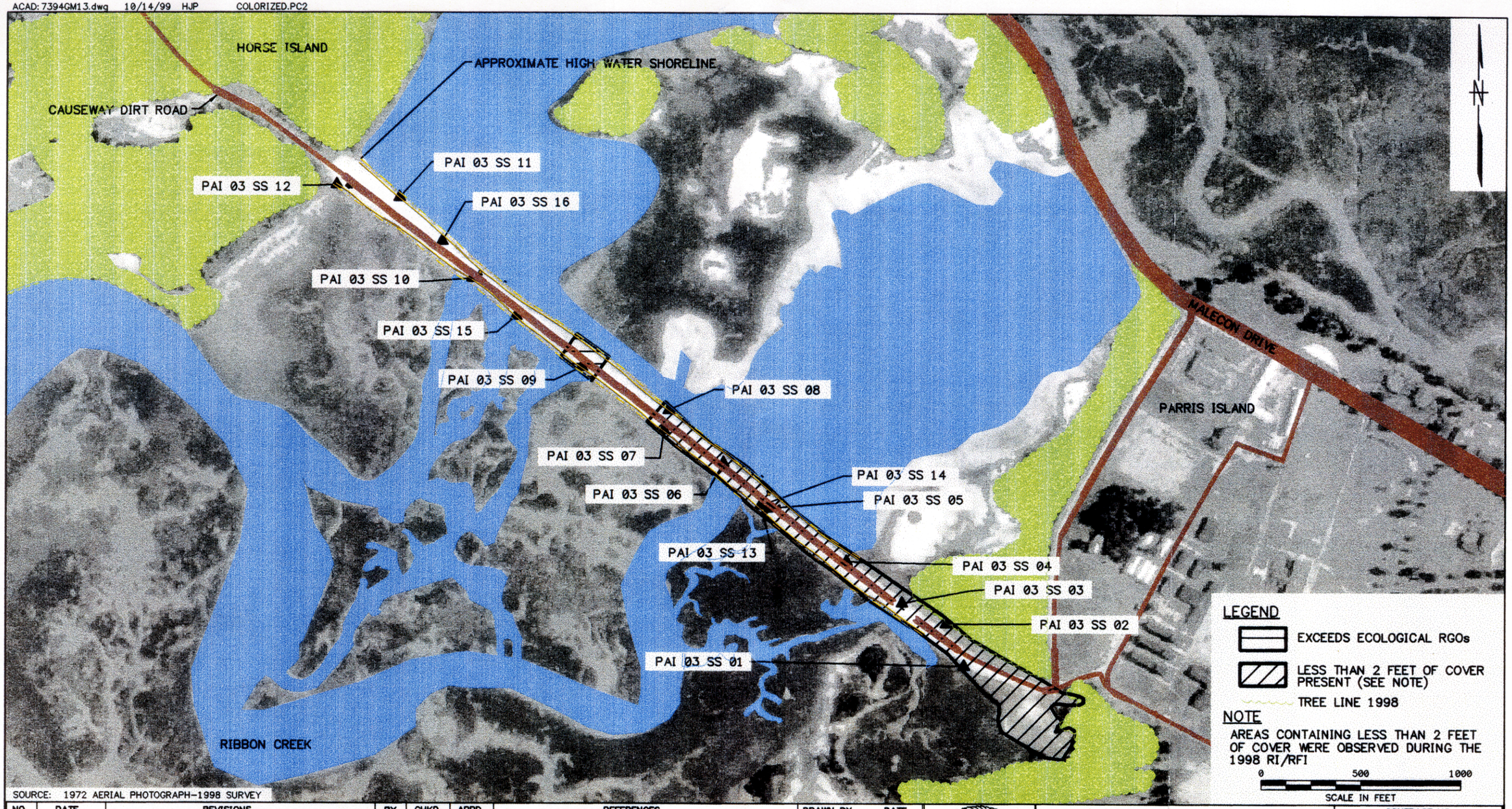
DRAWING NO. FIGURE 3-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GM13.dwg 10/14/99 HJP COLORIZED.PC2



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/29/99
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COST/SCHED-AREA
SCALE AS NOTED

EXTENT OF IMPACTED SOIL BASED ON RGOs REPRESENTING A HUMAN HEALTH ILCR OF 1.0E-04 AND HIGH RISK TO ECOLOGICAL RECEPTORS
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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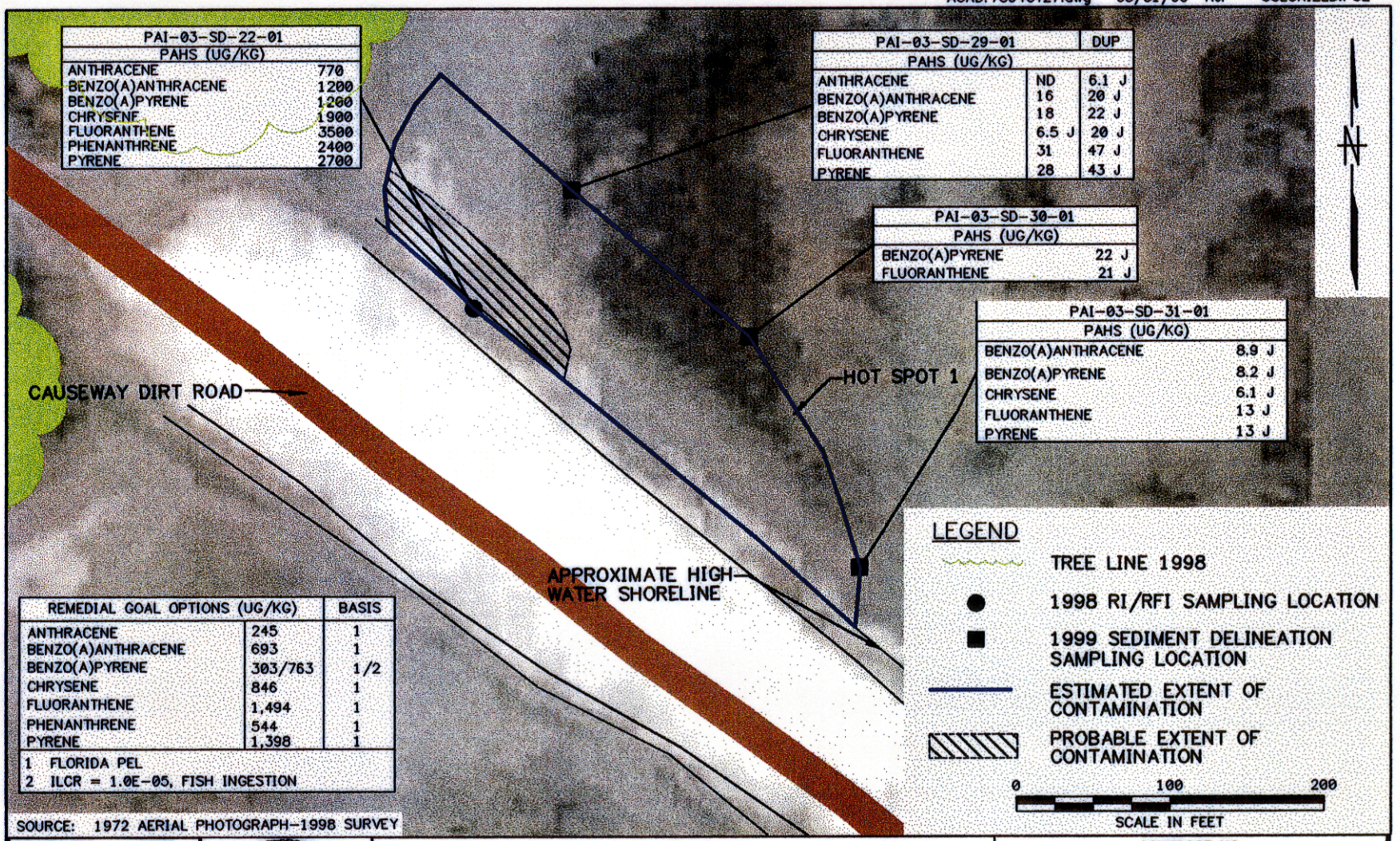
DRAWING NO. FIGURE 3-3
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 7394GT27.dwg 05/31/00 HJP COLORIZED.PC2



PAI-03-SD-22-01	
PAHS (UG/KG)	
ANTHRACENE	770
BENZO(A)ANTHRACENE	1200
BENZO(A)PYRENE	1200
CHRYSENE	1900
FLUORANTHENE	3500
PHENANTHRENE	2400
PYRENE	2700

PAI-03-SD-29-01		DUP
PAHS (UG/KG)		
ANTHRACENE	ND	6.1 J
BENZO(A)ANTHRACENE	16	20 J
BENZO(A)PYRENE	18	22 J
CHRYSENE	6.5 J	20 J
FLUORANTHENE	31	47 J
PYRENE	28	43 J

PAI-03-SD-30-01	
PAHS (UG/KG)	
BENZO(A)PYRENE	22 J
FLUORANTHENE	21 J

PAI-03-SD-31-01	
PAHS (UG/KG)	
BENZO(A)ANTHRACENE	8.9 J
BENZO(A)PYRENE	8.2 J
CHRYSENE	6.1 J
FLUORANTHENE	13 J
PYRENE	13 J

REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
ANTHRACENE	245	1
BENZO(A)ANTHRACENE	693	1
BENZO(A)PYRENE	303/763	1/2
CHRYSENE	846	1
FLUORANTHENE	1,494	1
PHENANTHRENE	544	1
PYRENE	1,398	1

1 FLORIDA PEL
2 ILCR = 1.0E-05, FISH INGESTION

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

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HJP	5/25/00
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COST/SCHED-AREA	
SCALE	AS NOTED

SOUTHERN DIV FACILITIES ENGINEERING COMD — DEPARTMENT OF THE NAVY

SEDIMENT HOT SPOT 1 – PAHs
EXTENT OF CONTAMINATION
ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394		
APPROVED BY	DATE	
APPROVED BY	DATE	
DRAWING NO. FIGURE 3-4		REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

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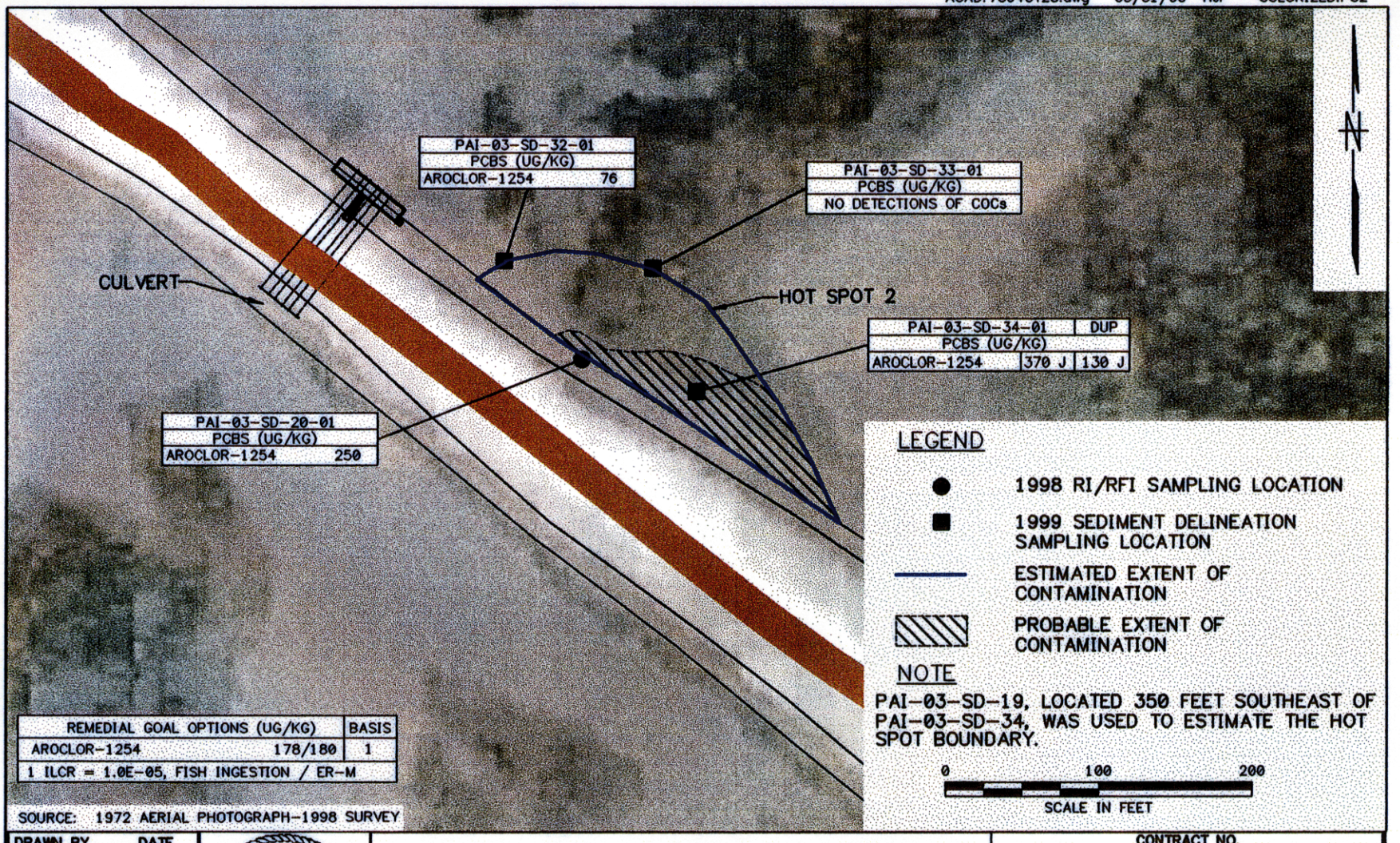
06/05/00

ACAD: 7394GT28.dwg 05/31/00 HJP COLORIZED.PC2



REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
AROCLOR-1254	178/180	1
1 ILCR = 1.0E-05, FISH INGESTION / ER-M		

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY HJP	DATE 5/25/00	SEDIMENT HOT SPOT 2 – PCBs EXTENT OF CONTAMINATION ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS SITE 3 – CAUSEWAY LANDFILL MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7394
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-5 REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

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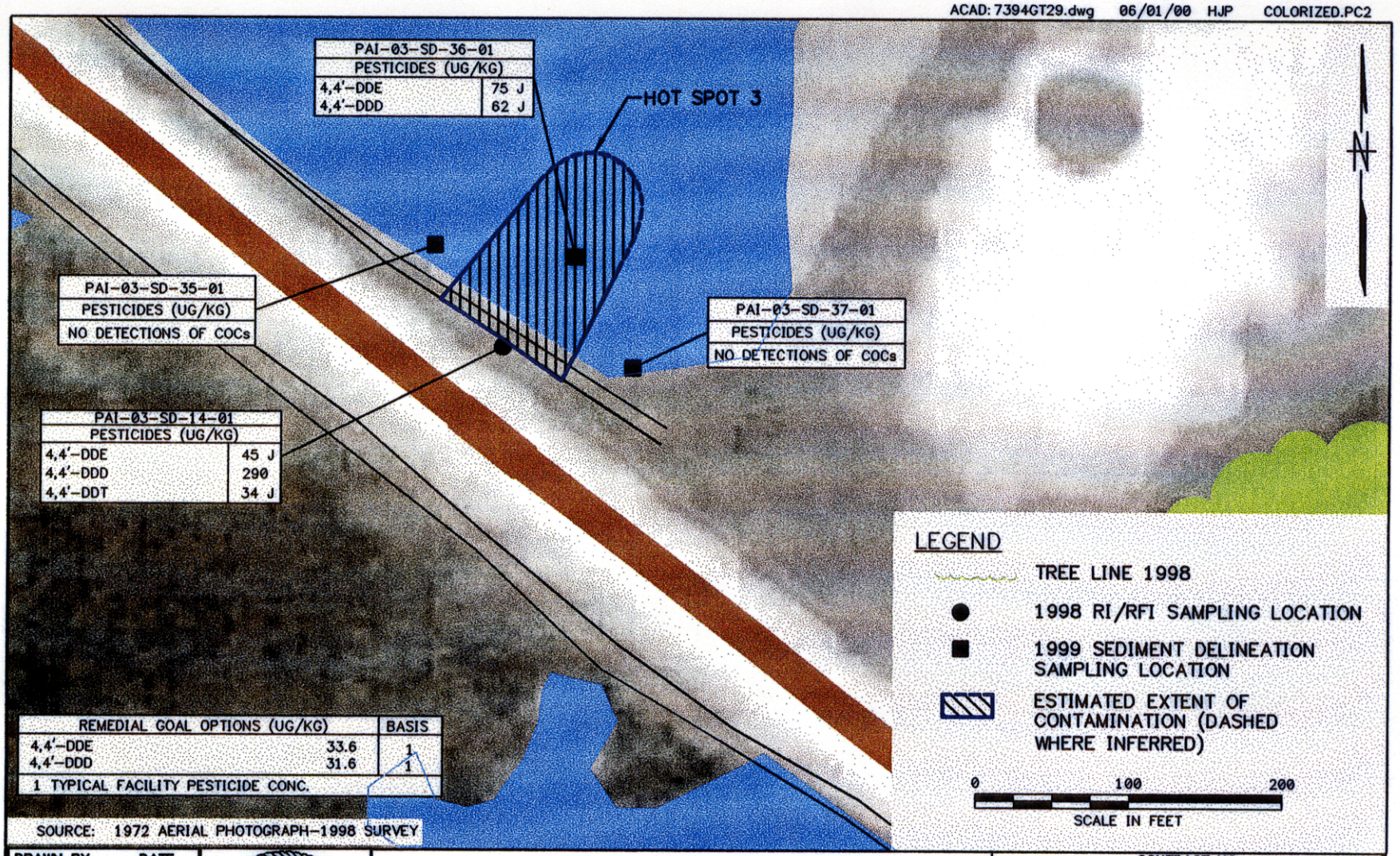

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HJP	5/25/00	7394
CHECKED BY	DATE	APPROVED BY / DATE
COST/SCHED-AREA		APPROVED BY / DATE
SCALE: AS NOTED		DRAWING NO. FIGURE 3-6 / REV. 1

SEDIMENT HOT SPOT 3 – PESTICIDES
EXTENT OF CONTAMINATION
ILCR = 1.0E-05 AND MODERATE RISK OF ECOLOGICAL RECEPTORS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

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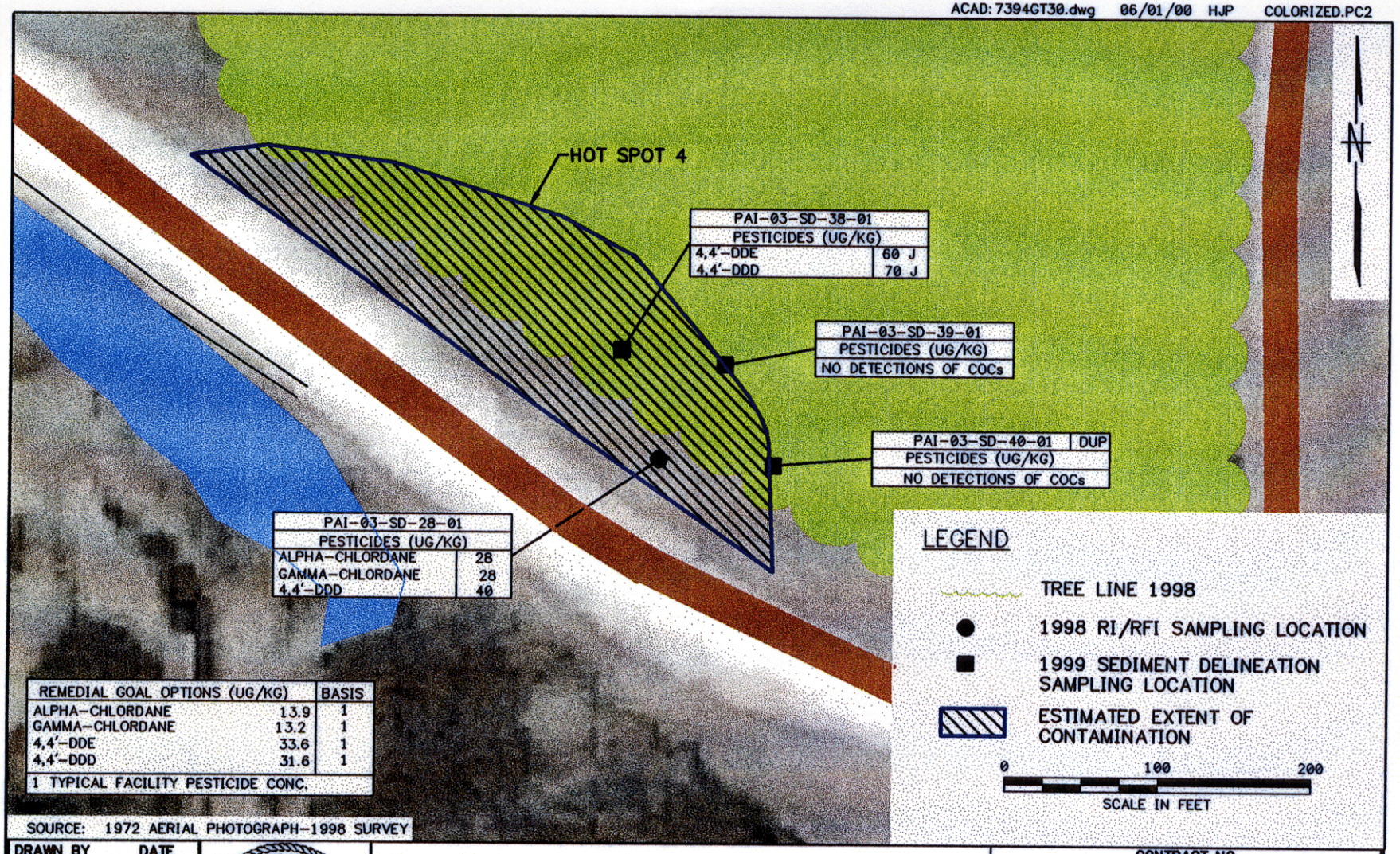

REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
ALPHA-CHLORDANE	13.9	1
GAMMA-CHLORDANE	13.2	1
4,4'-DDE	33.6	1
4,4'-DDD	31.6	1

1 TYPICAL FACILITY PESTICIDE CONC.

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

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HJP	5/25/00	
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SCALE AS NOTED		DRAWING NO. FIGURE 3-7 / REV. 1

DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD

SEDIMENT HOT SPOT 4 – PESTICIDES
EXTENT OF CONTAMINATION
ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

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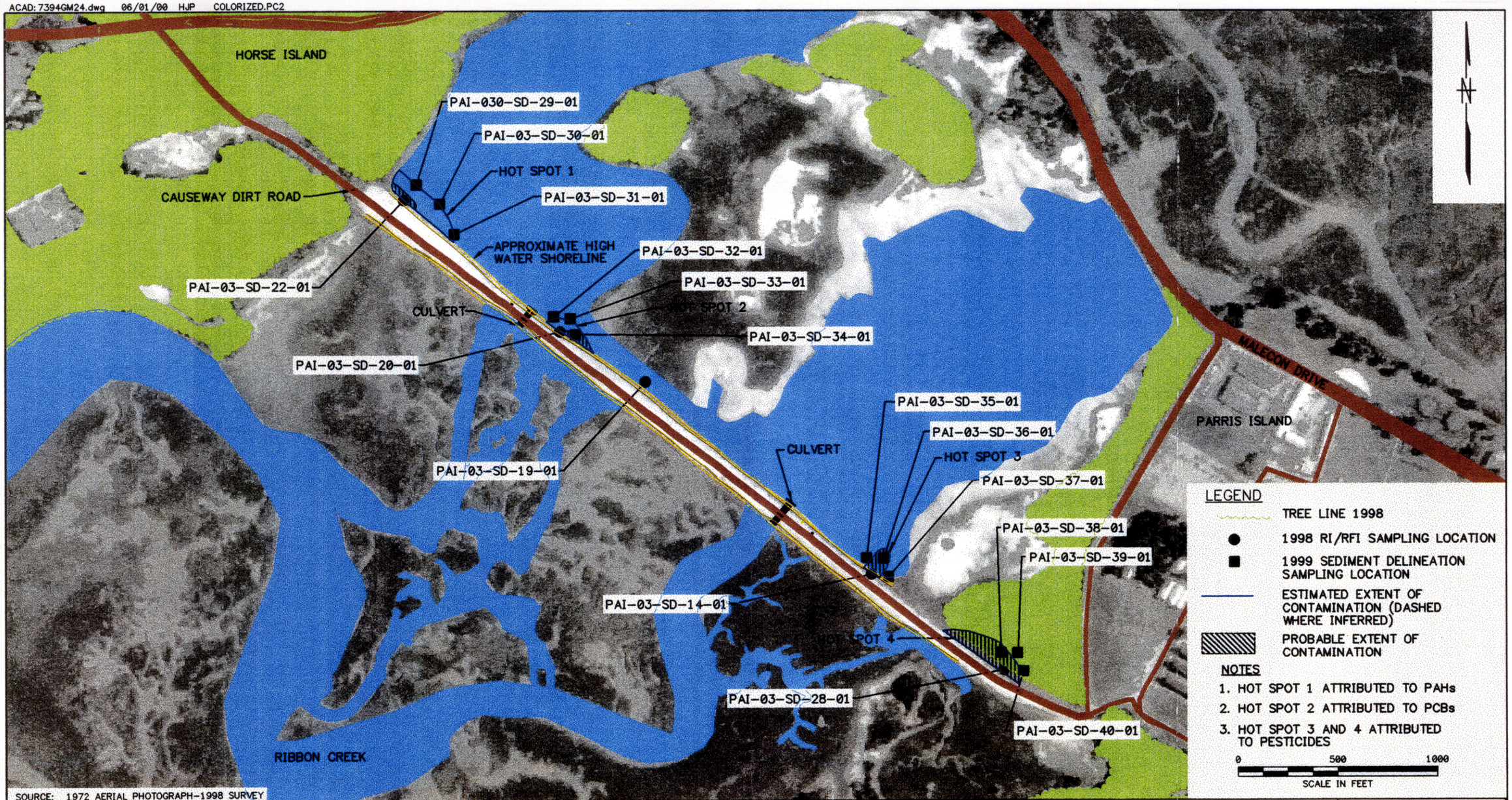

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 10/13/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

EXTENT OF IMPACTED SEDIMENT BASED ON RGOs REPRESENTING A HUMAN HEALTH ILCR EQUAL TO 1.0E--05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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APPROVED BY DATE
DRAWING NO. FIGURE 3-8
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

2.0 DESCRIPTION OF CURRENT CONDITIONS

2.1 SITE DESCRIPTION

MCRD Parris Island is located along the southern coast of South Carolina, approximately 1 mile south of the city of Port Royal and 3 miles south of the city of Beaufort within Beaufort County. MCRD Parris Island covers approximately 8,047 acres that consist of dry land, salt marshes, saltwater creeks, and ponds, as shown in Figure 1-1. MCRD Parris Island is the reception and recruit training facility for the Marine Corps for enlisted men from states east of the Mississippi River and for enlisted women nationwide.

Site 3 is an integral part of a causeway connecting Horse Island and Parris Island, in the north section of MCRD Parris Island, as shown in Figure 2-1. The causeway is a gravel, two-lane road consisting of alternate layers of solid waste and fill dirt constructed along a tidal marsh of the Broad River (across Ribbon Creek). At two locations along the causeway, three concrete pipes are buried beneath the causeway allow tidal movement between the surface water bodies separated by the unit.

The Causeway Landfill (Site 3) functioned as the major disposal area for trash and other materials discarded in dumpsters around the MCRD during most of the period between 1960 and 1972. Between 1960 and 1965, this landfill received approximately 75 percent of the solid waste generated by the Depot. The site was inactive between 1966 and 1968. Between 1969 and 1972, the site received all the Depot's solid waste. The solid waste reportedly disposed at the site included empty pesticide containers, oily rags, spent absorbent, petroleum and chlorinated solvent sludge, tetrachloroethene (PCE) still bottoms, mercury amalgam and beryllium waste, polychlorinated-biphenyl (PCB)-contaminated oil, and metal shavings. In 1972, landfilling operations ceased at Site 3 (NEESA, 1986).

The causeway was constructed in two separate sections across a tidal marsh of the Broad River. One section began from the northeast edge of Horse Island and was built primarily with fill dirt taken from the borrow pits on Horse Island. Some solid wastes were also reportedly placed in this section of the causeway. The other section started near the southern end of Talasesa Street on Parris Island and was built with the solid waste mentioned in the previous paragraph and with fill dirt. Aerial photos taken in 1951, 1965, and 1972 illustrate that the two sections of causeway gradually extended into the marsh until they met in 1972. At its completion in 1972, the causeway was approximately 10 acres in size, 4,000 feet long, 100 feet wide, and 10 feet high (above the water surface), with a gravel road surface and rip-rap sides overgrown with vegetation (NEESA, 1986). No landfilling activity has taken place at Site 3 since 1972.

2.2 SITE-SPECIFIC GEOLOGY AND HYDROGEOLOGY

To define the areal extent and thickness of cover material present above the contents of Site 3, auger and hand soil borings were installed during the RI/RFI at locations where monitoring wells were installed and surface soil samples were collected. Soil boring logs for locations that were converted into monitoring wells are provided in Appendix A of the RI/RFI report (TtNUS, 1999). For the surface soil sample locations, field personnel advanced the soil borings using a hand auger until the top of waste was observed. Table 2-1 presents the general lithology observed in these soil borings.

Based on the data obtained from the soil borings and other RI/RFI data, cross sections approximating existing conditions (e.g., ground surface and groundwater elevations, top and bottom of waste, surface features) have been generated. Longitudinal Cross Section A – A' extends from Horse Island to Parris Island and is presented in Figure 2-2. Transverse Cross Sections B – B' and C – C' intersect Cross Section A – A' and are presented in Figures 2-3 and 2-4.

A discussion of the site-specific geology and hydrogeology of Site 3 is presented in Section 3.3 and 3.4 of the RI/RFI report (TtNUS, 1999).

2.3 NATURE AND EXTENT OF CONTAMINATION

In addition to the RI/RFI, several investigations have been conducted at Site 3 and consist of the following:

- In 1986, the Naval Energy and Environmental Support Activity (NEESA) conducted an initial assessment study (IAS) (NEESA, 1986) under the Naval Assessment and Control of Installation Pollutants Program. The IAS is equivalent to the preliminary assessment phase of the CERCLA process.

- Based on the recommendations of the IAS, McClelland Consultants conducted a verification step at Site 3 (McClelland, 1990). The verification step is equivalent to the site inspection phase of the CERCLA process.

- Per the requirements of the MCRD's application for a RCRA permit, an Interim RFA was performed from January 1990 to March 1990 (Kearney, 1990).

- An extended site inspection was conducted in November 1993 to evaluate whether the consumption of fish and shellfish caught in the vicinity of the Causeway Landfill posed a risk to human health (ABB Environmental Services, Inc., 1993).

The results of these investigations are summarized in Section 1.4.3 of the RI/RFI report for Site 3 (TtNUS, 1999). Additionally, the nature and extent of contamination as determined during the RI/RFI is presented in Section 4.0 of the RI/RFI report (TtNUS, 1999).

2.4 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

A baseline human health risk assessment (HHRA) was conducted to characterize and quantify potential health risks at Site 3, in the absence of remedial action. The results of the HHRA are presented in Section 6.0 of the RI/RFI report (TtNUS, 1999).

Additionally, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors. The results of the ERA are presented in Section 7.0 of the RI/RFI report (TtNUS, 1999).

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TABLE 2-1

HAND DRIVEN-SOIL BORING LITHOLOGIES FROM SURFACE SOIL SAMPLE LOCATIONS SITE 3 – CAUSEWAY LANDFILL MCRD PARRIS ISLAND, SOUTH CAROLINA

Boring[1]	Description	Top of Waste (feet below ground surface)	Comments
PAI-03-SS-01	brown fine to medium - grained sand (0.0'-0.5')	0 - 0.5	
PAI-03-SS-02	brown fine to medium - grained sand (0.0'-1.1')	1.1	
PAI-03-SS-03	light brown fine to medium - grained sand (0.0'-2.0')	2.5	
	grayish fine to medium - grained sand (2.0'-2.5')		
PAI-03-SS-04	light brown fine to medium - grained sand (0.0'-1.7')	1.7	
PAI-03-SS-05	light brown fine to medium - grained sand (0.0'-1.9')	1.9	
PAI-03-SS-06	light brown fine to medium - grained sand (0.0'-1.5') grayish-brown fine to medium - grained sand (1.5'-3.5')	3.5	
PAI-03-SS-07	light brown fine to medium - grained sand (0.0'-0.5')	1.6	
	tan fine to medium sand (0.5'-1.6')		
PAI-03-SS-08	light brown fine to medium - grained sand (0.0'-2.6')	2.6	
PAI-03-SS-09	light brown fine to medium - grained sand (0'-1.0')	2.6	
	light brown to orange fine - medium to grained sand (1.0'-2.6')		
PAI-03-SS-10	light brown fine to medium - grained sand (0'-2.7')	2.7	gas smell
PAI-03-SS-11	light brown fine to medium - grained sand-dry/some gravel (0'-0.5')	2.2	
	light yellow fine to medium - grained sand-dry/some gravel (0.5'-1.0')		
	white fine to medium sand-dry/some gravel (0'-3.6')		gas smell
PAI-03-SS-12	light brown fine to medium - grained sand-dry/some gravel	3.6	
PAI-03-SS-13	light brown to tan fine to medium - grained sand (0.0'-0.5')	1.9	
	light brown fine to medium - grained sand (0.5'-1.9')		
PAI-03-SS-14	light brown to brown fine to medium - grained sand (0.0'-1.0') encountered	2.4	
	light gray to fine to medium - grained sand (1.0'-2.4')		(Refusal). Some waste debris observed in last few inches of boring
PAI-03-SS-15	light brown fine to medium - grained sand (0'-2.0')	3.2	
	gray fine to medium - grained sand (2.0'-3.2')		
PAI-03-SS-16	brown fine to medium - grained sand (0'-0.5')	2.6	
	light brown fine to medium - grained sand (0.5'-2.6')		gas smell

1 Borings hand augured to top of waste in May 1998.

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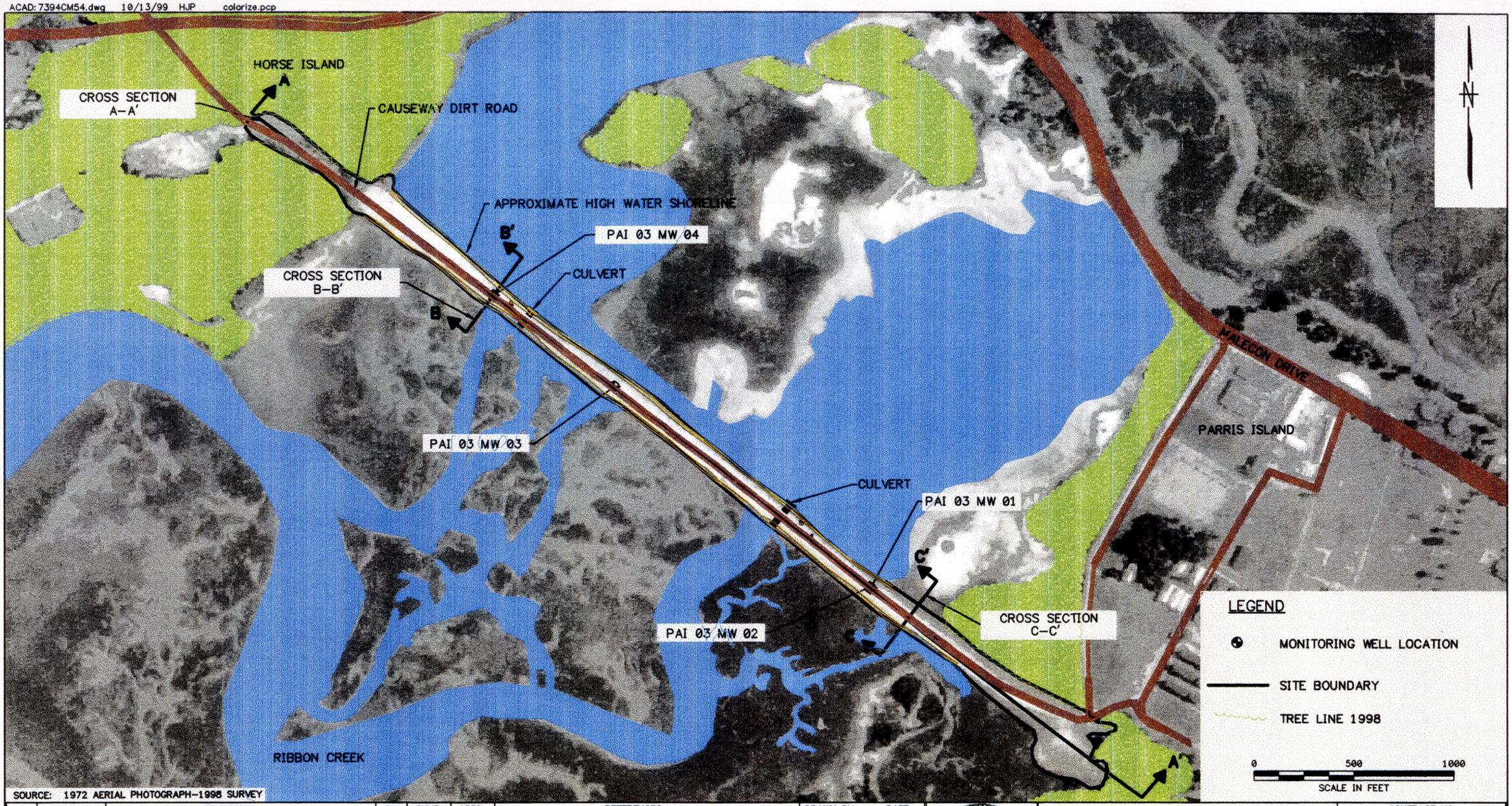

SOURCE: 1972 AERIAL PHOTOGRAPH–1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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EXTENT OF SITE 3 – AERIAL VIEW
SITE 3–CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 2–1
REV. 0

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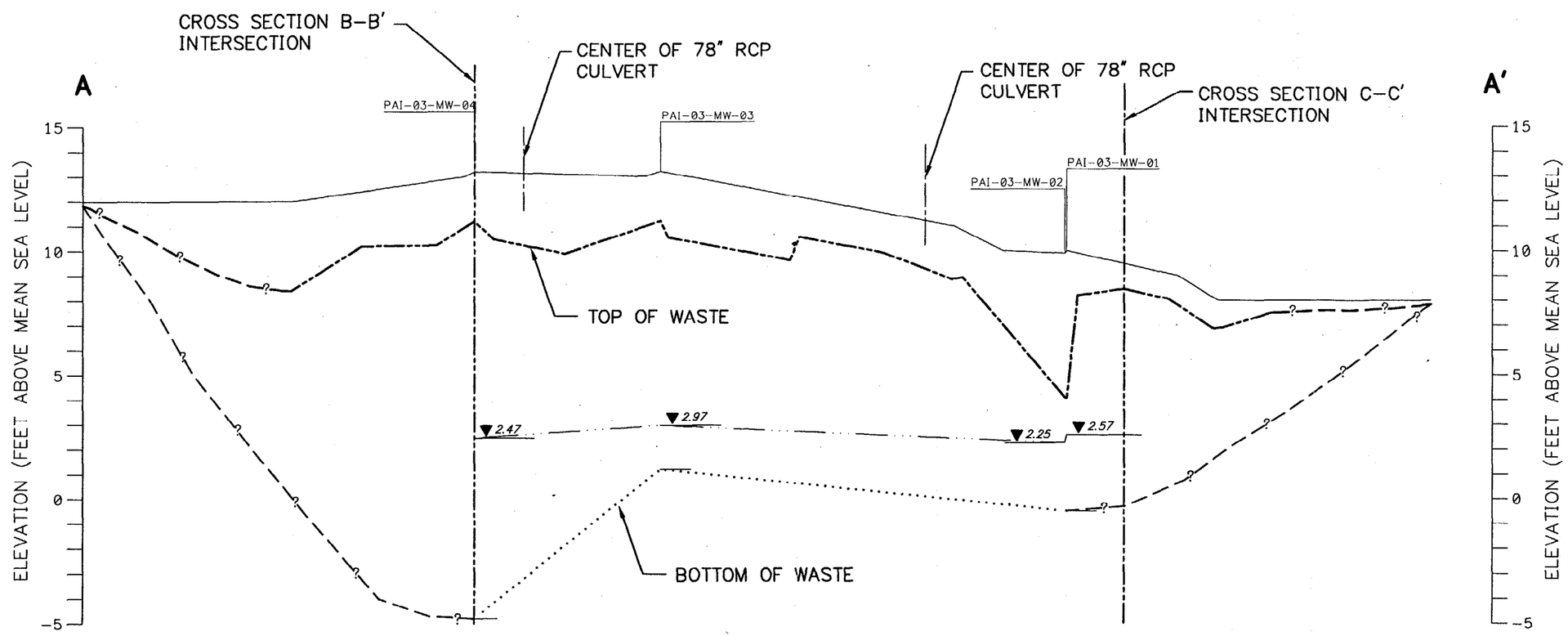

LEGEND:

PAI–03–MW–04 — MONITORING WELL

EXISTING GROUND SURFACE (DASHED WHERE INFERRED)

TOP OF WASTE (DASHED WHERE INFERRED)

2.47 ▼ — GROUNDWATER ELEVATION

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 500 1000
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 5/24/99
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COST/SCHED–AREA
SCALE AS NOTED

CROSS SECTION A–A′ – EXISTING CONDITIONS
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 2–2
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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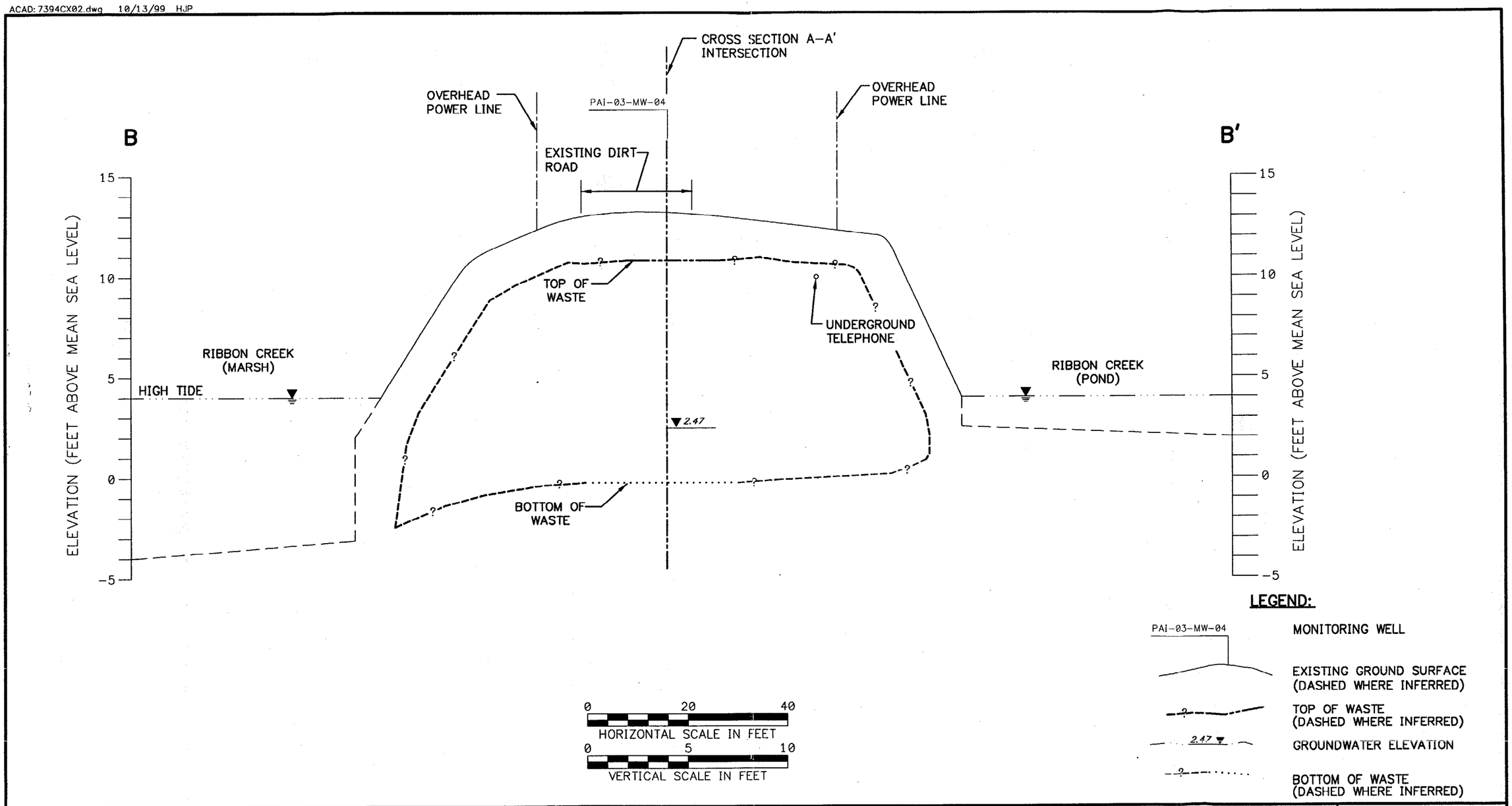

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DRAWN BY DLT DATE 5/12/99
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COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION B–B' – EXISTING CONDITIONS
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
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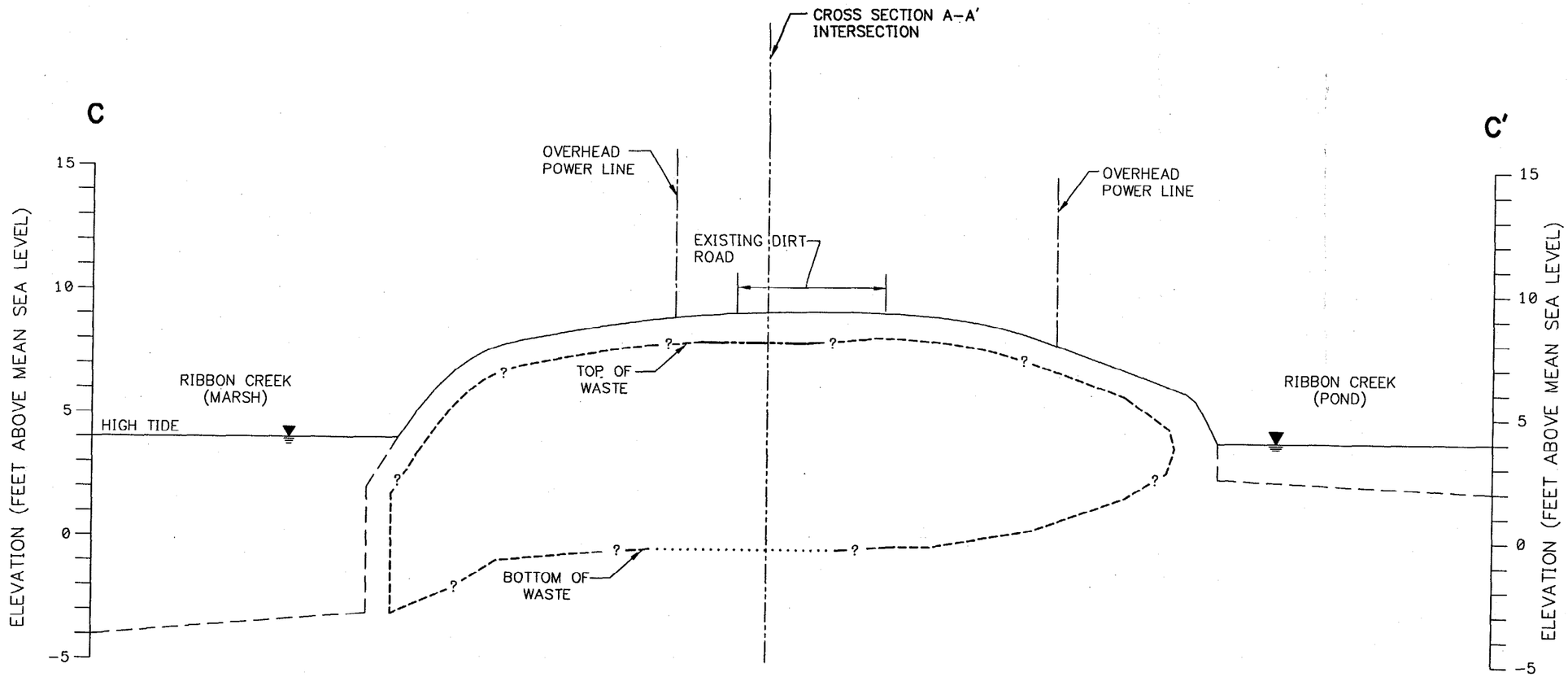
APPROVED BY DATE
DRAWING NO. FIGURE 2–3
REV. 0

FORM CADD NO. SOUTH-BH.DGN – REV 0 – 9/9/98

ACAD: 7394CX03.dwg 10/13/99 HJP



LEGEND:

EXISTING GROUND SURFACE (DASHED WHERE INFERRED)

TOP OF WASTE (DASHED WHERE INFERRED)

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 20 40
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 7/12/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION C-C' - EXISTING CONDITIONS
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 2-4
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

099904/P

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES/CORRECTIVE MEASURES OBJECTIVES

3.1 INTRODUCTION

Remedial action objectives/corrective action objectives (RAOs/CAOs) are developed as medium-specific and chemical-specific objectives that will result in the protection of human health and the environment. Typically, RAOs/CAOs are developed based on promulgated standards [e.g., Ambient Water Quality Criteria (AWQCs)], background concentrations determined from a site-specific investigation, and human health and ecological risk-based concentrations developed in accordance with the U.S. EPA risk assessment guidance.

Section 3.0 outlines the development of RAOs/CAOs for Site 3 at MCRD Parris Island. Section 3.2 presents applicable or relevant and appropriate requirements (ARARs). ARARs include requirements, criteria, or limitations promulgated under the federal and state law that address a chemical, action, or location at a site. Sections 3.3 and 3.4 discuss the media and chemicals of concern (COCs) that will be addressed in this FS/CMS. Based on ARARs and the identified media of concern and COCs, Section 3.5 presents site-specific RAOs/CAOs. A range of chemical-specific values or remedial goal options (RGOs) that would attain these objectives is presented in Section 3.6. Lastly, Section 3.7 presents areas of impacted soil and sediment at Site 3 based on the selected RGOs.

3.2 ARARS/MEDIA CLEAN-UP STANDARDS

ARARs/media clean-up standards (ARARs), which include the requirements, criteria, or limitations promulgated under the federal and state law that address a chemical, location, or action at a site, are presented in this section.

The definition of ARARs is as follows:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-citing law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

One of the primary concerns during the development of RAOs/CAOs is the degree of human health and environmental protection afforded by a given remedy. Consideration should be given to remedies that attain or exceed ARARs.

Definitions of the two types of ARARs, as well as other to be considered (TBC) criteria, are given below:

- Applicable Requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site.

- Relevant and Appropriate Requirements are those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at a site that their use is well suited (appropriate) to the particular site.

- TBC Criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial actions or necessary for determining what is protective of human health and/or the environment. Examples of TBC criteria include U.S. EPA Drinking Water Advisories and Risk-Based Concentrations.

These requirements are presented to provide decision makers with a complete evaluation of potential ARARs in developing, identifying, and selecting a corrective measure alternative.

ARARs fall into three categories, based on the manner in which they are applied:

- Chemical Specific: Health-/risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of chemical-specific ARARs include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) water quality criteria. Chemical-specific ARARs are considered in evaluating the extent of site clean-up.

- Location Specific: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial action/corrective measures or may apply only to certain portions of site. Examples of location-specific ARARs include floodplain and coastal zone management requirements. Location-specific ARARs pertain to special site features.

- Action Specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous waste. Action-specific ARARs pertain to implementing a given remedy.

Tables 3-1 and 3-2 present a summary of federal and state ARARs and TBCs for potential remedial action/corrective measures undertaken for Site 3 at MCRD Parris Island. The following sections present a brief description of each chemical-, location-, or action-specific ARAR and TBC contained in Tables 3-1 and 3-2.

3.2.1 Chemical-Specific ARARs and TBCs

This section presents a summary of federal and state chemical-specific ARARs and TBCs. These criteria provide medium-specific guidance on "acceptable" or "permissible" concentrations of chemicals.

The Safe Drinking Water Act (SDWA) (40 CFR 140-143) promulgated National Primary Drinking Water Standard MCLs (40 CFR 141). MCLs are enforceable standards for chemicals in public drinking water supply systems. They consider not only health factors but also the economic and technical feasibility of removing a chemical from a water supply system. Secondary MCLs (SMCLs) (40 CFR 143) are not enforceable but are intended as guidelines for chemicals that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and may deter public acceptance of drinking water provided by public water systems.

The SDWA also established MCL Goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs are set at levels of no known or anticipated adverse health effects, with an adequate margin of safety. The National Contingency Plan (NCP) [40 CFR 300.430(e)(2)(i)] states that MCLGs that are set at levels above zero shall be attained by remedial actions for groundwater or surface waters that are current or potential sources of drinking water [where the MCLGs are relevant and appropriate under the circumstances of the release based on the factors in Section 300.400(g)(2) of the NCP]. If an MCLG is found not to be relevant and appropriate, the corresponding MCL will be achieved where relevant and appropriate to the circumstances of the release. For MCLGs that are set at zero, the MCL promulgated for that chemical under the SDWA will be attained by the remedial action. In cases involving multiple contaminants or pathways where attainment of chemical-specific ARARs will result in a cumulative cancer risk in excess of 1E-04, criteria in paragraph (e)(2)(i)(A) of Section 300.430 (i.e., risk-based criteria) may be considered when determining the clean-up level to be attained. The NCP explains that clean-up levels set at zero (generally the case for carcinogens) are not appropriate because complete elimination of risk is not possible and because "true zero" cannot be detected.

Because the groundwater at Site 3 is saline to brackish and is not a viable source of drinking water, the SDWA is not applicable.

The CWA sets U.S. EPA AWQCs that are non-enforceable guidelines developed for pollutants in surface waters, pursuant to Section 304(a)(1) of the CWA. Although AWQCs are not legally enforceable, they should be considered as relevant and appropriate requirements. AWQCs are available for the protection of human health from exposure to chemicals in surface water as well as from ingestion of aquatic biota and for the protection of freshwater and saltwater aquatic life. AWQCs may be considered for existing discharges to the marsh and pond and actions that involve groundwater treatment and/or discharge to nearby surface waters.

RCRA Subtitle C regulates the treatment, storage, and disposal of hazardous waste from its generation until its ultimate disposal. In general, RCRA Subtitle C requirements for the treatment, storage, or disposal of hazardous waste will be applicable if

- The waste is a listed or characteristic waste under RCRA.
- The waste was treated, stored, or disposed (as defined in 40 CFR 260.10) after the effective date of the RCRA requirements under consideration.
- The activity at the CERCLA site constitutes current treatment, storage, or disposal as defined by RCRA.

The following chemical-specific requirements included in the RCRA Subtitle C regulations are potentially applicable to MCRD Parris Island.

- Identification and listing of hazardous waste (40 CFR 261)
- Groundwater protection and groundwater monitoring (40 CFR 264.90-264.101)
- Land disposal restrictions (40 CFR 268.1-268.50)

U.S. EPA Health Advisories (U.S. EPA, 1996a) are nonenforceable guidelines (TBCs) developed by the U.S. EPA Office of Drinking Water for chemicals that may be intermittently encountered in public water supply systems. Health advisories are available for short-term, longer-term, and lifetime exposure for a 10-kg child and/or a 70-kg adult. Health advisories may be pertinent for remedial action/corrective measures involving groundwater, especially for chemicals that are not regulated under the SDWA.

U.S. EPA Region III Risk Based Concentrations (RBCs) (U.S. EPA, 1999) are concentrations in soil and groundwater that, if exceeded, may be of potential concern to human receptors. These concentrations

are calculated for a Target Hazard Quotient of 1.0 for noncarcinogenic effects and a Target Risk of 1.0E-6 for carcinogenic effects. RBCs are TBC.

Generic Soil Screening Levels (SSLs) (U.S. EPA, 1996b) are soil levels that, if exceeded through three possible exposure pathways, may be of potential concern to human receptors. SSLs consider the following exposure pathways: direct ingestion of soil, inhalation of volatile compounds and fugitive dust, and migration to groundwater. SSLs are TBC.

Dutch Soil Clean-up Act Ecological Screening Values (ESVs) (Beyer, 1990) and Dutch Ministry of Housing Intervention Values and Target Values - Soil Quality Standards (MHSPE, 1994) are published ESVs for soil. Soil screening levels from the Netherlands were taken from the interim Dutch Soil Clean-up Act (Beyer, 1990). Three categories were identified by the Dutch: (1) category A refers to background concentrations in soil or detection limits, (2) category B refers to moderate soil contamination that requires additional study, and (3) category C refers to threshold values that require immediate clean-up. The newer Dutch values (MHSPE, 1994) include target values and intervention values. Target values represent the "soil quality required for the full restoration of the soil's functionality for human, animal and plant life," or "soil quality ultimately aimed for." The intervention values replace the 1990 C values and represent "the concentration levels of the contaminants in the soil...above which the functionality of the soil for human, plant, and animal life is seriously impaired or threatened." The 1994 intervention values also take into account ecotoxicological considerations. These values are TBC.

Oak Ridge National Laboratory Toxicity Benchmarks for Soil (Efroymson, 1997a and 1997b) are surface soil guidelines indicative of toxicity to soil invertebrates and terrestrial plants. The values were derived using data from field and laboratory studies, bibliographic databases, and published literature. These values are TBC.

Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997) is a listing of ESVs for surface soil. The derivation process for the guidelines considers adverse effects from direct soil contact and from the ingestion of soil and food. Four approaches were used to evaluate contact with soil: (1) weight of evidence, (2) lowest observed effect concentration method, (3) median effects method, and (4) comparison with nutrient and energy cycling. These values are TBC.

The memorandum entitled Ecological Risk Assessment at Military Bases (U.S. EPA Region 4, 1998) contains a listing of ecological screening values (ESVs) for surface soils, sediments, and surface water. The ESVs consist largely of the TBC sources cited this section (Section 3.2.1). Many of the surface water screening values are federal AWQCs and thus, are relevant and appropriate.

Effect Range-Low (ER-L) and Effects Range-Median (ER-M) Level (Long et al., 1995). ER-L and ER-M values are based on data from many studies where sediment concentrations were coupled with apparent biological effects (Long et al., 1995). With all data combined, the ER-L is the 10th percentile of sediment concentrations associated with effects to benthic organisms. The 50th percentile of the effects data is the ER-M. Concentrations below the ER-L represent a minimal effects range within which biological effects would rarely be observed. Concentrations between the ER-L and ER-M represent a possible effects range within which effects would occasionally occur. Concentrations above the ER-M represent a probable-effects range within which effects would frequently occur. These values are TBC.

Probable Effects Levels (PELs) and Threshold Effects Levels (TELs) (FDEP, 1994) are similar to ER-L and ER-M values; however, the TELs and PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The TEL is the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no effects data set. Sediment contaminant concentrations below the TEL (i.e., the minimal effects range) are not considered to represent significant hazards to aquatic organisms (FDEP, 1994). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of chemical concentrations that are usually or always associated with adverse biological effects. Contaminant concentrations between the TEL and the PEL constitute the possible effects range (i.e., adverse biological effects are possible). These values are TBC.

South Carolina State Primary Drinking Water Regulations (R.61-58) are promulgated pursuant to S.C. Code Sections 44-55-10 et seq. and are collectively known as the State Primary Drinking Water Regulations. Standards within these regulations are for maintaining the purity of the drinking water of the State. Regulation 61-58.5 establishes MCLs in groundwater for inorganic, organic, and volatile synthetic organic chemicals. Additionally, Regulation 61-58.5 establishes SMCLs and lead and copper action levels. These criteria are applicable to public water systems, defined as any public or privately owned waterworks system that provides drinking water, whether bottled or piped, for human consumption, including the source of supply whether the source of supply is of surface or subsurface origin; all structures and appurtenances used for the collection, treatment, storage or distribution of drinking water delivered to consumers; any part or portion of the system and including any water treatment facility that in any way alters the physical, chemical, radiological, or bacteriological characteristics of drinking water, provided that public water system shall not include a drinking water system serving a single private residence or dwelling.

Because the groundwater at Site 3 is saline/brackish and is not suitable as a drinking water source and Site 3 is not upgradient of a potential drinking water source, these MCLs, SMCLs, and lead and copper action levels are not applicable.

Hazardous Waste Management Regulations (R.61-79) promulgated pursuant to authority in the S.C. Hazardous Waste Management Act (§44-56-30) regulate the management of hazardous waste. Similar to RCRA, the following chemical-specific requirements included in the Hazardous Waste Management Regulations are potentially applicable to MCRD Parris Island.

- Identification and listing of hazardous waste (R.61-79.261)
- Groundwater protection and groundwater monitoring (R.61-79.264)
- Land disposal restrictions (R.61-79.268)

3.2.2 Location-Specific ARARs and TBCs

This section presents a summary of federal and state location-specific ARARs and TBCs. These potential ARARs and TBCs are as follows.

U.S. EPA's Groundwater Protection Strategy (U.S. EPA, 1984) policy is to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater:

- Class I - Special Groundwater: Waters that are highly vulnerable to contamination and are either irreplaceable or ecologically vital sources of drinking water.

- Class II - Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses: Waters that are currently used or that are potentially available.

- Class III - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use. Class III groundwater units are further subdivided into two subclasses.

  - Subclass IIIA includes groundwater units that are highly to intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as Class II groundwater, depending upon the potential for producing adverse effects on the quality of adjacent waters.

  - Subclass IIIB is restricted to groundwater characterized by a low degree of interconnection to adjacent surface waters or other groundwater units of a higher class within the Classification Review Area. These groundwaters are naturally isolated from sources of drinking waters in such a way that there is little potential for producing adverse effects on quality. They have low resource values outside of mining or waste disposal.

At Site 3, groundwater is likely considered Class IIIA.

CWA Section 404 River and Harbors Act, Section 10 (40 CFR 230, 33 CFR 320-330) prohibits the unauthorized obstruction or alteration of any navigable waters of the United States. Examples of activities requiring an Army Corps of Engineers permit (33 CFR 322) include constructing a structure in or over any waters of the United States, excavation or deposit of material in such waters, and various types of work performed in such waters, including fill and stream channelization.

Federal Floodplain Management Executive Order (E.O. 11988) requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with occupancy and modification of flood plains. Site 3 is located within the 100-year floodplain and is therefore a potentially applicable ARAR.

Federal Protection of Wetlands Executive Order (E.O. 11990) is an applicable ARAR that requires federal agencies, in carrying out their responsibilities, to take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

The Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.) provides for consideration of the impacts on endangered and threatened species and their critical habitats. Remedial action/corrective measures, if required, would need to be conducted in a manner such that the continued existence of any endangered or threatened species is not jeopardized or its critical habitat is not adversely affected. Consultation with the United States Fish and Wildlife Service (USFWS) is also required.

The Fish and Wildlife Coordination Act (16 U.S.C. 661, et seq.) (40 CFR 122.49) provides for consideration of the impacts on wetlands and protected habitats. The act requires that federal agencies, before issuing a permit or undertaking federal action for the modification of any body of water, consult with the appropriate state agency exercising jurisdiction over wildlife resources to conserve those resources. Consultation with the USFWS is also required.

The Coastal Zone Management Act of 1972 (16 U.S.C. 1451, et seq.) provides for the preservation and protection of coastal zone areas, management of coastal zones to be the state's responsibility, and the management of coastal zone development to be in such a way as to minimize the effects on coastal zone resources. Section 304(1) excludes federal lands from the coastal area if those lands are subject solely to the discretion of or are held in trust by the federal government. However, under Section 307 (c), paragraphs (1) and (2), federal activities and development projects in or directly affecting the coastal zone must be consistent to the maximum extent practicable with a federally approved state management program.

Historic Sites, Buildings, and Antiquities Act of 1935 (16 U.S.C. 461 et seq.) states that it is federal policy to preserve historic and prehistoric properties of national significance. Site 3 is not classified as such a property nor is it known to possess aspects of historic or prehistoric significance; however, this Act would be applicable if information were found to classify it as such a property. As such, this Act is potentially applicable.

Archaeological and Historic Preservation Act of 1974 (16 U.S.C. 469 et seq.) contains provisions for the protection of historic and archaeological data affected by any federal construction project or federally licensed project, activity, or program. Although no such data are known to exist within the boundaries of Site 3, this Act would be applicable if such data were to be found.

Archeological Resources Protection Act of 1979 [16 U.S.C. 479(aa) et seq.] requires federal land managers to issue permits for the excavation or removal of archeological artifacts from lands under their jurisdiction. The Act requires that relevant Native American tribes be notified of permit issuance if significant religious or cultural sites will be affected. Artifacts have not previously been discovered within the boundaries of Site 3; however, if such artifacts were to be found during remedial activities, this Act would be applicable.

Native American Grave Protection and Repatriation Act of 1990 (25 U.S.C. 3001 et seq.) is an applicable requirement and requires, upon discovery of human remains during a federal undertaking, cessation of activity for a minimum of 30 days and consultation with Native American groups.

Bald Eagle Protection Act of 1940, as amended (16 U.S.C. 688 et seq.), is an applicable requirement and contains provisions for prohibiting the disturbance of bald eagles. Because a bald eagle is known to nest within the vicinity of Site 3, remedial activities would need to be conducted to minimize the disturbance to this species.

Conservation Programs on Military Reservations (Sikes Act) of 1960, as amended (16 U.S.C. 670(a) et seq.), is an applicable requirement and requires that military installations manage natural resources for multipurpose uses and public access appropriate for those uses consistent with the military department's mission.

Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361 et seq.), mandates a moratorium on the killing, capturing, harming, importing, and disturbing of marine mammals and marine mammal products. Marine mammals are not known to inhabit the pond or Ribbon Creek; as such, this Act is not applicable.

Water Classifications and Standards (R.61-68) promulgated pursuant to authority in the South Carolina Pollution Control Act (Section 48-1-10 et seq.) establish a system and rules for managing and protecting the quality of South Carolina's surface and groundwater. The regulations establish the state's official classified water uses for all State waters, establish general rules and specific numeric water quality standards for protecting classified and existing water uses, and establish procedures for classifying waters of the state. Classified Water (R.61-69) contains classifications of water bodies in South Carolina.

Runoff from Site 3 flows to Ribbon Creek and the pond northeast of the causeway. Both bodies of water are tributaries of the Broad River. Per R.61-69, Ribbon Creek and the pond are classified as shellfish harvesting waters; therefore, the quality standards listed in R.61-68 for shellfish harvesting waters are applicable. These quality standards include meeting the AWQCs for toxic pollutants listed in §307 of the federal CWA and for which the U.S. EPA has developed national criteria.

Under R.61-68, an underground source of drinking water, is defined as a water with fewer than 10,000 mg/L total dissolved solids (TDS). During the RI/RFI, Site 3 groundwater had an average TDS of 10,050 mg/L. Therefore, Site 3 groundwater is not an underground source of drinking water.

South Carolina Coastal Zone Management Act (§44-39-10) was promulgated to encourage development of coastal resources within the framework of a coastal planning program. The program is designed to protect the sensitive and fragile areas from inappropriate development and provide adequate environmental safeguards with respect to the construction of facilities in the critical areas of the coastal zone. This statute is applicable in that remedial action/corrective measures would need to be implemented to protect nearby coastal areas.

Groundwater Mixing Zone Application Guidance (SCDHEC, 1997b) provides guidance on preparing groundwater mixing zone applications and to furnish technical recommendations on meeting the conditions for a groundwater mixing zone established under R.61-68. A mixing zone is a hydrogeologically controlled three-dimensional flow path in the subsurface, which constitutes the pathway for waste constituents to migrate from a source. Non-attainment of MCLs within the mixing zone is permitted upon acceptance of the mixing zone application to SCDHEC.

3.2.3 Action-Specific ARARs and TBCs

This section presents a summary of federal and state action-specific ARARs and TBCs. These potential ARARs and TBCs are as follows.

RCRA Subtitle C regulates the treatment, storage, and disposal of hazardous waste from its generation until its ultimate disposal. In general, RCRA Subtitle C requirements for the treatment, storage, or disposal of hazardous waste will be applicable if

- The waste is a listed or characteristic waste under RCRA.
- The waste was treated, stored, or disposed (as defined in 40 CFR 260.10) after the effective date of the RCRA requirements under consideration.
- The activity at the CERCLA site constitutes current treatment, storage, or disposal as defined by RCRA.

RCRA Subtitle C requirements may be applicable when the waste is sufficiently similar to a hazardous waste and/or the on-site remedial action constitutes treatment, storage, or disposal and the particular RCRA requirement is well suited to the circumstances of the contaminant release and site. RCRA Subtitle C requirements may also be applicable when the remedial action constitutes generation of a hazardous waste. On-site activities, mandated by a federally ordered Superfund clean-up, must comply with the substantive requirements of RCRA Subtitle C but not with the administrative requirements (i.e., permits) of RCRA. All RCRA Subtitle C requirements must be met if the clean-up is not under federal order and/or when the hazardous waste moves off site.

The following requirements included in the RCRA Subtitle C regulations may pertain to the MCRD Parris Island.

- Hazardous waste generator requirements (40 CFR 262) – Regulations with which a generator that treats, stores, or disposes of hazardous waste on site must comply. Applicable if hazardous waste is generated during remedial action.
- Transportation requirements (40 CFR 263) – Regulations for the manifest and recordkeeping systems and for the immediate action and clean-up of hazardous waste discharges (spills) during transportation. Applicable if hazardous waste is shipped off site.
- Standards for owners and operators of hazardous waste treatment, storage, and disposal (TSD) facilities (40 CFR 264). Regulations that govern the treatment, storage, and disposal of hazardous waste. Applicable if hazardous waste is sent to a TSD.

- Interim status standards for owners and operators of hazardous waste TSD facilities (40 CFR 265) – Includes regulations for final cover requirements for final closure of interim status landfills. Under these regulations, the owner or operator must cover the landfill with a final cover designed and constructed to provide long-term minimization of migration of liquids through the closed landfill, function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, accommodate settling and subsidence so that the cover's integrity is maintained, and have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. Because the type of waste disposed in the causeway was primarily nonhazardous in nature, these requirements are not applicable; however, certain aspects are relevant and appropriate.

- Land Disposal Restrictions (40 CFR 268) - applicable if hazardous waste is shipped off site.

Based on data obtained during the RI/RFI and other investigations, surface soil, sediment, surface water, and groundwater at Site 3 are not expected to be characteristic or a listed RCRA-hazardous waste.

The Hazardous and Solid Waste Amendments (HWSA) are the 1984 amendments to RCRA that require phasing out land disposal of hazardous waste. Additionally, the HSWA establishes a corrective actions program requiring four basic elements (assessment, investigation, CMS, implementation) and establishes a regulatory program for underground storage tanks (USTs).

RCRA Subtitle D establishes design and operating criteria for solid waste (nonhazardous) landfills. In general, RCRA Subtitle D establishes minimum design and operating criteria for all solid waste landfills that

- Receive municipal solid waste as defined in 40 CFR 258
- Codispose sewage sludge with municipal solid waste
- Receive nonhazardous municipal solid waste combustion ash
- Are not regulated under Subtitle C of RCRA

The closure and post-closure care requirements under RCRA Subtitle D are intended to minimize the infiltration of water into the landfill and maintain the integrity of the cover during the post-closure period by minimizing cover erosion. They include closure and post-closure plans (post-closure plans must include a description of monitoring and maintenance activities as well as a description of any uses of the property during the post-closure period) and minimum requirements for a final landfill cover. The landfill cover is designed to minimize infiltration and erosion and

- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present or a permeability no greater than 1×10^{-5} cm/sec, whichever is less.

- Minimize infiltration through the closed Municipal Solid Waste Landfill (MSWLF) by the use of an infiltration layer that contains a minimum 18 inches of earthen material.

- Minimize erosion of the final cover by the use of an erosion layer that contains a minimum 6 inches of earthen material that is capable of sustaining native plant growth.

These criteria do not apply to municipal solid waste landfill units that do not receive waste after October 9, 1991 and are therefore not are not applicable; however, certain aspects are relevant and appropriate.

The Clean Water Act (CWA), as amended, governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), discharge or dredge or fill material, and oil and hazardous waste spills to United States waters. NPDES requirements (40 CFR 122) will be applicable if the direct discharge of pollutants into surface waters is part of the remedial action.

Toxic Substances Control Act (TSCA) (40 CFR 761.60-761.79 Subpart D Storage and Disposal) specifies treatment, storage, and disposal requirements for PCBs based on PCB concentration of the original material. Specifically, remediation for non-liquids (soil, rags, debris) exceeding 50 ppm is addressed in 40 CFR 761.6. TSCA is not considered an ARAR because PCBs were not detected in site media at a concentration greater than 50 ppm.

National Ambient Air Quality Standards (NAAQS) (40 CFR 50) promulgated under the Clean Air Act (CAA) (42 U.S.C. 7401) require the attainment and maintenance of primary and secondary NAAQS to protect public health and public welfare, respectively. These standards are not source specific but rather are national limitations on ambient air quality. States are responsible for assuring compliance with the NAAQS. The implementation, maintenance, and enforcement of NAAQS are potentially applicable ARARs.

Also promulgated under the CAA are New Source Performance Standards (NSPS) (40 CFR 60) and National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61). NSPS are established for new sources of air emissions to ensure that the new stationary sources minimize emissions. These standards are for categories of stationary sources that cause or contribute to air pollution that may endanger public health or welfare. NSPS regulations are not considered an ARAR at MCRD Parris Island. NESHAPs, which are emission standards for source types (i.e., industrial categories) that emit hazardous air pollutants, are considered potentially applicable for MCRD Parris Island.

Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171-179) regulate the transport of hazardous materials, including packaging, shipping equipment, and placarding. These rules are considered potentially applicable to wastes shipped off site for laboratory analysis, treatment, or disposal.

The OSHA Standards (29 CFR 1910) regulate occupational safety and health requirements applicable to workers engaged in on-site field activities.

National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.) requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement. Specifically, NEPA requires federal agencies to consider five issues during the planning of major action: (1) the environmental impact of the proposed action; (2) any adverse impacts that cannot be avoided with the proposed implementation; (3) alternatives to the proposed action; (4) the relationship between short-term and long-term effects; and (5) any irreversible and irretrievable commitments of resources that would be involved in a proposed action. Remedial action/corrective measures could constitute significant activities, thereby making NEPA requirements ARARs; however, activities conducted in accordance with the NCP are considered to meet the substantive NEPA requirements.

Soil Conservation Act (U.S.C. 5901 et seq.) provides for the application of soil conservation practices on federal lands. During remedial activities, implementation of such practices would be required.

Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable. Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (U.S. EPA, 1996c) provides guidance on applying the containment presumptive remedy to military landfills.

Well Standards (R. 61-71) set forth requirements for protecting underground sources of drinking water from contamination and include provisions for the classification and regulation of wells and establishment of standards for location, construction, materials, reporting, operation, maintenance, and abandonment. These regulations are applicable for any remedial action/corrective measure that involves the installation or abandonment of monitoring wells at Site 3.

Hazardous Waste Management Regulations (R.61-79) promulgated pursuant to authority in the S.C. Hazardous Waste Management Act (§44-56-30) regulate the management of hazardous waste. Similar to RCRA requirements, Hazardous Waste Management Regulations may be applicable when the waste is sufficiently similar to a hazardous waste and/or the on-site remedial action constitutes treatment, storage, or disposal and the particular requirement is well suited to the circumstances of the contaminant release

and site. Hazardous Waste Management Regulations may also be applicable when the remedial action constitutes generation of a hazardous waste.

The following requirements included in the Hazardous Waste Management Regulations are potentially applicable at Site 3.

- Hazardous waste generator requirements (R.61-79.262)
- Transportation requirements (R.61-79.263)
- Standards for owners and operators of hazardous waste treatment, storage, and disposal (TSD) facilities (R.61-79.264).
- Interim status standards for owners and operators of hazardous waste TSD facilities (R.61-79.265)
- Land Disposal Restrictions (R.61-79.268) - applicable if hazardous waste is shipped off site. A summary of Land Disposal Restrictions is available from SCDHEC (SCDHEC, 1993).

Based on data obtained during the RI/RFI and other investigations, surface soil, sediment, surface water, and groundwater at Site 3 are not expected to be characteristic nor a listed RCRA-hazardous waste.

The interim status standards for owners and operators of hazardous waste TSD facilities (R.61-79.265) also include regulations for final cover requirements for final closure of interim status landfills. Under these regulations, the owner or operator must cover the landfill with a final cover designed and constructed to provide long-term minimization of migration of liquids through the closed landfill, function with minimum maintenance, promote drainage and minimize erosion or abrasion of the cover, accommodate settling and subsidence so that the cover's integrity is maintained, and have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. Because the type of waste disposed in the causeway was primarily nonhazardous in nature, these requirements are not applicable; however, certain aspects are relevant and appropriate.

Air Pollution Control Regulations and Standards (R.61-62) are promulgated pursuant to the Pollution Control Act S.C. Code Sections 48-1-10 et seq. Standards within these regulations are for maintaining the purity of the air resources of the State. Regulation 62-5 establishes Air Pollution Control Standards and include Ambient Air Quality Standards and Standards for VOCs and Toxic Air Pollutants. These regulations would be applicable for remedial action/correctives measures that would result in emissions to the atmosphere.

Solid Waste Management: Collection, Temporary Storage, and Transportation of Municipal Solid Waste (R.61-107.5) establishes minimum standards for the collection, temporary storage, and transportation of solid waste prior to processing, disposal, etc. of that waste. This regulation applies to any person who collects, temporarily stores, and/or transports municipal solid waste. This regulation is applicable to the management of any solid waste generated during remedial action/corrective measures at Site 3.

Solid Waste Management: Construction, Demolition, and Land-Clearing Debris Landfills (R.61-107.11) establishes minimum standards for the site selection, design, operation, and closure of construction, demolition, and land-clearing debris landfills. Although construction, demolition, and land-clearing debris was disposed at Site 3, other types of waste were also co-mingled with such debris and other South Carolina landfill regulations would supercede. Therefore, this regulation is not applicable; however, certain aspects are relevant and appropriate.

Solid Waste Management: Municipal Solid Waste Landfills (R.61-107.258) establishes minimum criteria under the South Carolina Solid Waste Policy and Management Act of 1991, as amended, and all applicable federal regulations, for all MSWLF units, as well as for MSWLFs that are used to dispose of sewage sludge. These regulations apply to owners and operators of new MSWLF units, existing MSWLF units, and lateral expansions. The effective date of this regulation is October 9, 1993.

These regulations include a description of a final cover system for the landfill that is designed to minimize infiltration and erosion. The final cover system is to be designed and constructed to

- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present or a permeability no greater than 1×10^{-5} cm/sec, whichever is less.

- Minimize infiltration through the closed MSWLF by the use of an infiltration layer that contains a minimum 18 inches of earthen material.

- Minimize erosion of the final cover by the use of an erosion layer that contains a minimum 1 foot of earthen material that is capable of sustaining native plant growth.

Because disposal activities ceased in 1972, this regulation is not applicable; however, certain aspects are relevant and appropriate.

Sanitary Landfill Design, Construction, and Operation (R.61-70) sets forth regulations for the disposal of refuse (solid waste) on land without creating pollution, nuisances, environmental threats, or hazards to

public health and safety. The regulation states that, beginning July 1, 1972, no system for land disposal of refuse (solid waste) shall be operated in South Carolina without a written permit issued by the State Board of Health. Per this regulation, "a final cover shall be applied to any surface that represents the final grade of the sanitary landfill. A minimum of two feet of a well-graded soil cover, compacted and graded, will usually fulfill the requirements of final cover." Because disposal activities ceased in 1972, this regulation is not applicable; however, certain aspects are relevant and appropriate.

Standards For Stormwater Management And Sediment Reduction (R.72-300 and R.72-405) requires that all land disturbing activities under the jurisdiction of SCDHEC must be performed in a manner that erosion is controlled and sediment is retained on the site to the maximum extent feasible and stormwater is managed in a manner such that neither any significant on-site or off-site damage and/or problem is caused or increased. Approval of a stormwater management and sediment control plan is necessary prior to engaging in any land disturbing activity related to residential, commercial, industrial, or institutional land use. This regulation is applicable if remedial action/corrective measures involve land-disturbance activities.

General Objectives and Components of Contamination Assessments and Remedial Actions (SCDHEC, 1994) is a TBC that provides guidance for conducting contamination assessments and remedial action activities.

Soil/Groundwater Remediation Guidance Document (SCDHEC, 1992) is a TBC that provides guidance for conducting groundwater and soil remediation.

Stormwater Management and Sediment Control Handbook for Land Disturbance Activities (SCDHEC, 1997a) is a compilation of existing South Carolina stormwater management regulations and supporting information for land disturbance permitting.

3.3 MEDIA OF CONCERN

In accordance with the U.S. EPA's *Presumptive Remedy* for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) and Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills (Interim Guidance) (U.S. EPA, 1996), the Site 3 RI/RFI characterized media where potential for off-site migration of contamination was suspected. Media that were investigated during the RI/RFI consist of surface water and sediment downgradient of the path of surface water runoff from Site 3, surface soil throughout the causeway, and groundwater within the surficial aquifer. The following sections contain a discussion of which of these media will be retained in this FS/CMS.

3.3.1 Surface Soil and Sediment

Based on the results of the Site 3 RI/RFI nature and extent of contamination, human health risk assessment (HHRA), and ecological risk assessment (ERA), surface soil and sediment is retained as media of concern. Please refer to the RI/RFI for further information regarding soil and sediment.

3.3.2 Surface Water

Based on a comparison of surface water analytical results to ARARs, TBCs, and site-specific RGOs, surface water is retained as a medium of concern in this FS/CMS; however, surface water will be addressed through the management of surface soil. A comparison of surface water preliminary COCs to ARARs, TBCs, and site-specific RGOs is presented in Appendix A. Site-specific RGOs are derived in Appendix B.

In the comparison of surface water data to surface water criteria for the protection of human health, exceedances of carcinogenic PAHs and arsenic were observed. Several PAHs exceeded AWQCs and benzo(a)pyrene exceeded a site-specific RGO for dermal contact based on an incremental lifetime cancer risk (ILCR) of 1.0E-06. However, PAHs were detected in surface water at only two of out 20 locations (PAI-03-SW-14 and PAI-03-SW-17). These surface water locations are near surface soil samples where PAHs were detected above RI/RFI surface soil screening criteria. At one location (PAI-03-SW-27), arsenic was detected above surface water RGOs. This detection is located in the vicinity of an arsenic detection of 11.8 mg/kg at PAI-03-SS-03. Carcinogenic PAHs and arsenic were not observed in sediment above RI/RFI sediment screening criteria near PAI-03-SW-14 and PAI-03-SW-17.

In the comparison of filtered surface water results to surface water criteria for the protection of ecological receptors, AWQCs for aluminum were exceeded and site-specific RGOs based on a no observable adverse effects level (NOAEL) Hazard Quotient (HQ) of 1 for aluminum and iron were exceeded. However, aluminum was detected in only two out of 20 filtered surface water samples at concentrations of 323 µg/L (PAI-03-SW-27-F) and 650 µg/L (PAI-03-SW-25-F). Similarly, iron was detected in only two of 20 filtered surface water samples at concentrations of 175 µg/L (PAI-03-SW-27-F) and 549 µg/L (PAI-03-SW-25-F). Additionally, aluminum and iron are commonly found elements in the earth's surface. As a result, the slightly elevated aluminum and iron concentrations may not be site related.

In summary, COCs in surface water consist of PAHs and arsenic. PAHs are present in surface water at two locations and arsenic at one location above ARARs, TBCs, and site-specific RGOs; however, these surface water exceedances are located near elevated surface soil concentrations of PAHs and arsenic. Therefore, it is anticipated that remedial action/corrective measures for the surface soil would reduce potential migration of these COCs to surface water. For example, capping of soil would contain the

source of the surface water contamination, which would result in a decrease in concentration of the contaminants in the surface water. Consequently, surface water will addressed through the management of surface soil.

3.3.3 Groundwater

Groundwater chemicals of potential concern (COPCs) for human health from the Site 3 RI/RFI were compared to federal and state chemical-specific criteria for the protection of human health. This comparison is presented in Appendix A. Groundwater is not currently used as a potable water supply at the site nor is it expected to be used in the future as a potable water supply. This scenario is based on configuration of the site, the high TDS of the groundwater, and the current and future use of the site as a landfill, and the relative absence of toxic constituents. The site is approximately 5,000 feet long and 100 feet wide, with a 20 foot wide road running down the middle. In addition, above ground and underground utilities are located on the sides of the road. As a result, these features would effectively preclude the installation of potable water supply wells. Secondly, the TDS of the groundwater averages greater than 10,000 mg/l. The high TDS results from a salt water pond on one side, a salt water marsh on the other side, and a limited precipitation infiltration area. Attempts to pump water from this area would be more likely to draw from the abundant supply of salt water from either side of the causeway than from accumulated precipitation infiltration. Thirdly, the causeway is a landfill. Under future scenarios considered for the causeway, restrictions would be placed to prevent the installation of wells for this purpose. Finally, with the exception of minor exceedances of benzene, chlorobenzene, and thallium in one well each, federal and state MCLs are not exceeded in the site groundwater. In addition, there are no off-site residents located downgradient in the immediate vicinity of the site who might use groundwater as a potable water supply. As a result, groundwater will not be retained as a medium of concern for human health reasons.

In addition, groundwater COPCs for ecological receptors from the Site 3 RI/RFI were compared against U.S. EPA Region IV saltwater surface water ecological screening values (ESVs). None of the organic or inorganic COPCs in Site 3 groundwater, with the exception of chlorobenzene exceeded Region IV ESVs, and chlorobenzene's exceedance was slight (a detection of 130 ug/L compared to an ESV of 105 ug/L). Furthermore, chlorobenzene was not detected in surface water at Site 3. This can be attributed to attenuation that occurs at groundwater's discharge to surface water. As a result, groundwater will not be retained as a medium of concern for ecological concerns.

3.4 CHEMICALS OF CONCERN

The following sections present the COCs that are used to identify impacted surface soil and sediment at Site 3. First, preliminary surface soil and sediment COCs are selected from the RI/RFI. This selection is

presented in Section 3.4.1. Next, site-specific RGOs are derived for the preliminary COCs. This derivation is outlined in Section 3.4.2. Lastly, surface soil and sediment COCs are selected through comparison of preliminary COCs against available ARARs, TBCs, and site-specific RGOs. This selection is summarized in Section 3.4.3.

3.4.1 Preliminary COCs

Human health and ecological preliminary COCs were selected for both surface soil and sediment and are discussed as follows.

Surface Soil

Preliminary soil COCs for protection of human health are selected from chemicals from the Site 3 RI/RFI HHRA that exceeded an ILCR of 1.0E-06 or an HQ of 1 for exposure to surface soil by the existing maintenance worker and future construction worker. Several chemicals exceeded the ILCR of 1.0E-06; however, no chemicals exceed an HQ of 1. The chemicals retained are as follows.

Organics

Carcinogenic PAHs

- benzo(a)pyrene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- indeno(1,2,3-cd)pyrene

Inorganics

- arsenic

Preliminary soil COCs for protection of ecological receptors (macroinvertebrates) are selected from chemicals of potential concern from the Site 3 RI/RFI Ecological Risk Assessment for which an ecological screening criterion exists. Preliminary soil COCs for protection of ecological receptors (site-specific food-chain receptors) are selected from chemicals from the Site 3 RI/RFI Ecological Risk Assessment food-chain modeling that exceeded an ecological protection value based on a NOAEL HQ of 1. The following chemicals were selected as preliminary ecological COCs for soil.

Organics

- chloroform
- benzo(a)anthracene
- benzo(g,h,i)perylene
- fluoranthene
- pyrene
- acenaphthylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- indeno(1,2,3-cd)pyrene
- 4,4'-DDE

anthracene
benzo(b)fluoranthene
chrysene
phenanthrene
4,4'-DDT

- Aroclor-1254
- Aroclor-1260

Inorganics

- aluminum
- arsenic
- iron
- lead
- mercury
- vanadium
- zinc

Sediment

Preliminary sediment COCs for protection of human health are selected from chemicals from the Site 3 RI/RFI HHRA that exceed an ILCR of 1.0E-06 or a HQ of 1 for

- Exposure to sediment by the existing maintenance worker and future construction worker
- Ingestion of fish (conservative ingestion assumptions) by the adult recreational user

The following chemicals were retained as preliminary human health COCs for sediment.

Organics

- Carcinogenic PAHs
  - benzo(a)pyrene
  - benzo(a)anthracene
  - benzo(b)fluoranthene
  - benzo(k)fluoranthene
  - chrysene
  - dibenzo(a,h)anthracene
  - indeno(1,2,3-cd)pyrene
- carbazole
- Aroclor-1254
- Aroclor-1260
- alpha-chlordane
- dieldrin
- 4,4'-DDD
- 4,4'-DDE
- 4,4'-DDT
- gamma-chlordane

Inorganics

- arsenic

Preliminary sediment COCs for protection of ecological receptors (macroinvertebrates) are selected from chemicals of potential concern from the Site 3 RI/RFI Ecological Risk Assessment for which an ecological screening criterion exists. Preliminary sediment COCs for protection of ecological receptors (site-specific food-chain receptors) are selected from chemicals from the Site 3 RI/RFI Ecological Risk Assessment food-chain modeling that exceeded an ecological protection value based on a NOAEL HQ of 1. The following chemicals were retained as preliminary ecological COCs for sediment

Organics

- anthracene
- 4,4'-DDT
- phenanthrene
- fluoranthene
- benzo(b)fluoranthene
- gamma-chlordane
- 4,4'-DDD
- pyrene

- indeno(1,2,3-cd)pyrene
- alpha-chlordane
- benzo(a)anthracene
- chrysene
- Aroclor-1254
- benzo(a)pyrene
- 4,4'-DDE
- Aroclor-1260

Inorganics

- aluminum
- cobalt
- lead
- thallium
- arsenic
- copper
- mercury
- vanadium
- barium
- iron
- selenium
- zinc

3.4.2 Derivation of Site-Specific Remedial Goal Options

Site-specific RGOs were developed to support in COC selection and to aid in assessing impacted soil and sediment at Site 3. A summary of these site-specific RGOs is discussed as follows.

Surface Soil

The following site-specific RGOs were calculated for surface soil. Derivations of these RGOs are located in Appendix B.

- Site-specific human health RGOs based on exposure to surface soil. RGOs were calculated for the protection of the existing maintenance worker and future construction worker. The RGOs are surface soil concentrations that correspond to an ILCR of 1.0E-04, 1.0E-05, and 1.0E-06 for these receptors. Compliance with these values would also achieve compliance with other reasonable human health risk scenarios. These values are presented in Table 3-3.

- Site-specific ecological RGOs for protection of terrestrial receptors. RGOs were calculated for the protection of terrestrial receptors for macroinvertebrates and high food chain receptors using the ERA terrestrial food-chain modeling. The RGOs are values based on a NOAEL HQ of 1 and low observable adverse effects level (LOAEL) HQs of 1 and 10. These values are presented in Table 3-4.

Sediment

The following site-specific RGOs were calculated for sediment. Derivations of these RGOs are located in Appendix B.

- Human health RGOs based on ingestion of fish using conservative ingestion assumptions. RGOs were calculated for the protection of the adult recreational user. The RGOs are sediment-based values that correspond to an ILCR of 1.0E-04, 1.0E-05, and 1.0E-06 or a HQ of 1 for the adult recreational user through fish consumption. Protection is achieved by controlling sediment COC

concentrations to reduce the bioaccumulation of sediment COCs into fish. U.S. EPA standard default values for fish ingestion are assumed. These values are presented in Table 3-5.

- Human health RGOs based on ingestion of fish using site-specific ingestion assumptions. RGOs were calculated for the protection of the adult recreational user. The RGOs are sediment-based values that correspond to an ILCR of 1.0E-04, 1.0E-05, and 1.0E-06 or a HQ of 1 for the adult recreational user through fish consumption. Protection is achieved by controlling sediment COC concentrations to reduce the bioaccumulation of sediment COCs into fish. Site-specific assumptions for fish ingestion were used. These values are presented in Table 3-5.

- Site-specific human health RGOs based on exposure to sediment. RGOs were calculated for the protection of the existing maintenance worker and future construction worker. The RGOs are sediment concentrations that correspond to an ILCR of 1.0E-04, 1.0E-05, and 1.0E-06 for these receptors. Compliance with these values would also achieve compliance with other reasonable human health risk scenarios. These values are presented in Table 3-5.

- Site-specific ecological RGOs for protection of aquatic receptors. RGOs were calculated for the protection of aquatic receptors based on the ERA terrestrial food-chain modeling. The RGOs are values based on a NOAEL HQ of 1 and LOAEL HQs of 1 and 10. These values are presented in Table3-6.

3.4.3 COC Selection

Preliminary COCs were compared against available ARARs, TBCs, and site-specific RGOs. Based on this comparison, COCs were selected for use in assessing impacted surface soil and sediment at Site 3. A discussion of COC selection is provided in the following sections.

3.4.3.1 Surface Soil

Selection of Surface Soil COCs for Protection of Human Health

Based on a comparison of the maximum detected concentrations of surface soil human health preliminary COCs to chemical-specific human health criteria, benzo(a)pyrene is retained as a surface soil COC for human health (see Table 3-3). Although several other preliminary COCs exceed U.S. EPA Generic Soil Screening Levels for potential impacts to groundwater, these chemicals were not identified as groundwater COPCs in the RI/RFI; therefore, these chemicals will not be retained as COCs. Additionally, while several preliminary COCs exceed residential RBCs, the causeway's use as a residential area is not a reasonable future land-use scenario. The physical characteristics of the site (long, narrow road with

steep banks) make its use as a residential area unlikely. Lastly, even though arsenic exceeds its industrial RBC, it did not exceed its site-specific RGO based on exposure by the construction worker. The site-specific RGO is more indicative of the risks posed to Site 3 industrial receptors.

Selection of Surface Soil COCs for Protection of Ecological Receptors

Based on a comparison of the maximum detected concentrations of surface soil ecological preliminary COCs to chemical-specific ecological criteria, several SVOCs, Aroclor-1254, Aroclor-1260, arsenic, lead, mercury, vanadium, and zinc are retained as surface soil COCs for ecological receptors (see Table 3-4).

Chloroform was detected above its Dutch Ministry Standard Target Value of 1 ug/kg at two out of 16 surface soil locations. At both locations, a concentration of 2 ug/kg was observed. Because of the infrequent detection of this compound and the fact that the target value was only slightly exceeded, chloroform will not be retained as a soil COC. 4,4'-DDE and 4,4'-DDT will not be retained as a soil COC because the detected concentrations are below the typical facility pesticide concentrations (TtNUS, 1999).

Although concentrations of aluminum exceeded Oak Ridge National Laboratory criteria and RGOs for the protection of terrestrial receptors, these criteria are orders of magnitude less than the established background concentration for aluminum. Three surface soil samples out of 16 exceeded the background concentration of 7,270 mg/kg with a maximum observed detection of 10,800 mg/kg. Furthermore, aluminum is not readily adsorbed through the skin, and adsorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and Luckey, 1978). Lastly, aluminum is a commonly found element in soil. Consequently, aluminum will not be retained as a soil COC. For similar reasons, iron will not be retained as a soil COC.

Summary of Surface Soil COCs

The following chemicals have been retained as COCs for surface soil

- acenaphthylene – E
- benzo(a)pyrene – H, E
- benzo(k)fluoranthene – E
- indeno(1,2,3-cd)pyrene – E
- Aroclor-1254 – E
- lead – E
- zinc – E
- anthracene – E
- benzo(b)fluoranthene – E
- chrysene – E
- phenanthrene – E
- Aroclor-1260 – E
- mercury – E
- benzo(a)anthracene – E
- benzo(g,h,i)perylene – E
- fluoranthene – E
- pyrene – E
- arsenic – E
- vanadium – E

E – selected for protection of ecological receptors
H – selected for protection of human health

Selection of Sediment COCs for Protection of Human Health

Based on a comparison of the maximum detected concentrations of sediment preliminary human health COCs to chemical-specific human health criteria, the following chemicals are retained as COCs for protection of human health: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, carbazole, indeno(1,2,3-cd)pyrene, Aroclor-1254, Aroclor-1260, alpha-chlordane, 4,4'-DDD, 4,4'-DDE, gamma-chlordane, and arsenic (see Table 3-5). 4,4'-DDT is retained as a COC because its breakdown products, 4,4'-DDD and 4,4'-DDE, are retained as COCs.

Based on the HHRA, carcinogenic PAHs as a class of chemicals were retained as preliminary COCs; however, two carcinogenic PAHs, benzo(k)fluoranthene and dibenzo(a,h)anthracene, were not detected in sediment; therefore, these chemicals will not be retained as sediment COCs. Chrysene will not be retained as sediment COC because it was detected below the chemical-specific criteria. Dieldrin was retained as a preliminary COC based on the 1993 Extended Site Investigation fish tissue data (ABB, 1993). However, dieldrin was not detected during the 1998 RI/RFI; therefore, dieldrin will not be retained as a COC.

Selection of Sediment COCs for Protection of Ecological Receptors

Based on a comparison of the maximum detected concentrations of sediment ecological preliminary COCs to chemical-specific ecological criteria, several SVOCs, pesticides/PCBs, and inorganics are retained as sediment COCs for ecological receptors as shown in Table 3-6.

Barium will not be retained as a sediment COC because detected concentrations of these elements were below chemical-specific criteria.

Although concentrations of aluminum exceeded RGOs for the protection of aquatic receptors, these values are orders of magnitude less than the established background concentration for aluminum. Three sediment samples out of 21 exceeded the background concentration of 24,200 mg/kg with a maximum observed detection of 29,700 mg/kg. Furthermore, aluminum is not readily adsorbed through the skin, and adsorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and Luckey, 1978). Lastly, aluminum is a commonly found element in sediment. Consequently, aluminum will not be retained as a sediment COC. For similar reasons, iron will not be retained as a sediment COC.

Summary of Sediment COCs

The following chemicals have been retained as COCs for sediment.

- anthracene – E
- benzo(b)fluoranthene - H
- fluoranthene – E
- pyrene
- 4,4'-DDT – E,H
- Aroclor-1254 – E, H
- copper - E
- thallium – E
- cobalt
- benzo(a)anthracene – H
- carbazole – H
- indeno(1,2,3-cd)pyrene - H
- 4,4'-DDD – E, H
- alpha-chlordane - H
- Aroclor-1260 - H
- lead – E
- vanadium – E
- selenium
- benzo(a)pyrene - H
- chrysene – E
- phenanthrene – E
- 4,4'-DDE – E, H
- gamma-chlordane - H
- arsenic – E, H
- mercury – E
- zinc – E

E – selected for protection of ecological receptors

H – selected for protection of human health

3.5 REMEDIAL ACTION OBJECTIVES/CORRECTIVE ACTION OBJECTIVES

Site-specific RAOs/CAOs consist of medium-specific goals for protecting human health and the environment. RAOs/CAOs are developed to permit consideration of a range of alternatives. The following RAOs/CAOs have been developed for Site 3.

- Control human exposure (the existing maintenance worker, the future construction worker, and the recreational user) to COCs in surface soil and sediment at concentrations in excess of RGOs. RGOs take into consideration an ILCR range of 1.0E-06 to 1.0E-04. Additionally, RGOs take into consideration a HQ of 1 where noncarcinogenic effects would be expected. The COCs and range of RGOs for surface soil and sediment are presented in Tables 3-7 and 3-8, respectively.

- Protect adult recreational users from consumption of fish and shellfish containing COCs at concentrations in excess of sediment-based RGOs. Protection would be achieved by controlling sediment COC concentrations to reduce the bioaccumulation of sediment COCs into fish. Sediment-based RGOs take into consideration an ILCR range of 1.0E-06 to 1.0E-04. Additionally, RGOs take into consideration a HQ of 1 where noncarcinogenic effects would be expected. The COCs and range of RGOs are presented in Table 3-8.

- Control exposure of ecological receptors to COCs in surface soil and sediment at concentrations greater than RGOs. The RGOs take into account direct contact of COCs by macroinvertebrates and ingestion and bioaccumulation of COCs by site-specific food chain receptors. RGOs address a range

of risks where "low effects" to "high effects" may be anticipated by ecological receptors. The COCs and range of RGOs for surface soil and sediment are presented in Tables 3-7 and 3-8, respectively.

- Eliminate the migration of COCs from the fill material to sediment, surface water, and groundwater.
- Comply with chemical-specific, location-specific, and action-specific federal and state ARARs.

3.6 REMEDIAL GOAL OPTIONS

RGOs have been developed to illustrate a range of clean-up alternatives for surface soil and sediment at Site 3. For both surface soil and sediment, three sets of RGOs are established. In each RGO set, a value protective of human health and ecological receptors is selected.

The human health values in the first set of RGOs represent a baseline condition where, if the human health RGOs are achieved through remedial action/corrective measures, the ILCR to human health would be estimated at less than 1.0E-06. Likewise, the human health values in the second and third set of RGOs represent conditions where, if the human health RGOs are achieved through remedial action/corrective measures, the ILCR to human health would be estimated at less than 1.0E-05 and 1.0E-04, respectively.

The ecological values in the first set of RGOs represents a baseline condition where "low risk" to ecological receptors would be anticipated if concentrations of COCs were to exceed the first set of RGOs, but were less than the second set of RGOs. The low risk RGOs consist of the most conservative ecological criteria identified in Tables 3-4 and 3-6 and are generally based on Screening Levels and NOAELs. The ecological values in the second set of RGOs (moderate risk RGOs) consist of criteria where moderate risks would be anticipated if concentrations of COCs were to exceed the second set of RGOs, but were less than the third set of RGOs. The moderate risk values are generally based on ER-Ms and PELs. Lastly, the ecological values in the third set of RGO (high risk RGOs) consist of criteria where relatively high risks would be anticipated if concentrations of COCs were to exceed the third set of RGOs.

3.6.1 Surface Soil RGOs

Three sets of surface soil RGOs have been established to be protective of human health receptors (existing maintenance worker and future construction workers) and ecological receptors (macroinvertebrates and terrestrial food-chain receptors). Surface soil RGOs are summarized in Table 3-7.

3.6.1.1 RGOs: Human Health ILCR Equal to 1.0E-06 and Low Risk to Ecological Receptors

For protection of human health, the selected RGO is the chemical concentration in surface soil protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-06. Compliance with this value would also achieve compliance with other reasonable human health risk scenarios

For protection of ecological receptors, the minimum value of the following criteria is used as the RGO. If this minimum value is below background or the typical facility pesticide concentration, the background or typical facility pesticide concentration is used as the RGO.

- Dutch Soil Clean-up Act "a" Values - refers to background concentrations in soil or detection limits.
- Oak Ridge National Laboratory Earthworm, Microorganism, and Soil Phytotoxicity Benchmark Values - guidelines indicative of toxicity to soil invertebrates and terrestrial plants.
- U.S. EPA Region IV Ecological Screening Values for soil.
- Value protective of terrestrial food-chain receptors based on a NOAEL HQ of 1.

3.6.1.2 RGOs: Human Health ILCR Equal to 1.0E-05 and Moderate Risk to Ecological Receptors

For protection of human health, the selected RGO is the chemical concentration in surface soil protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-05.

For protection of ecological receptors, the minimum value of the following criteria is used as the RGO. If this minimum value is below background or the typical facility pesticide concentration, the background or typical facility pesticide concentration is used as the RGO.

- Dutch Soil Clean-up Act "b" Values - refers to moderate soil contamination that requires additional study.
- Value protective of terrestrial food-chain receptors based on a LOAEL HQ of 1.

3.6.1.3 RGOs: Human Health ILCR Equal to 1.0E-04 and High Risk to Ecological Receptors

For protection of human health, the selected RGO is the chemical concentration in surface soil protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-04.

For protection of ecological receptors, the value used as the High Risk RGO is the Moderate Risk ecological RGO multiplied by 10. This value is used to identify potential hot spots.

3.6.2 Sediment RGOs

Three sets of sediment RGOs have been established to be protective of human health receptors (existing maintenance worker, future construction workers and adult recreational users) and ecological receptors (macroinvertebrates and aquatic food-chain receptors). Sediment RGOs are summarized in Table 3-8.

3.6.2.1 RGOs: Human Health ILCR Equal to 1.0E-06 and Low Risk to Ecological Receptors

For protection of human health, the minimum value of the following criteria is used as the RGO. If the minimum criterion is below background or the typical facility pesticide concentration, the background or typical facility pesticide concentration is used as the RGO.

- The chemical concentration in sediment protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-06. Compliance with this criterion would also achieve compliance with other reasonable human health risk scenarios.

- The chemical concentration in sediment that corresponds to an ILCR of 1.0E-06 to the adult recreational user through consumption of fish. Conservative ingestion rates by the adult recreational user are assumed.

For protection of ecological receptors, the minimum value of the following criteria is used as the RGO. If this minimum value is below background or the typical facility pesticide concentration, the background or typical facility pesticide concentration is used as the RGO.

- ER-L Values - The ER-L is the 10th percentile of sediment concentrations associated with effects to benthic organisms.

- TEL Values - similar to ER-L values; however, the TELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data).

- U.S. EPA Region IV Effects Values.

- Value protective of aquatic food-chain receptors based on a NOAEL HQ of 1.

3.6.2.2 RGOs: Human Health ILCR Equal to 1.0E-05 and Moderate Risk to Ecological Receptors

For protection of human health, the minimum value of the following criteria is used as the RGO.

- The chemical concentration in sediment protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-05.

- The chemical concentration in sediment that corresponds to an ILCR of 1.0E-05 to the adult recreational user through ingestion of fish. Site-specific ingestion rates by the adult recreational user are assumed.

For protection of ecological receptors, the minimum value of the following criteria is used as the RGO.

- ER-M Values - The ER-M is the 50th percentile of sediment concentrations associated with effects to benthic organisms.

- PEL Values - similar to ER-M values; however, the PEL also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data).

- Value protective of aquatic food-chain receptors based on a LOAEL HQ of 1.

- In the event that one of the above criteria is not available for a particular chemical, 10 times the Low Risk ecological RGO is used as the RGO.

3.6.2.3 RGOs: Human Health ILCR Equal to 1.0E-04 and High Risk to Ecological Receptors

For protection of human health, the minimum value of the following criteria is used as the RGO.

- The chemical concentration in sediment protective of the construction worker or maintenance worker that corresponds to an ILCR of 1.0E-04.

- The chemical concentration in sediment that corresponds to an ILCR of 1.0E-04 to the adult recreational user through ingestion of fish. Site-specific ingestion rates by the adult recreational user are assumed.

For protection of ecological receptors, the value used as the High Risk RGO is the Moderate Risk ecological RGO multiplied by 10. This value is used to identify potential hot spots.

3.7 IMPACTED SOIL AND SEDIMENT

The quantities of impacted surface soil and sediment are estimated based on a comparison of the RGO sets identified in Section 3.6 to surface soil and sediment analytical results. The supporting calculations for these quantities are presented in Appendix C.

3.7.1 Impacted Surface Soil

Figure 3-1 illustrates the estimated area of contaminated soil when the surface soil analytical database is compared against the RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors. Figure 3-2 illustrates the estimated area of contaminated soil when the surface soil analytical database is compared against the RGOs that represent a human health ILCR equal to 1.0E-05 and moderate risk to ecological receptors. Lastly, Figure 3-3 illustrates the estimated area of contaminated soil when the surface soil analytical database is compared against the RGOs that represent a human health ILCR equal to 1.0E-04 and high risk to ecological receptors. The area of impacted soil for these scenarios is summarized below.

RGO Set Used	Area of Impacted Surface Soil (acres)
Human Health ILCR = 1.0E-06 and Low Risk to Ecological Receptors	15.6
Human Health ILCR = 1.0E-05 and Moderate Risk to Ecological Receptors	9.6
Human Health ILCR = 1.0E-04 and High Risk to Ecological Receptors	8.8

3.7.2 Impacted Sediment

When 1998 sediment results are compared against RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors, COC concentrations at 18 out of 20 sediment locations exceed RGOs. In this scenario, RGOs that represent a human health ILCR equal to 1.0E-06 are exceeded at 11 locations and RGOs that represent a low risk to ecological receptors are exceeded at 16 locations. Since these exceedances were low level and random, a boundary of these exceedances was not identified, a figure was not provided.

When 1998 sediment concentrations were compared against RGOs that represent an ILCR of 1.0E-05 to human receptors and moderate risk to ecological receptors, four "hot spots" were identified.

- Hot Spot 1 contains elevated levels of PAHs and is illustrated in Figure 3-4.
- Hot Spot 2 contains elevated levels of Aroclor-1254 (a PCB) and is illustrated in Figure 3-5.
- Hot Spots 3 and 4 contain elevated levels of pesticides and are illustrated in Figures 3-6 and 3-7.

Figure 3-8 illustrates the locations of all four sediment hot spots. The area and volume of impacted sediment associated with these hot spots is presented as follows.

Hot Spot	Estimated Extent[1]		Probable Extent[2]	
	Area of Impacted Sediment (ft^2)	Volume of Impacted Sediment[3] (yd^3)	Area of Impacted Sediment (ft^2)	Volume of Impacted Sediment[3] (yd^3)
Hot Spot 1	37,800	2,800	5,400	400
Hot Spot 2	13,600	1,000	4,300	320
Hot Spot 3	9,300	690	9,300	690
Hot Spot 4	35,300	2,620	35,300	2,620
Totals	96,000	7,110	54,300	4,030

1. Based on delineation samples defined as clean boundary points or determined by logarithmic decay.
2. Clean boundary determined by logarithmic decay
3. Assumes a 2-foot depth of impacted sediment (based on geometry of the causeway and water depth of the pond).

Because sediment concentrations did not exceed the RGOs that represent a human health ILCR equal to 1.0E-04 and high risk to ecological receptors, a figure for this scenario was not developed.

TABLE 3-1

FEDERAL ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 4

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
Chemical-Specific ARARs			
Safe Drinking Water Act MCLs, MCLGs, and SMCLs	40 CFR 140-143	Not applicable	Would be used as protective levels for groundwater that are current or potential drinking water sources; however, groundwater is saline to brackish and is not a viable drinking water source.
Ambient Water Quality Criteria	Section 304 of the Clean Water Act	Relevant and appropriate	Criteria for assessing the need for surface water remedial action/corrective measures.
Clean Air Act National Ambient Air Quality Standards (NAAQs)	42 U.S.C §7401- 7642, 40 CFR Part 50	Potentially applicable	Remedial action/corrective measures involving treatment of media could result in emissions to the atmosphere.
RCRA Subtitle C – Hazardous Waste Identifications and Listing Regulations	40 CFR 261	Potentially applicable	Would be used to identify a material as a hazardous waste and thus determine the applicability and relevance of RCRA C Hazardous Waste Rules.
U.S. EPA Health Advisories	U.S. EPA, 1996a	To be considered criteria (TBC)	Benchmark values for assessing the need for groundwater remedial action/corrective measures.
Risk-Based Concentration (RBCs)	U.S. EPA Region III, 1998	TBC	Benchmark values for assessing the need for soil and groundwater remedial action/corrective measures.
Generic Soil Screening Levels	U.S. EPA, 1996b	TBC	Benchmark values for assessing the need for soil remedial action/corrective measures.
Dutch Soil Clean-up Act Ecological Screening Values	Beyer, 1990	TBC	Benchmark values for assessing the need for soil remedial action/corrective measures.
Dutch Ministry of Housing Intervention Values and Target Values – Soil Quality Standards	MHSPE, 1994	TBC	Benchmark values for assessing the need for soil remedial action/corrective measures.
Oak Ridge National Laboratory Toxicity Benchmarks for Soil	Efroymson, 1997a and 1997b	TBC	Benchmark values for assessing the need for soil remedial action/corrective measures.
Canadian Council of Ministers of the Environment Soil Quality Guidelines	CCME, 1997	TBC	Benchmark values for assessing the need for soil remedial action/corrective measures.
Ecological Risk Assessment at Military Bases	U.S. EPA Region 4, 1998	TBC	Memorandum consists of benchmark values for assessing the need for surface soils, sediment and surface water remedial action/corrective measures.
ER-L and ER-M Levels	Long et al., 1995	TBC	Benchmark values for assessing the need for sediment remedial action/corrective measures.
PELs and TELs	FDEP, 1994	TBC	Benchmark values for assessing the need for sediment remedial action/corrective measures.

TABLE 3-1

FEDERAL ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 4

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
Location-Specific ARARs			
U.S. EPA's Groundwater Protection Strategy	U.S. EPA, 1984	TBC	Surficial groundwater at Site 3 is likely designated Class IIIA.
CWA Section 404 River and Harbors Act, Section 10	40 CFR 230, 33 CFR 320-330	Not applicable	Prohibits the unauthorized obstruction or alteration of any navigable waters of the United States; however, waters within the vicinity of Site 3 are not classified as navigable waters.
Floodplain Management	Executive Order 11988	Applicable	Site 3 is located within the 100-year floodplain.
Protection of Wetlands	Executive Order 11990	Applicable	Site 3 is located within a wetlands area.
Endangered Species Act	16 U.S.C 1531 et seq.	Applicable	A bald eagle is known to nest in the vicinity of Site 3. Wood storks and alligators are sometimes observed in the vicinity.
Fish and Wildlife Coordination Act	16 U.S.C 661 et seq., 40 CFR Part 122.49	Applicable	Ensures that remedial action/corrective measures protect nearby wetlands and protected habitats.
Coastal Zone Management Act	16 U.S.C. 1451 et seq.	Applicable	Ensures that remedial action/corrective measures protect coastal resources.
Historic Sites, Buildings, and Antiquities Act	16 U.S.C. 461 et seq.	Potentially Applicable	This Act would be applicable if information is found to classify Site 3 as a historic or prehistoric property of national significance
Archaeological and Historic Preservation Act of 1974	16 U.S.C. 469 et seq.	Potentially Applicable	This Act would be applicable if historic and archaeological artifacts were to be affected by remedial activities. No such artifacts are known to exist within the boundaries of Site 3.
Archeological Resources Protection Act of 1979	16 U.S.C. 479(aa) et seq.	Potentially Applicable	This Act would be applicable if archeological artifacts were discovered during remedial activities.
Native American Grave Protection and Repatriation Act of 1990	25 U.S.C. 3001 et seq.	Potentially Applicable	This Act would be applicable if human remains were discovered during remedial activities.
Bald Eagle Protection Act of 1940, as Amended	16 U.S.C. 688 et seq.	Potentially Applicable	This Act includes provisions for prohibiting the disturbance of bald eagles. Because a bald eagle is known to nest within the vicinity of Site 3, remedial activities would need to be conducted to minimize the disturbance to this species.
Conservation Programs on Military Reservations (Sikes Act) of 1960, as Amended	16 U.S.C. 670(a) et seq.	Applicable	This act requires that military installations manage natural resources for multipurpose uses and public access appropriate for those uses consistent with the military department's mission.
Marine Mammal Protection Act of 1972 as Amended	16 U.S.C. 1361 et seq.	Not Applicable	Marine mammals are not known to inhabit the Pond or Ribbon Creek. Marine mammals are usually not associated with shallow marshes and small tidal inlets like those near Site 3.

TABLE 3-1

FEDERAL ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 3 OF 4

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
Action-Specific ARARs			
Solid Waste Disposal Act (SWDA)/ Resource Conservation Recovery Act (RCRA) Subtitle C	42 U.S.C 6905, 6912a, 6924-6925	–	–
• Standards for Hazardous Waste Generators	40 CFR 262	Potentially applicable	Applicable for removed site wastes determined to be hazardous.
• Standards for Hazardous Waste Transporters	40 CFR 263	Potentially applicable	Applicable for removed site wastes determined to be hazardous that are transported off site.
• Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	40 CFR 264	Potentially applicable	These regulations would be applicable to waste removed from the site including both on-site and off-site management.
• Interim status standards for owners and operators of hazardous waste TSD facilities	40 CFR 265	Relevant and appropriate	Establishes design and operating criteria for hazardous landfills. Because the type of waste disposed in the causeway was primarily nonhazardous in nature, these requirements are not applicable; however, certain aspects are relevant and appropriate.
• RCRA Land Disposal Restrictions (LDR) Requirements	40 CFR 268	Potentially applicable	Treatment or disposal of contaminated media and/or disposal of treatment residuals that may be considered hazardous waste would be subject to land disposal restrictions.
Hazardous and Solid Waste Amendments of 1984	42 U.S.C. 6926	Potentially Applicable	Establishes a corrective actions program requiring four basic elements (assessment, investigation, CMS, implementation).
RCRA Subtitle D	40 U.S.C 6901	Relevant and appropriate	Establishes design and operating criteria for solid waste (nonhazardous) landfills; however, disposal activities ceased prior to the effective date of the regulation.
The Clean Water Act (CWA) National Pollution Discharge Elimination System	40 CFR 122	Potentially applicable	These requirements are applicable for all alternatives that include a water discharge.
Toxic Substances Control Act	40 CFR 761	Not an ARAR	Remedial action/corrective measures may be driven by reducing PCB concentrations in affected media to meet published levels.
U.S. EPA Clean Air Act New Source Performance Standards (NSPS)	40 CFR 60	Not an ARAR	Remedial action/corrective measures involving treatment of media could result in emissions to the atmosphere.
Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 60	Potentially applicable	Existing source types are not present on site.

TABLE 3-1

FEDERAL ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 4 OF 4

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
DOT Hazardous Materials Transportation	49 CFR	Potentially applicable	These rules are considered potentially applicable to wastes shipped off site for laboratory analysis, treatment, or disposal.
OSHA Standards	29 CFR 1910.120	Applicable	On site activities are required to follow OSHA requirements.
National Environmental Policies Act	42 U.S.C 4321 et seq.	Relevant and appropriate	Remedial action/corrective measures could constitute significant activities, thereby making NEPA requirements ARARs; however, activities conducted in accordance with the NCP are considered to meet the substantive NEPA requirements.
Soil Conservation Act	U.S.C. 5901 et seq.	Applicable	During remedial activities, implementation of soil conservation practices would be required.
Presumptive Remedy for CERCLA Municipal Landfill Sites	U.S. EPA, 1993	TBC	Site 3 was constructed with municipal trash and solid waste from the Depot. Through this directive, U.S. EPA has identified containment as the presumptive remedy for such landfill sites.
Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills	U.S. EPA, 1996c	TBC	Provides the framework for determining the applicability of the containment presumptive remedy to military landfills.

TABLE 3-2

STATE OF SOUTH CAROLINA ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
Chemical-Specific ARARs			
State Primary Drinking Water Regulations Groundwater Sources and Treatment Surface Water Sources and Treatment MCL in Drinking Water Control of Lead and Copper	R.61-58 to R.61-58.11 R.61-58.2 R.61-58.3 R.61-58.5 R.61-58.11	Not applicable	Would be used as protective levels for groundwaters that are current or potential drinking water sources.
South Carolina Hazardous Waste Management Act Hazardous Waste Management Regulations	§44-56-10 R.61-79	Potentially applicable	Would be used to identify a material as a hazardous waste and thus determine the applicability and relevance of Hazardous Waste Management Regulations.
Location-Specific ARARs			
Water Classifications and Standards	R.61-68	Applicable	Surficial groundwater is not an underground source of drinking water. Surface water near Site 3 is classified as shellfish harvesting waters.
Coastal Zone Management Act	§48-39-10	Applicable	Ensures that remedial action/corrective measures protect coastal resources.
Groundwater Mixing Zone Application Guidance	SCDHEC, 1997b	TBC	Guidance for completing an application to obtain groundwater waiver for non-attainment of MCLs.
Action-Specific ARARs			
Well Standards	R.61-71	Potentially applicable	Applicable if remedial action/corrective measures involving the installation or abandonment of monitoring wells.
Hazardous Waste Management Act	§44-56-30	-	-
• Standards for Hazardous Waste Generators	R.61-79.262	Potentially applicable	Applicable for removed site wastes determined to be hazardous.
• Standards for Hazardous Waste Transporters	R.61-79.263	Potentially applicable	Applicable for removed site wastes determined to be hazardous that are transported off site.
• Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal (TSD) Facilities	R.61-79.264	Potentially applicable	These regulations would be applicable to waste removed from the site including both on-site and off-site management.
• Interim status standards for owners and operators of hazardous waste TSD facilities	R.61-79.265	Relevant and appropriate	Establishes design and operating criteria for hazardous landfills. Because the type of waste disposed in the causeway was primarily non-hazardous in nature, these requirements are not applicable; however, certain aspects are relevant and appropriate.
• Land Disposal Restrictions (LDR) Requirements	R.61-79.268	Potentially applicable	Treatment or disposal of contaminated media and/or disposal of treatment residuals that may be considered hazardous waste would be subject to land disposal restrictions.

TABLE 3-2

STATE OF SOUTH CAROLINA ARARs/MEDIA CLEAN-UP STANDARDS AND TBCs
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

ARAR	Citation/Reference	ARAR Type	Rationale for Use at MCRD Parris Island
Air Pollution Control Regulations and Standards	R.61-62	Potentially applicable	Remedial action/corrective measures involving treatment of media could result in emissions to the atmosphere.
Solid Waste Management: Collection, Temporary Storage, and Transportation of Solid Waste	R.61-107.5	Potentially applicable	Applicable if solid waste is generated during remedial action/corrective measures.
Solid Waste Management: Construction, Demolition, and Land Clearing Debris Landfills	R.61-107.11	Relevant and appropriate	Construction, demolition, and land-clearing debris is co-mingled with other wastes.
Solid Waste Management: Municipal Solid Waste Landfills	R.61-107.258	Relevant and appropriate	Contains design and construction requirements for municipal landfills; however, disposal activities ceased prior to the effective date of the regulation.
Sanitary Landfill Design, Construction, and Operation	R.61-70	Relevant and appropriate	Contains design and construction requirements for sanitary landfills; however, disposal activities ceased prior to the effective date of the regulation.
Standards for Stormwater Management and Sediment Reduction	R.72-300 and R.72-405	Potentially applicable	Applicable if remedial action/corrective measures involve land-disturbance activities.
General Objectives and Components of Contamination Assessments and Remedial Actions	SCDHEC, 1994	TBC	Provides guidance for conducting remedial action activities.
Soil/Groundwater Remediation Guidance Document	SCDHEC, 1992	TBC	Provides guidance for conducting groundwater and soil remediation.
Stormwater and Management and Sediment Control Handbook for Land Disturbance Activities	SCDHEC, 1997a	TBC	Guidance document to be following if remedial action/corrective measures involve land-disturbance activities.

TABLE 3-3

SELECTION OF SURFACE SOIL COCS FOR PROTECTION OF HUMAN HEALTH
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Preliminary COCs	Maximum Concentration	Background[1]	U.S. EPA RBCs[2]		U.S. EPA Generic SSLs[3]			Site-Specific Human Health RGOs[4]			Selected as COC?
			Residential	Industrial	Inhalation	1 DAF	20 DAF	ILCR 1.00E-04	ILCR 1.00E-05	ILCR 1.00E-06	
Organics (µg/kg)											
BENZO(A)PYRENE	4,000	ND	**87**	**780**	-	**400**	8,000	89,000	8,900	**890**	**Yes**
BENZO(A)ANTHRACENE	3,000	ND	**870**	7,800	-	**80**	**2,000**	890,000	89,000	8,900	No
BENZO(B)FLUORANTHENE	3,400	ND	**870**	7,800	-	**200**	5,000	890,000	89,000	8,900	No
BENZO(K)FLUORANTHENE	1,300	ND	8,700	78,000	-	2000	49,000	8,900,000	890,000	89,000	No
CHRYSENE	2,900	ND	87,000	780,000	-	8000	160,000	89,000,000	8,900,000	890,000	No
DIBENZO(A,H)ANTHRACENE	ND	ND	87	780	-	80	2,000	89,000	8,900	890	No
INDENO(1,2,3-CD)PYRENE	2,600	ND	**870**	7,800	-	**700**	14,000	890,000	89,000	8,900	No
Inorganics (mg/kg)											
ARSENIC	11.8	1.4	*0.43*	**3.8**	750	[5]	[5]	1,221[6]	123[6]	13.6[6]	No

1 MCRD Parris Island Background Values for Inorganics (TtNUS, 1999).
2 U. S. EPA, 1999. Risk-Based Concentration Table, U. S. EPA Region III. April. Concentrations correspond to fixed levels of risk (hazard quotient of 1 or lifetime cancer risk of 1.0E-06, whichever occurs at a lower concentration).
3 U.S. EPA, 1996. Soil Screening Guidance – Generic Soil Screening Levels, May.
4 Lower of the site-specific cleanup levels calculated for the construction and maintenance worker.
5 DAFs for inorganic compounds are not appropriate to use.
6 Criterion is equal to the RGO corresponding to the ICR plus background.
"-" = Not Applicable or Not Available
DAF = Dillution Attenuation Factor
ILCR = Incremental Lifetime Cancer Risk
ND = Non Detected Value
RBC = Risked-Based Concentration
SSL = Soil Screening Levels
Shaded and bold values indicate that the criterion has been exceeded.
Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background.

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TABLE 3-4

SELECTION OF SURFACE SOIL COCS FOR PROTECTION OF ECOLOGICAL RECEPTORS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Preliminary COCs	Maximum Concentration	Background[1]/ Typical Facility Pest. Conc.	Dutch Soil Clean-up Act			Oak Ridge National Lab[5]			CCME[6]	Dutch Ministry Standards[7]			U.S. EPA Region IV Soil Ecological Screening Values [12]	Protection of Terrestrial Recepters[8] Based on				Selected as COC?
			a[2]	b[3]	c[4]	Earthworms	Mircoorg.	Soil Phytotoxicity		Target Value	Intervention Value	Max. Permissible Conc.		NOAELs HQ = 1	LOAELs HQ = 1	LOAELs HQ = 10	Receptor	
VOCs (µg/kg)																		
CHLOROFORM	2	ND	-	-	-	-	-	-		1	10000	-	1	(9)	(9)	(9)	(9)	No
SVOCs (µg/kg)																		
ACENAPHTHYLENE	1,800	ND	100[10]	5,000[10]	50,000[10]	-	-	-	600[10]	-	-	-	20,000	(9)	(9)	(9)	(9)	Yes
ANTHRACENE	340	ND	100	10,000	100,000	-	-	-	600[10]	-	-	-	100	(9)	(9)	(9)	(9)	Yes
BENZO(A)ANTHRACENE	3,000	ND	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
BENZO(A)PYRENE	4,000	ND	100	1,000	10,000	-	-	-	700	-	-	-	100	(9)	(9)	(9)	(9)	Yes
BENZO(B)FLUORANTHENE	3,400	ND	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
BENZO(G,H,I)PERYLENE	2,500	ND	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
BENZO(K)FLUORANTHENE	1,300	ND	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
CHRYSENE	2,900	ND	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
FLUORANTHENE	5,100	ND	100	10,000	100,000	-	-	-	700[11]	-	-	-	100	(9)	(9)	(9)	(9)	Yes
INDENO(1,2,3-CD)PYRENE	2,600	518	100[11]	1,000[11]	10,000[11]	-	-	-	700[11]	-	-	-	-	(9)	(9)	(9)	(9)	Yes
PHENANTHRENE	1,200	ND	100	5,000	50,000	-	-	-	600[10]	-	-	-	100	(9)	(9)	(9)	(9)	Yes
PYRENE	4,500	ND	100	10,000	100,000	-	-	-	700[11]	-	-	-	100	(9)	(9)	(9)	(9)	Yes
Pesticides and PCBs (µg/kg)																		
4,4'-DDE	4.1	31.6	-	-	-	-	-	-		*2.5*	4,000	-	*2.5*	(9)	(9)	(9)	(9)	No
4,4'-DDT	4.5	34.5	-	-	-	-	-	-		*2.5*	4,000	-	*2.5*	(9)	(9)	(9)	(9)	No
AROCLOR-1254	56	ND	50	1,000	10,000	-	-	40,000	-	20	1,000	-	20	23.8	238	2,384	Shrew	Yes
AROCLOR-1260	100	ND	50	1,000	10,000	-	-	40,000	-	20	1,000	-	20	23.8	238	2,384	Shrew	Yes
Inorganics (mg/kg)																		
ALUMINUM	10,800	7270/33,000[13]	-	-	-	-	*600*	*50*	-	-	-	-	*50*	*24.4*	*244*	*2,438*	Shrew	No
ARSENIC	11.8	1.4	20	30	50	60	100	10	19	29	55	34	10	*0.78*	7.79	78	Shrew	Yes
IRON	7,370	3,920	-	-	-	-	*200*	-	-	-	-	-	*200*	*169*	*1,689*	16,890	Robin	No
LEAD	264	12.5	50	150	600	500	900	50	70	85	530	140	50	*6.19*	61.9	619	Robin	Yes
MERCURY	0.43	0.11	0.5	2	10	*0.1*	30	0.3	10	0.3	10	2.2	*0.1*	*0.010*	*0.029*	0.29	Robin	Yes
VANADIUM	21.4	9.5	-	-	-	-	20	*2*	130	-	-	43	*2*	*2.89*	28.9	289	Shrew	Yes
ZINC	205	9.7	200	500	3000	200	100	50	200	140	720	160	50	10.6	95.5	955	Robin	Yes

1 For inorganics, the presented value is the MCRD Parris Island Background Value (TtNUS, 1999). For pesticides, the presented value is the MCRD Parris Island Typical Facility Pesticide Concentration (TtNUS, 1999).
2 Refers to background concentrations in soil or detection limits - U.S. Fish and Wildlife Service (Beyer, 1990).
3 Refers to moderate soil contamination that requires additional study - U.S. Fish and Wildlife Service (Beyer, 1990).
4 Refers to threshold values that require immediate cleanup - U.S. Fish and Wildlife Service (Beyer, 1990).
5 Efroymson et al., 1997.
6 CCME, 1997.
7 Dutch Ministry Standards, Ministry of Housing, Spatial Planning, and Environment, 1994.
8 Minimum no observable adverse effects levels and low observable adverse effects levels calculated for the shrew, robin, mouse, and hawk. The receptor that corresponds to these site-specific values are also listed.
9 This analyte was not retained for protection of food-chain receptors. For these chemicals, HQs using maximum detected concentrations were less than 1.0.
10 For low-molecular weight PAHs, the value for naphthalene is used as a surrogate value.
11 For high-molecular weight PAHs, the value for benzo(a)pyrene is used as a surrogate value.
12 Contained within memorandum entitled "Ecologcial Risk Assessment at Military Bases" (U.S. EPA, 1998).
13 The first value (7,270 mg/kg) is the MCRD Parris Island background value for aluminum. The second value is a typical eastern United States background soil value for aluminum (USGS, 1984).
"-" = Not Applicable or Not Available
ND = Non-Detected Value
Shaded and bold values indicate that the criterion has been exceeded.
Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background.

TABLE 3-5

SELECTION OF SEDIMENT COCS FOR PROTECTION OF HUMAN HEALTH
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Preliminary COCs	Maximum Concentration	Background[1]/ Typical Facility Pesticide Concentration	Human Health RGOs Based on Ingestion of Fish - Conservative Inputs[2][5]				Human Health RGOs Based on Ingestion of Fish - Site-Specific Inputs[2][5]				Site-Specific Human Health RGOs Based on Dermal Contact[2][6]			Retain as COC?
			ILCR			HQ	ILCR			HQ	ILCR			
			1.00E-04	1.00E-05	1.00E-06	1.0	1.00E-04	1.00E-05	1.00E-06	1.0	1.00E-04	1.00E-05	1.00E-06	
PAHs (µg/kg)														
BENZO(A)PYRENE	1200	ND	**209**	**20.9**	**2.09**	-	3,030	**303**	**30.3**	-	22,000	2,200	**220**	**Yes**
BENZO(A)ANTHRACENE	1200	ND	2,100	**209**	**20.9**	-	30,300	3,030	**303**	-	220,000	22,000	2,200	**Yes**
BENZO(B)FLUORANTHENE	990	ND	2,100	**209**	**20.9**	-	30,300	3,030	**303**	-	220,000	22,000	2,200	**Yes**
BENZO(K)FLUORANTHENE	ND	ND	(7)	(7)	(7)	-	(7)	(7)	(7)	-	(7)	(7)	(7)	No
CARBAZOLE	570	ND	21,900	2,190	**219**	-	317,000	31,700	3,170	-	-	-	-	**Yes**
CHRYSENE	1900	ND	209,000	20,900	2,090	-	3,030,000	303,000	30,300	-	22,000,000	2,200,000	220,000	No
DIBENZO(A,H)ANTHRACENE	ND	ND	(7)	(7)	(7)	-	(7)	(7)	(7)	-	(7)	(7)	(7)	No
INDENO(1,2,3-CD)PYRENE	660	NA	2,100	**209**	**20.9**	-	30,300	3,030	**303**	-	220,000	22,000	2,200	**Yes**
PCBs (µg/kg)														
AROCLOR-1254	370	ND	**119**	**11.9**	**1.19**	**20.8**	1,780	**178**	**17.8**	**59.5**	-	-	-	**Yes**
AROCLOR-1260	70	ND	119	**11.9**	**1.19**	-	1,750	175	**17.5**	-	-	-	-	**Yes**
Pesticides (µg/kg)														
ALPHA-CHLORDANE	28	13.9	253	**25.3**	*2.53*	-	3,820	382	38.2	-	-	-	-	**Yes**
DIELDRIN	ND	ND	(8)	(8)	(8)	-	(8)	(8)	(8)	-	-	-	-	No
4,4'-DDD	290	33.6	6,591	659	**65.9**	-	96,700	9,670	967	-	-	-	-	**Yes**
4,4'-DDE	75	31.6	167	*16.7*	*1.67*	-	2,510	251	*25.1*	-	-	-	-	**Yes**
4,4'-DDT	34	34.5	781	78.1	*7.81*	-	11,500	1,150	115	-	-	-	-	**Yes**
GAMMA-CHLORDANE	28	13.2	571	57.1	*5.71*	-	8,240	824	82.4	-	-	-	-	**Yes**
Inorganics (mg/kg)														
ARSENIC	19.8	12	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	489[4]	59.7[4]	**16.8[4]**	**Yes**

1 For inorganics, the presented value is the MCRD Parris Island Background Value (TtNUS, 1999). For pesticides, the presented value is the MCRD Parris Island Typical Facility Pesticide Concentration (TtNUS, 1999).
2 Site-specific RGOs based on ingestion of fish and dermal contact for carcinogenic PAHs were calculated using benzo(a)pyrene equivalents.
3 In the HHRA, ingestion risks from inorganics were evaluated on the surface water to fish tissue pathway. The sediment to fish tissue pathway was not evaluated.
4 Criterion is equal to the RGO corresponding to the ILCR plus background.
5 Calculated for the Recreational User.
6 Lower of the site-specific cleanup levels calculated for the construction and maintenance worker.
7 Carcinogenic PAHs were retained as preliminary COCs based on the Site 3 RI/RFI HHRA; however, this specific PAH was not detected in sediment. Therefore, it will not be retained as a COC for sediment.
8 Dieldrin was retained as a preliminary COC based on 1993 ESI fish tissue data. However, dieldrin was not detected during the 1998 RI/RFI. Therefore, it will not be retained as a COC.
- = Not applicable or not available
ND = Non-Detected Value
Shaded and bold values indicate that the criterion has been exceeded.
Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background or the typical facility pesticide concentration.

TABLE 3-6

SELECTION OF SEDIMENT COCS FOR PROTECTION OF ECOLOGICAL RECEPTORS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Rev. 1
06/05/00

Preliminary COCs	Maximum Concentration	Background[1]/ Typical Facility Pest. Conc.	NOAA[2]		FDEP[3]		U.S. EPA Region IV Effects Value[4]	NOAELs - Aquatic Receptors[5] Based on		LOAELs - Aquatic Receptors[6] Based on			Retain as COC?
			ER-L	ER-M	TEL	PEL		HQ = 1	Receptor	HQ = 1	HQ = 10	Receptor	
SVOCs (µg/kg)													
ANTHRACENE	770	ND	**85.3**	1,100	**46.9**	**245**	**46.9**	(8)	(8)	(8)	(8)	(8)	**Yes**
BENZO(A)ANTHRACENE	1,200	ND	**261**	1,600	**74.8**	**693**	**74.8**	(8)	(8)	(8)	(8)	(8)	**Yes**
BENZO(A)PYRENE	1,200	ND	**430**	1,600	**88.8**	**763**	**88.8**	(8)	(8)	(8)	(8)	(8)	**Yes**
BENZO(B)FLUORANTHENE	990	ND	-	-	-	-	**655**	(8)	(8)	(8)	(8)	(8)	**Yes**
CHRYSENE	1,900	ND	**384**	2,800	**108**	**846**	**108**	(8)	(8)	(8)	(8)	(8)	**Yes**
FLUORANTHENE	3,500	ND	**600**	5,100	**113**	**1,494**	**113**	(8)	(8)	(8)	(8)	(8)	**Yes**
INDENO(1,2,3-CD)PYRENE	660	518	-	-	-	-	**655**	(8)	(8)	(8)	(8)	(8)	**Yes**
PHENANTHRENE	2,400	ND	**240**	**1,500**	**86.7**	**544**	**86.7**	(8)	(6)	(8)	(8)	(8)	**Yes**
PYRENE	2,700	ND	**665**	**2,600**	**153**	**1,398**	**153**	(8)	(8)	(8)	(8)	(8)	**Yes**
Pesticides/PCBs (µg/kg)													
ALPHA-CHLORDANE	28	13.9	*0.5*[9]	*6*[9]	*2.26*[9]	*4.79*[9]	*0.5*[9]	(8)	(8)	(8)	(8)	(8)	**Yes**
4,4'-DDD	290	33.6	*2*	*20*	*1.22*	*7.81*	*1.22*	*22.2*	Heron	**222**	2,220	Heron	**Yes**
4,4'-DDE	75	31.6	*2.2*	*27*	*2.07*	374	*2.07*	*0.81*	Heron	*8.09*	80.9	Heron	**Yes**
4,4'-DDT	34	34.5	*1*	*7*	*1.19*	*4.77*	*1.19*	*3.73*	Heron	37.3	373	Heron	**Yes**
AROCLOR-1254	370	ND	**22.7**[7]	**180**[7]	**21.6**[7]	**189**[7]	**21.6**[7]	**74**	Heron	740	7,400	Raccoon	**Yes**
AROCLOR-1260	70	ND	**22.7**[7]	180[7]	**21.6**[7]	189[7]	**21.6**[7]	(8)	(8)	(8)	(8)	(8)	**Yes**
GAMMA-CHLORDANE	28	13.2	*0.5*[9]	*6*[9]	*2.26*[9]	*4.79*[9]	*0.5*[9]	(8)	(8)	(8)	(8)	(8)	**Yes**
Inorganics (mg/kg)													
ALUMINUM	29,700	24200/33,000[10]	-	-	-	-	-	*9.0*	Raccoon	*90*	*900*	Raccoon	No
ARSENIC	19.8	12	*8.20*	70	*7.24*	41.6	*7.24*	*0.59*	Raccoon	*5.9*	59	Raccoon	**Yes**
BARIUM	53.8	28	-	-	-	-	-	23.8	Raccoon	232	2,320	Heron	No
COBALT	5.6	2.6	-	-	-	-	-	**4.66**	Raccoon	46.6	466	Raccoon	**Yes**
COPPER	46.9	1.5	**34**	270	**18.7**	108	**18.7**	(8)	(8)	(8)	(8)	(8)	**Yes**
IRON	28,000	24,000	-	-	-	-	-	*233*	Raccoon	*2,330*	*23,300*	Raccoon	No
LEAD	105	21	**46.7**	218	**30.2**	112	**30.2**	*6.28*	Heron	**62.8**	628	Heron	**Yes**
MERCURY	0.35	0.09	**0.15**	0.71	**0.13**	0.7	**0.13**	*0.036*	Heron	**0.117**	1.17	Raccoon	**Yes**
SELENIUM	1.1	ND	-	-	-	-	-	**0.93**	Raccoon	1.54	15.4	Raccoon	**Yes**
THALLIUM	0.62	0.41	-	-	-	-	-	*0.034*	Raccoon	*0.34*	3.4	Raccoon	**Yes**
VANADIUM	63.7	50	-	-	-	-	-	*0.98*	Raccoon	*9.8*	98	Raccoon	**Yes**
ZINC	159	45	**150**	410	**124**	271	**124**	**80.6**	Heron	728	7,280	Heron	**Yes**

1 For inorganics, the presented value is the MCRD Parris Island Background Value (TtNUS, 1999). For pesticides, the presented value is the MCRD Parris Island Typical Facility Pesticide Concentration (TtNUS, 1999).
2 Long, et al., 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management. 19(1):81-97.
3 MacDonald, D. D., 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. FDEP.
4 U.S. EPA (United States Environmental Protection Agency), 1995. U.S. EPA Region IV Sediment Screening Values, Supplemental Guidance to RAGS – Bulletin Number 2, U. S. EPA Region IV, November.
5 Minimum no observable adverse effects level calculated for the raccoon, heron, mummichog, red drum, and eagle. The receptor that corresponds to this value is also listed.
6 Minimum low observable adverse effects level calculated for the Raccoon, Heron, Mummichog, Red Drum, and Eagle. The receptor that corresponds to this value is also listed.
7 Criteria for Total PCBs.
8 This analyte was not retained for protection of food-chain receptors. For these chemicals, HQs using maximum detected concentrations were less than 1.0.
9 Value for total chlordane.
10 The first value (24,200 mg/kg) is the MCRD Parris Island background value for aluminum. The second value is a typical eastern United States background soil value for aluminum (USGS, 1984).

CLP – Contract Laboratory Protocol
ER-L = Effects Range-Low
ER-M = Effects Range-Median
"-" = Not Applicable or Not Available
ND = Non-Detected Value
NA = Not applicable or not available
ND = Non Detected Value
PEL = Probable Effects Level
PQL = Practical Quantitation Limit

Shaded and bold values indicate that the criterion has been exceeded.
Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background or the typical facility pesticide concentration.

4.0 IDENTIFICATION, SCREENING, AND DEVELOPMENT OF REMEDIAL ACTION/CORRECTIVE MEASURE ALTERNATIVES

4.1 INTRODUCTION

This section presents the identification and screening of remedial technologies and the development of remedial action/corrective measure alternatives formulated to achieve RAOs/CAOs for Site 3. The identification and screening of technologies and the development of alternatives are based upon the information presented in Section 3.0 and involve the following activities:

- Identification of technologies and applicable process options.
- Screening of potential technologies and applicable process options.
- Development of alternatives by assembling the remaining technologies into alternatives that have the potential to achieve the defined RAOs/CAOs.

4.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies potential remedial technologies and process options that may be used to achieve RAOs/CAOs. Technologies and process options can be grouped according to general response actions. Alternatives are then formulated by combining general response actions to address the RAOs/CAOs. The categories of general response actions that could be implemented to achieve or address the RAOs/CAOs for Site 3 include

- No action
- Institutional controls (land use controls)
- Containment
- Removal
- Treatment
- Disposal

Each of the general response actions is discussed below (Sections 4.2.1 through 4.2.6).

4.2.1 <u>No Action</u>

No action is a general response action wherein the status quo is maintained at the site. No action is normally retained to provide a baseline for comparison with other alternatives. No additional activities would be conducted at the site to address existing soil and sediment contamination. There are no

implementability concerns, because the contaminated media are considered to be left "as is". Institutional controls, containment, removal, treatment, or other mitigating actions are not provided to reduce the potential for exposure.

4.2.2 Institutional Controls (Land Use Controls)

Access controls (e.g., physical barriers) and/or site development through the MCRD Parris Island Master Plan and Land Use Control Assurance Plan (LUCAP) and the Site 3 Land Use Control Implementation Plan (LUCIP) are institutional control options that may be considered for implementation to reduce or control pathways of exposure to hazardous substances at the site. Controls could involve the use of such measures as groundwater use restriction or surface soil, sediment, and groundwater monitoring networks. The application of institutional controls alone does not reduce the volume, mobility, and toxicity of the contaminants.

4.2.3 Containment

Containment involves the application of physical measures to reduce the potential for contaminant migration and thereby reduce the risk from both chemical and physical exposure to the public and the environment. The contaminated media must be isolated from the primary transport mechanisms (i.e., wind, erosion, surface water, and groundwater) to reduce the migration of contaminants. Contaminated media are isolated by the installation of surface and subsurface barriers that either block or divert any transport media from the contaminants.

4.2.4 Removal

Removal action is a general response action wherein technologies are used to move contaminated media from its present location in order to be treated and/or disposed elsewhere. Treatment and/or disposal process options can be combined with removal process options to develop alternatives.

4.2.5 Treatment

The treatment response action, including both in-situ and ex-situ treatment process options, includes physical, chemical, biological, solidification or thermal technologies designed to reduce the mobility, toxicity, and/or volume of the contaminants present. Treatment can be used with removal and disposal process options to develop alternatives.

4.2.6 Disposal

Disposal technologies include placement of removed or treated materials in an on-site or an off-site permanent disposal facility. Removal options and possibly treatment options can be used with disposal process options to develop alternatives. The toxicity, mobility, or volume of the contaminants is not reduced through the singular application of disposal. This response action would reduce or control exposure pathways related to direct human contact with contaminated material.

4.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SURFACE SOIL AND SEDIMENT

In this section, technologies and process options are identified under each general response action (discussed in Section 4.2) and screened at a preliminary level to focus on relevant technologies and process options. In Section 4.5, screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected in Section 4.6 to represent the technologies that have passed the detailed evaluation and screening.

Tables 4-1 and 4-2 summarize the preliminary screening of technologies and process options applicable to surface soil and sediment. It presents the general response actions, identifies the technologies and process options, and provides a brief description of each process option followed by the screening comments. All technologies and process options that are not eliminated because of implementation concerns will be evaluated in greater detail in Section 4.5.

4.4 EVALUATION CRITERIA

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening in Section 4.3 are effectiveness, implementability, and cost. The following are descriptions of the evaluation criteria:

- Effectiveness
  - Protection of human health and environment; reduction in toxicity, mobility, and volume; and permanence of solution
  - Ability of the technology to address the estimated areas or volumes of contaminated media
  - Ability of the technology to meet the remediation goals identified in the remedial action objectives
  - Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions

- Implementability
  - Overall technical feasibility at the site

- Availability of vendors, mobile units, storage and disposal services, etc
- Administrative feasibility
- Special long-term maintenance and operation requirements

- Cost (Qualitative)
  - Capital cost
  - Operation and maintenance (O&M) costs

All of the items listed above may not apply directly to each technology and, therefore, will be addressed only as appropriate. Screening evaluations at this stage generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Technologies whose use would be precluded by waste characteristics and inapplicability under the given site conditions are screened and eliminated from further consideration. Each technology presented in this section is not necessarily intended to be implemented alone because it may be combined with other technologies into remedial action alternatives.

4.5 FINAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SURFACE SOIL AND SEDIMENT

4.5.1 Technologies and Process Options for Surface Soil

The final screening of technologies and process options is based on the evaluation criteria described in Section 4.4. The following are the surface soil technologies and process options that passed preliminary screening and remain for final screening.

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Institutional Controls	Access/Use Restrictions	Limited Site Access Site Development Restrictions
	Monitoring	Surface Soil, Sediment, Surface Water, Groundwater Monitoring
Containment	Soil Cover	Native Soil
	Capping	Single Layer Cap/Multilayer Cap
	Bank Revetment (Slope Stabilization and Erosion Control Measures)	Riprap, gabions, erosion control matting, vegetation, resloping of banks

4.5.1.1 No Action

No action consists of maintaining status quo at the site. No action is retained as a baseline for comparison purposes.

Effectiveness

No action would not be effective in achieving the RAOs/CAOs for surface soil where human and ecological exposure to impacted surface soil would continue. Migration of waste material and surface soil COCs to the adjacent sediment and surface water would continue.

Implementability

There are no implementability concerns with no action.

Cost

There are no costs associated with no action.

Conclusion

No action is retained as required by NCP to provide a baseline comparison.

4.5.1.2 Institutional Controls (Land Use Controls) and Monitoring

Institutional controls (land use controls) are measures for reducing contact with contaminated media. Such measures could include restrictions to on-site access that include signs, fencing, and/or security gates near the entrances of the causeway to prohibit unauthorized site access. Site development restrictions may be imposed to allow only non-residential development and restrictions on construction practices and prohibit use of groundwater as a drinking source. Monitoring could be conducted that would involve the collection of environmental samples such as groundwater, soil, surface water, and sediment, followed by analysis for target contaminants to determine whether conditions are changing.

Effectiveness

Restrictions to limit site access would not reduce the exposure of the existing maintenance worker and the future construction worker to surface soil. These individuals would still be required to conduct activities associated with causeway and road maintenance and potential construction. Fencing and security gates near the entrances to the causeway would not be effective for protecting ecological receptors.

Site development restrictions would be effective in reducing exposure risks. Restrictions could be implemented to prohibit use of groundwater as a drinking water source. Since the groundwater is predominantly saline, residential use of the groundwater is unlikely. Also, restrictions could be imposed to allow only nonresidential development although the causeway's use as a residential area is unlikely because of the physical characteristics of the site (long, narrow road with steep banks). Restrictions for prohibiting unauthorized intrusive activity could include provision for site workers to wear proper personal protection equipment (PPE) during such activities.

Sampling and analysis of environmental media by themselves are ineffective in minimizing the migration of contaminants in the environment, but they can be used for assessing the migration of contaminants. In particular, they can be used to determine if actual migration of contaminants is occurring or if contaminants are attenuating through natural processes such as biodegradation, advection, adsorption, and dilution. Sampling and analysis of environmental samples would also be required to aid in assessing the effectiveness of remedial activities.

Implementability

The institutional controls listed above are readily available and implementable. Site access and development restrictions could be implemented by incorporating the restrictions into the MCRD Parris Island Master Plan and LUCAP, as well as the LUCIP for the site.

Cost

Costs of access/use restrictions are low. Costs associated with sampling and analysis are also low.

Conclusion

Retain the use of institutional controls to enforce access/use restrictions. Controls could include restrictions on fish consumption, unauthorized intrusive activities, groundwater usage, and residential development. Fencing and security gates at the causeway's entrances would not be an effective method of reducing exposure risks and should not be retained. Monitoring could be implemented to ensure that remedial actions are effective. These controls could be considered as a stand-alone option or could be used in conjunction with other remedial alternatives addressed in this FS/CMS.

4.5.1.3 Containment

The technologies considered under containment are soil cover with native soil, capping, and slope stabilization and erosion control measures. These remedial alternatives serve different purposes in containment and are not mutually exclusive.

4.5.1.3.1 Soil Cover with Native Soil

This technology involves covering impacted areas with native soils to minimize human and ecological exposure. The native soil cover would also reduce the transport of impacted media. This technology would be coupled with revegetation and other control measures to minimize erosion.

Effectiveness

This alternative would reduce risk associated with human and ecological exposure to impacted surface soil at the site, as well as reduce the erosion of impacted surface soil due to surface water runoff, waves, and/or wind.

Implementability

Applying a native soil cover is fully implementable. It is anticipated that borrow sources of cover soil can be identified on or relatively close to the MCRD. The main concern with the implementation of the soil cover is the maintenance of the soil cover under the influence of natural (erosion and slope failure) and human interferences (uncontrolled excavations). However, since the site is under federal control, human interferences can be minimized.

Cost

This alternative has a relatively low capital cost compared to other alternatives. Capital costs would include the purchase cost (if any) and transportation costs of the native soil, labor associated with applying the soil, and equipment (e.g., loaders) costs. O&M costs are relatively low and would involve periodic soil application to areas that have been eroded through wave action, rainfall, or wind.

Conclusion

Retain native soil cover for use with other remedial alternatives for impacted surface soils at Site 3.

4.5.1.3.2 Capping

Multilayer caps consist of layers of soil, clay, and/or synthetic materials placed over contaminated areas. Materials used in the construction of such caps include clay or synthetic, low-permeability material such as low-density polyethylene (LDPE) or polyvinyl chloride (PVC). Low-permeability caps composed of synthetic material or clay are also suited for reducing contaminant migration to groundwater due to rainfall infiltration and surface runoff. The purpose of the cap at Site 3 would be to minimize the potential for human and ecological contact with the soil and to reduce erosion of impacted surface soil due to surface water runoff, waves, and/or wind.

Effectiveness

Multilayer caps can be effective in reducing risk associated with human and ecological exposure to contaminated media beneath the cap. Multilayer caps can also be effective in reducing the infiltration of rainfall/surface water runoff into the wastes beneath the cover. However, because groundwater is not significantly impacted by site contaminants and waste materials have been subject to leaching at the site for over 25 years, current site COCs are expected to have a low leaching potential and reduced infiltration is not a requirement.

Implementability

Capping is a common remedial alternative and would be fully implementable. Synthetic materials are readily available from several vendors and the materials are commonly used. It is anticipated that borrow sources can be identified relatively close to the base. The main concern with the implementation of the cap is its maintenance under the influence of natural and human interferences. However, since the site is under federal control, human interferences can be minimized.

Cost

Costs of caps are moderate to high, depending on the materials and labor involved in placement. O&M costs for caps are typically low to moderate.

Conclusion

Do not retain multilayer caps. The primary advantage of a multilayer cap over a soil cover is to reduce the infiltration and therefore the leaching potential. Due to the anticipated low leaching potential of the surface soil COCs, a multilayer cap is not warranted.

4.5.1.3.3 Slope Stabilization and Erosion Control Measures

Slope stabilization and erosion control measures consist of methods for minimizing the potential for failure of the causeway's sideslopes and reducing the erosion rate of the surface soil due to surface water runoff, waves, and/or wind. Slope stabilization measures could include riprap or gabions at the toe of slope to function as a toe fill buttress. Erosion control measures could consist of providing a vegetated cover, erosion control matting, gabions, and/or riprap on the causeway landfill as required to control erosion. Typically, vegetation is seeded on flatter grades, whereas riprap material and other devices are used on steeper grades. The type and extent of slope stabilization and erosion control measures implemented are a function of site conditions, which include the shear strength of the materials comprising the causeway landfill and underlying soil, geometry, location (pond or marsh side), and water surface elevations.

Effectiveness

Slope stabilization methods could be an effective way to minimize the potential failure of the sideslopes of the causeway. However, to determine whether these measures would be adequate in the long term to protect against failure from weather and seismic events, additional loading, and other factors, geotechnical study would be required. Erosion control measures would be an effective way of reducing the transport of impacted surface soil and waste material to sediment and surface water.

Implementability

The construction of stabilization and erosion control measures could be implemented. The main concern with the implementation of the soil cover is the maintenance of the soil cover under the influence of natural and human interferences. However, because the site is under federal control, human interferences can be minimized.

Cost

The cost of implementation of slope stabilization and erosion control measures are moderate to high.

Conclusion

Retain the use of slope stabilization and erosion control measures as an effective means of minimizing failure of the causeway's sideslopes and reducing the migration of contaminated material into the environment.

4.5.2 Technologies and Process Options for Sediment

The final screening of technologies and process options is based on the evaluation criteria described in Section 4.4. The following are the sediment technologies and process options that passed preliminary screening and remain for final screening.

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Institutional Controls	Access/Use Restrictions	Limited Site Access Site Development Restrictions
	Monitoring	Surface Soil, Sediment, Surface Water, Groundwater Monitoring
Removal	Bulk Excavation	Bulk Excavation
	Dredging	Dredging
In-Situ Treatment	Biological	Natural Attenuation
Disposal	On-Site Consolidation/ Disposal	On-Site Consolidation/ Disposal
	Off-Site Disposal	Permitted Treatment/Storage/Disposal Facility

4.5.2.1 No Action

No action consists of maintaining status quo at the site. No action is retained as a baseline for comparison purposes.

Effectiveness

No action would not be effective in achieving the RAOs/CAOs for sediment where human and ecological exposure to impacted sediment would continue. The identified risks are primarily associated with localized population of macroinvertebrate. However, some hot spot areas can represent a potential risk to human and food chain receptors (raccoon, heron, and eagle). Migration of sediment COCs to surface water would continue.

Implementability

There are no implementability concerns.

Cost

There are no costs associated with no action.

Conclusion

No action is retained as required by NCP to provide a baseline comparison.

4.5.2.2 Institutional Controls (Land Use Controls) and Monitoring

Institutional controls (land use controls) are measures for reducing contact with contaminated media. Such measures could include restrictions for on-site access that include signs, fencing, and/or security gates near the entrances of the causeway to prohibit unauthorized site access. Site development restrictions may be imposed to allow only non-residential development. Monitoring could be conducted that would involve the collection of environmental samples followed by analysis for target contaminants to determine whether conditions are changing.

Effectiveness

Institutional controls and monitoring would be partially effective. They would not address potential risks to ecological receptors. For human health considerations, (adult recreational user), exposure risks are attributed to fish consumption where the concentration of contaminants in fish have bioaccumulated from fish exposure to sediment. As concluded in the baseline HHRA, estimated risk associated with fish consumption by the adult recreational user are within the U.S. EPA acceptable ILCR risk range of 1.0E-06 to 1.0E-04 when lower fish ingestion rates are used in lieu of the U.S. EPA's default fish consumption assumptions. As a result, signs warning of risks associated with high fish consumption rates could be an effective method for reducing risks to the adult recreational user.

Sampling and analysis of environmental media by themselves are ineffective in minimizing the migration of contaminants in the environment, but they can be used for assessing the migration of contaminants. In particular, they can be used to determine if actual migration of contaminants is occurring or if contaminants are attenuating through natural processes such as biodegradation, advection, adsorption, and dilution. Sampling and analysis of environmental samples would also be required to aid in assessing the effectiveness of remedial activities.

Implementability

The institutional controls listed above are readily available and implementable. Site access and development restrictions could be implemented by incorporating the restrictions into the MCRD Parris Island Master Plan and LUCAP, as well as the site's LUCIP.

Cost

Costs of access/use restrictions are low. Costs associated with sampling and analysis are also low.

Conclusion

Retain the use of institutional controls to enforce access/use restrictions. Controls could include restrictions on fish consumption and residential development. Monitoring could be implemented to ensure that remedial actions are effective. Although institutional controls may not be protective of ecological receptors, they could be considered as a stand-alone option or could be used in conjunction with other remedial alternatives addressed in this FS/CMS.

4.5.2.3 Removal

Bulk excavation and dredging are two types of removal alternatives that are under consideration for sediment. Bulk excavation would apply to sediment in the event that the water level of the pond is lowered to accommodate removal. If the level of the pond is not lowered, dredging could be performed to remove sediment. Migration of some contaminated sediment would occur. Excavation can be performed by a variety of equipment, such as tractor shovels (front-end loaders), backhoes, grade-alls, etc. Dredging can be performed by clamshells, draglines, etc. The type of equipment selected must take into consideration several factors, such as type of material, load-supporting ability of the soil, rate of excavation required, depth of excavation, etc. Usually power shovels, draglines, clamshells, or backhoes are used for deep excavation and/or when required excavation rates are high. These types of equipment are typically mounted on mobile units and operated hydraulically.

Effectiveness

Excavation/dredging can be effective in removing contaminated material from the site because it is applicable to the complete range of contaminant groups with no particular target group. Additionally, the volume of contaminated sediment does not prohibit the use of such measures. Confirmatory sampling is required to verify the completion of the removal action. Samples must be taken from the exposed faces of the excavation area and analyzed for the COCs to ensure that the residual material is not contaminated at unacceptable levels. Bulk excavation/dredging may require the use of temporary containment measures to minimize the migration of contaminated sediments into the surface waters (e.g., cofferdams or silt fences) during removal activities.

Implementability

The availability of excavation/dredging equipment is not of concern. The technology is well proven and established in the construction/remediation industry. Because the causeway is more than 10 feet in elevation above the sediment and a steep slope separates the top of the causeway and the sediment, implementation of bulk excavation/dredging could be hindered to the equipment access problems. During sediment removal, OSHA requirements must be met to ensure that the exposure of the workers to COCs is minimized.

Cost

Excavation/dredging costs are directly proportional to the extent of excavation required but are typically low. Excavation/dredging costs also depend upon the accessibility of the sediments.

Conclusion

Retain excavation/dredging of sediment for further consideration in the development of remedial alternatives/corrective measures.

4.5.2.4 In-Situ Treatment: Natural Attenuation

Based on the results of the preliminary screening section, this section evaluates one in-situ treatment technology for sediment, natural attenuation. Under natural attenuation, concentrations of site COCs would gradually decrease due to processes such as biodegradation, advection, dispersion, adsorption, and dilution. PAHs, pesticides, and PCBs can biodegrade naturally under certain conditions. Concentrations of inorganics can diminish over time due to natural processes such as advection and dispersion.

Effectiveness

The primary COCs in sediment consist of PAHs, pesticides, and PCBs. The concentrations of PAHs in sediment would be expected to be reduced through biodegradation. Half-lives for the PAHs of concern in sediment are not available, although PAH half-lives in soil range from 50 days to 2.72 years (Howard, 1991). Pesticides and PCBs in sediment would also biodegrade, but at a much slower rate where half-lives for several pesticides are reported in periods of years (Howard, 1991). To determine whether concentrations of sediment contaminants are attenuating over time, it would be necessary to monitor the sediments and surface water.

Implementability

Methods, equipment, and personnel to conduct monitoring activities are readily available and implementable.

Cost

Costs associated with sampling and analysis are low.

Conclusion

Retain the use of natural attenuation as a technology for sediment.

4.5.2.5 Disposal

4.5.2.5.1 On-Site Consolidation/Disposal

On-site consolidation/disposal of contaminated sediment would involve dredging and dewatering of impacted areas followed by consolidation on the causeway with a cover. Monitoring of groundwater would be required to detect any migration of contaminants.

Effectiveness

On-site consolidation/disposal can be effective for the impacted sediment. This technology is especially effective if the wastes are nonhazardous and dredging and disposal does not trigger federal LDRs as would be expected with the impacted sediment at Site 3. Because the sediment is expected to have a low leaching potential, the use of a multilayer cap would not be required to reduce rain infiltration and the use of a soil cover would be adequate to minimize human and ecological contact with impacted sediment. Excavated over-sized debris would not be suitable for placement under the cover and would be loaded into suitable containers for transportation and disposal off site.

Implementability

On-site disposal technologies can be implemented. Consolidation and placement of a cover or multilayer cap is easily implementable. Excavation and deposition activities may expose the workers to the contaminants present in the sediment, but adequate PPE and observance of OSHA requirements can

address potential health concerns. Potentially, land use controls and the base master plan would be required on any site where wastes are allowed to remain with or without treatment.

Cost

Capital and O&M costs of on-site consolidation with a cover are low to moderate.

Conclusion

Retain on-site consolidation/disposal of sediment for further consideration in the development of remedial alternatives. Sediments would be dewatered and placed under a soil cover as required.

4.5.2.5.2 Off-Site Disposal

Off-site disposal involves transport of dredged sediment to an off-site disposal facility. A permitted treatment, storage, and disposal facility would be required for any hazardous waste, as defined by RCRA. In addition, LDRs currently require that some hazardous wastes be treated to render them nonhazardous prior to disposal. A permitted, solid waste disposal facility would be used for all nonhazardous waste, as defined by RCRA.

Effectiveness

Off-site landfilling is effective because contaminated media are taken off site, and minimal residual risks would remain. Landfills are effective at isolating wastes from the environment. The waste-specific requirements vary from state to state and by individual landfills. The selection is based on waste-specific effectiveness, permitting, and cost considerations.

Implementability

Off-site landfilling of soil wastes is implementable. Permitting requirements are variable based on the particular state and landfill. In general, the more protective a landfill is, the easier it is to obtain waste approval. Dewatering of the sediments would be required prior to disposal.

Cost

The cost of off-site landfilling is highly variable, ranging from low to high for nonhazardous and hazardous waste landfills, respectively.

Conclusion

Except for over-sized debris found within sediment, eliminate off-site disposal of excavated sediment for further consideration in the development of remedial alternatives due to cost.

4.6 SUMMARY OF SCREENING AND SELECTION OF REPRESENTATIVE PROCESS OPTIONS FOR SURFACE SOIL AND SEDIMENT

Based on the screening process conducted in Sections 4.5, the following technologies have been retained and are summarized as follows.

Selected Technologies and Process Options for Surface Soil

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Institutional Controls	Access/Use Restrictions	Limited Site Access Site Development Restrictions
	Monitoring	Monitoring
Containment	Soil Cover	Native Soil
	Bank Revetment (Slope Stabilization and Erosion Control Measures)	Riprap, gabions, erosion control matting, vegetation, resloping

Selected Technologies and Process Options for Sediment

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Institutional Controls	Access/Use Restrictions	Limited Site Access Site Development Restrictions
	Monitoring	Monitoring
Removal	Bulk Excavation Dredging	Bulk Excavation Dredging
In-Situ Treatment	Biological	Natural Attenuation
Disposal	On-Site Consolidation/ Disposal	On-Site Consolidation/ Disposal
	Off-Site Disposal	Permitted Treatment/Storage/Disposal Facility

4.7 IDENTIFICATION OF REMEDIAL ACTIONS/CORRECTIVE MEASURE ALTERNATIVES FOR SITE 3

This section describes alternatives for Site 3 considering the information provided in the previous sections. Alternatives are briefly explained in this section and a detailed description and evaluation of each alternative is provided in Section 5.0.

Alternatives were developed that address the COCs and exposure pathways in order to achieve the RAOs/CAOs. Alternatives were developed to show a range of alternatives to address all contaminants that could potentially effect ecological and human receptors.

The following alternatives have been developed for Site 3:

- Alternative 1 - No Action: This alternative is developed per the NCP to provide a baseline for comparison to other alternatives.

- Alternative 2a – Partial Containment: This alternative is developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection would be achieved by assuring that a minimum of two feet of clean soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. In addition, in areas where a concern to only terrestrial ecological receptors is present under the *high*-risk scenario, a minimum of 1 foot of soil cover would be placed. The soil cover described in this alternative would be placed over the southeast half of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway). Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

- Alternative 2b – Full Containment: This alternative is also developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection is achieved by assuring that a minimum of two feet of soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. Alternative 2b provides equal protection to human health as Alternative 2a; however, Alternative 2b is more protective of terrestrial ecological receptors. In areas where a concern to only terrestrial ecological receptors is present under the *low*-risk scenario, a minimum of 1 foot of soil cover would be placed. As a result of the evaluation, the soil cover described in this alternative would be placed over the entire length of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway).

Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

- Alternative 3a – Partial Containment with Further Sediment Evaluation: Alternative 3a consists of all the components of Alternative 2a; however, Alternative 3a also contains components for the intentional delineation and potential covering or excavating of the more contaminated sediment found on the pond side of the causeway. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

- Alternative 3b – Full Containment with Further Sediment Evaluation: Alternative 3b consists of all the components of Alternative 2b; however, Alternative 3b also contains components for the intentional delineation and potential covering and excavating of the more contaminated sediment found on the pond side of the causeway. The sediment component would be the same as proposed in Alternative 3a. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

These alternatives are further described as follows.

4.7.1 Alternative 1 - No Action

The no-action alternative maintains the site at status quo. This alternative is retained to provide a baseline for comparison to other alternatives and, therefore, does not address the wastes present or impacted surface soil and sediment.

4.7.2 Alternative 2a – Partial Containment

Alternative 2a consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring. A process flow diagram detailing components of this alternative is presented in Figure 4-1. The components of Alternative 2a are summarized as follows.

A soil cover would be placed over the southeastern half of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-04 and high risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the

soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. Limited/incidental sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

Land use controls would be implemented to control or eliminate pathways of exposure to COCs at the site. Site restrictions would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates and contact with sediment. Existing "No Swimming/ Wading signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

4.7.3 Alternative 2b – Full Containment

Alternative 2b consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring. Alternative 2b is similar to Alternative 2a; however, with Alternative 2b, the soil cover is placed over the entire length of the causeway instead of the causeway's southeastern half. This action has the additional benefit of protecting terrestrial ecological receptors from surface soil COC concentrations that exceed the most stringent ecological criteria. A process flow diagram detailing components of this alternative is presented in Figure 4-2. The components of Alternative 2b are summarized as follows.

A soil cover would be placed over the entire length of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. Limited/incidental sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

Land use controls would be implemented to control or eliminate pathways of exposure to COCs at the site. Site restrictions would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates and contact with sediment. Existing "No Swimming/Wading" signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

4.7.4 Alternative 3a – Partial Containment with Further Sediment Evaluation

Alternative 3a consists of four components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, 3) Further Sediment Evaluation, and 4) Land Use Controls and Long-term Monitoring. Alternative 3a is similar to Alternative 2a; however, Alternative 3a addresses sediment as a remedial component. A process flow diagram detailing components of this alternative is presented in Figure 4-3. The components of Alternative 3a are summarized as follows.

A soil cover would be placed over the southeastern half of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where COC concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-04 and high risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to

surface water runoff, waves, and/or wind. Limited sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

After the soil cover and slope stabilization and erosion control measures are installed, sediment on the pond side of the causeway would be further delineated. Sediment in excess of clean-up goals would be either covered, excavated and consolidated on site, or allowed to naturally biodegrade in place. Additional biota testing may also be conducted to refine the clean-up goals.

Land use controls would be implemented to control or eliminate pathways of exposure to COCs at the site. Site restrictions would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates and contact with sediment. Existing "No Swimming/Wading" signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

4.7.5 Alternative 3b – Full Containment with Further Sediment Evaluation

Alternative 3b consists of four components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, 3) Further Sediment Evaluation and 4) Land Use Controls and Long-term Monitoring. Alternative 3b is similar to Alternative 2b; however, Alternative 3b addresses sediment as a remedial component. A process flow diagram detailing components of this alternative is presented in Figure 4-4. The components of Alternative 3b are summarized as follows.

A soil cover would be placed over the entire length of the causeway. The cover would be placed so that a minimum of 2 feet of soil cover would be present above waste material within the causeway. Additionally, in areas where contaminant concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and low risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological exposure and to eliminate the migration of impacted surface soil to surface water due to surface water runoff and/or wind. After placement of the soil cover, an asphalt road would be constructed along the length of the causeway. To reduce infiltration, drainage ditches would be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential of failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. Limited sediment excavation or covering along the base of the causeway may be required as part of the implementation of these measures.

After the soil cover and slope stabilization and erosion control measures are installed, sediment on the pond side of the causeway would be further delineated. Sediment in excess of clean-up goals would be either covered, excavated and consolidated on site, or allowed to naturally biodegrade in place. Additional biota testing may also be conducted to refine the clean-up goals.

Land use controls would be implemented to control or eliminate pathways of exposure to COCs at the site. Site restrictions would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Signs would also be posted to warn of risk associated with high fish ingestion rates and contact with sediment. Existing "No Swimming/Wading" signs would be maintained. Annual sediment and groundwater sampling and inspections of the soil cover would be performed to ensure the integrity and effectiveness of the soil cover and slope stabilization and erosion control measures. Sampling results would be reported to the regulatory agencies annually. A reevaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

TABLE 4-1

PRELIMINARY SCREENING OF REMEDIATION TECHNOLOGIES FOR SURFACE SOIL
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
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TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS	OPTION RETAINED
		GENERAL RESPONSE ACTION: NO ACTION		
No Action	No Action	No activities conducted to address contamination.	Retained as baseline for comparison.	Yes
		GENERAL RESPONSE ACTION: INSTITUTIONAL CONTROLS		
Institutional Controls (1)	Limited Site Access	Physical barrier used to restrict access to the site.	Physical restrictions could be effective in reducing human exposure to site contaminants. Does not reduce contaminant exposure to ecological receptors.	Yes
	Site Development Restrictions	Administrative action used to restrict future site use.	Administrative action is used to reduce human exposure to site contaminants. Does not reduce contaminant exposure to ecological receptors.	Yes
	Monitoring	Sampling and analysis of environmental media to assess contaminant migration and future environmental impacts.	Effective only to assess contaminant levels on site and migration off site. Can be used to determine if conditions are changing and to determine whether remedial actions/corrective measures are effective.	Yes
		GENERAL RESPONSE ACTION: CONTAINMENT		
Soil Cover	Native Soil	Layer of native soil is placed over the site to reduce human and ecological exposure to impacted surface soil. The soil layer also reduces migration of contaminants.	Would provide a barrier for potential human and ecological exposure pathways and reduce transport of COCs in soil to sediment and surface water.	Yes
Capping	Clay Cap/Synthetic Membrane/ Asphalt/ Concrete	Use of low permeability materials constructed over the site to provide a barrier to water infiltration and also reduce direct contact with and ingestion of chemicals, as well as migration to surface water.	Would provide a barrier for potential human and ecological exposure pathways and reduce transport of COCs in soil to sediment and surface water. Would also reduce migration water infiltration; however, groundwater is not significantly impacted by site contaminants.	Yes
Bank Revetment	Slope Stabilization and Erosion Control (2,3)	Permanent or temporary sloping of banks and/or protecting the banks with stone rip rap, vegetation, matting, etc. to stabilize slopes.	Measures for minimizing the potential slope failure of the causeway and reducing the transport of waste and impacted surface soil to nearby sediment and surface water. The type and extent of slope stabilization measures implemented are a function of site conditions which include the shear strength of the materials comprising the causeway landfill and underlying soil, geometry, location (pond or marsh side), and water surface elevations.	Yes
Vertical Barrier	Slurry Wall (2,3,4)	Soil/bentonite or soil/cement barriers are installed around waste area to isolate waste materials. This low permeable barrier restricts contaminant migration to groundwater	Groundwater is not significantly impacted by site contaminants. Do not retain.	No
Horizontal Barrier	Grout Injection (2,3,5,6)	Pressure injection of cement at depth through closely spaced drill holes to reduce contaminant migration to groundwater.	Groundwater is not significantly impacted by site contaminants. Do not retain.	No

TABLE 4-1

PRELIMINARY SCREENING OF REMEDIATION TECHNOLOGIES FOR SURFACE SOIL
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 2

TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS	OPTION RETAINED
GENERAL RESPONSE ACTION: REMOVAL				
Bulk Excavation	Bulk Excavation [2,4]	Mechanical removal of solid materials using common construction equipment such as bulldozers and highlifts.	Although a statutory preference for treatment exists for CERCLA Remedial Actions and RCRA Corrective Measures Implementations, the quantity of material at the site is too large to effectively move and significant environmental damage would result. Consequently, alternatives will not include off-site disposal for the surface soil and contents of Site 3.	No
GENERAL RESPONSE ACTION: IN-SITU AND EX-SITU TREATMENT				
In-Situ and Ex-Situ Treatment	Physical, Chemical, and Biological Treatment Processes	Physical, chemical, and biological treatment processes are employed to reduce the toxicity, mobility, and/or volume of contaminates.	Although a statutory preference for treatment exists for CERCLA Remedial Actions and RCRA Corrective Measures Implementations, the shallow depth of groundwater and the presence of an adjacent environmentally sensitive marsh preculdes in-situ and ex-situ treatment. Consequently, alternatives will not include treatment technologies for the surface soil and contents of Site 3.	No
GENERAL RESPONSE ACTION: DISPOSAL				
Disposal	On-site Consolidation/ Disposal [3,7]	Soil is excavated and characterized as required. Soil is then disposed of/consolidated on site.	Surface soil and landfill contents are already consolidated on site.	No
	Off-site Landfill [3,4,7]	Soil is excavated and characterized as required. Hazardous wastes are treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Soil is then disposed of in a secure, off-site, RCRA-permitted facility.	Although a statutory preference for treatment exists for CERCLA Remedial Actions and RCRA Corrective Measures Implementations, the quantity of material at the site is too large to effectively move and significant environmental damage would result. Consequently, alternatives will not include off-site disposal for the surface soil and contents of Site 3.	No

1 United States Environmental Protection Agency. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, October 1988.
2 Rogosnewski, P., Bryson H., and Wagner, K., JRB Associates, Inc. for the U.S. EPA. Remedial Action Technology for Waste Disposal Sites, Noyes Data Corporation.
3 Corbitt, Robert A. Standard Handbook of Environmental Engineering, McGraw-Hill Publishing Company, 1990.
4 United States Department of Defense Environmental Technology Transfer Committee. Remediation Technologies Screening Matrix and Reference Guide, Version 3.0 as of August 1999, http://www.frtr.gov/matrix2/top_page.html.
5 Kiang, Yen-Hsiung and Metry, Amir A. Hazardous Waste Processing Technology, Butterworth Publishers, 1982.
6 EM Database, January 1995. US Department of Energy Office of Environmental Management Information Posted on The Internet, January 19, 1995.
7 Dillon, A.P. Pesticide Disposal and Detoxification, Noyes Data Corporation, 1981.

TABLE 4-2

PRELIMINARY SCREENING OF REMEDIATION TECHNOLOGIES FOR SEDIMENT
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 3

TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS	OPTION RETAINED
GENERAL RESPONSE ACTION: NO ACTION				
No Action	No Action	No activities conducted to address contamination.	Retained as baseline for comparison.	Yes
GENERAL RESPONSE ACTION: INSTITUTIONAL CONTROLS				
Institutional Controls[1]	Limited Site Access	Physical barrier used to restrict access to the site.	Only effective in reducing direct contact regarding human exposure. Does not reduce contaminant exposure to ecological receptors.	Yes
	Site Development Restrictions	Administrative action used to restrict future site use.	Administrative action is used to reduce direct contact regarding human exposure. Does not reduce contaminant exposure to ecological receptors.	Yes
	Monitoring	Sampling and analysis of environmental media to assess contaminant migration and future environmental impacts.	Effective only to assess contaminant levels on site and migration off site. Can be used to determine if conditions are changing and to determine whether remedial actions/corrective measures are effective.	Yes
GENERAL RESPONSE ACTION: CONTAINMENT				
Soil Cover	Native Soil	Layer of native soil is placed over sediment to reduce human and ecological exposure to impacted sediment. The soil layer also reduces migration of contaminants.	The sediments are present in an environmentally sensitive area. Barriers placed at the site would destroy the wetlands and the cover would not be permanent in the long term because of erosion.	No
Capping	Clay Cap/Synthetic Membrane/ Asphalt/ Concrete	Use of low permeability materials constructed over the site to provide a barrier to water infiltration and also reduce direct contact with and ingestion of chemicals, as well as migration to surface water.	The sediments are present in an environmentally sensitive area. Barriers placed at the site would destroy the wetlands and the cover would not be permanent in the long term because of erosion.	No
GENERAL RESPONSE ACTION: REMOVAL				
Bulk Excavation	Bulk Excavation [2,4]	Mechanical removal of solid materials using common construction equipment such as bulldozers and highlifts.	Effective in removing contaminated sediment; however, the pond level would likely have to be lowered during construction.	Yes
Dredging	Dredging [2]	Use of mechanical, hydraulic, or pneumatic dredge to remove sediments or saturated soils.	Effective in removing contaminated sediments. A cofferdam system would likely need to be implemented to reduce contaminant migration during dredging.	Yes

TABLE 4-2

PRELIMINARY SCREENING OF REMEDIATION TECHNOLOGIES FOR SEDIMENT
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 2 OF 3

TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS	OPTION RETAINED
GENERAL RESPONSE ACTION: IN-SITU TREATMENT				
Biological	Natural Attenuation	In-situ degradation of organics using microorganisms in an aerobic/anaerobic environment.	PAHs in sediment would be reduced through biodegradation over moderate periods of time. Pesticides and PCBs in sediment would biodegrade, but at a much slower rate than the PAHs. Not applicable to inorganics.	Yes
	Enhanced Biodegradation	In-situ degradation of organics using microorganisms in an aerobic/anaerobic environment. Nutrients are injected into the sediment to promote biological activity.	Low permeability of sediment may impede distribution of nutrients and decrease the effectiveness of this technology. Also, not applicable to inorganics.	No
Thermal	Vitrification [4]	Electrodes for applying electricity are used to melt contaminated sediment, producing a glass and crystalline structure with very low leaching characteristics and destroys organics.	High water content of sediment would make vitrification or any other thermal treatment technology impractical.	No
Physical/ Chemical	Stabilization/ Solidification [2,4]	Pressure injection or mechanical mixing of cement/pozzolanic materials to form an impermeable solid and immobilize contaminants.	Not applicable to sediment. Solidified/stabilized mass would be in contact with surface water and would compromise the integrity of the solidified mass.	No
GENERAL RESPONSE ACTION: EX-SITU TREATMENT				
Physical/ Chemical	Stabilization/ Solidification [2,4]	Excavated sediment is mixed with cement lime, fly ash, or other pozzolanic materials are mixed with excavated sediment to immobilize contaminants.	The concentration of organics and inorganics in sediments is too low to consider this technology for sediments.	No
	Soil Washing/ Solvent Extraction [4]	Separating hazardous contaminants from sediments by using an organic chemical as a solvent, thereby reducing the volume of the hazardous waste.	The target contaminant groups for soil washing are SVOCs, fuels, and heavy metals. The technology can be used on selected VOCs and pesticides. The technology offers the ability for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soil/sediment; however, soil washing has limited effectiveness where soil/sediment is composed of large percentages of silt and clay.	No
Thermal	Thermal Desorption [4]	Application of heat at high temperature (200 to 1,000 °F) to remove organics from excavated sediment by volatilization. Vapor phase, typically is treated by incineration or carbon adsorption.	Technology targets remediation of high concentrations of PAHs, PCBs, and pesticides. The concentration of organics in sediments is too low to consider this technology. Most inorganics remain in the sediment and may require further treatment. Requires dewatering of sediment prior to treatment.	No

TABLE 4-2

PRELIMINARY SCREENING OF REMEDIATION TECHNOLOGIES FOR SEDIMENT
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 3 OF 3

TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS	OPTION RETAINED
GENERAL RESPONSE ACTION: EX SITU TREATMENT (continued)				
Thermal (continued)	Incineration [4,5,6]	Sediment is excavated and treated by on-site or off-site incinerator that employs thermal decomposition via thermal oxidation at high temperature to destroy organics.	Potentially applicable. An effective technology for PAHs, pesticides, and PCBs; however, the concentration of organics in sediments is too low to consider this technology. Additional treatment may be required for inorganics. Dewatering of sediments would be required prior to treatment.	No
	Vitrification [4]	Excavated sediment is melted at high temperature to form a glass and crystalline structure with very low leaching characteristics and destroys organics.	The concentration of organics in sediments is too low to consider this technology. Dewatering of sediments would be required prior to treatment.	No
GENERAL RESPONSE ACTION: DISPOSAL				
Landfill	On-site Disposal/ Consolidation [3,6]	Sediment is excavated and characterized as required. Sediment is then disposed of/consolidated on site.	Potentially Applicable.	Yes
	Off-site Landfill [3,4,6]	Sediment is excavated and characterized as required. Hazardous wastes are treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Sediment is then disposed of in a secure, off-site, RCRA-permitted facility.	Potentially Applicable.	Yes

(1) United States Environmental Protection Agency. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, October 1988.
(2) Rogosnewski, P., Bryson H., and Wagner, K., JRB Associates, Inc. for the U.S. EPA. Remedial Action Technology for Waste Disposal Sites, Noyes Data Corporation.
(3) Corbitt, Robert A. Standard Handbook of Environmental Engineering, McGraw-Hill Publishing Company, 1990.
(4) United States Department of Defense Environmental Technology Transfer Committee. Remediation Technologies Screening Matrix and Reference Guide, Version 3.0 as of August 1999, http://www.frtr.gov/matrix2/top_page.html.
(5) Kiang, Yen-Hsiung and Metry, Amir A. Hazardous Waste Processing Technology, Butterworth Publishers, 1982.
(6) Dillon, A.P. Pesticide Disposal and Detoxification, Noyes Data Corporation, 1981.

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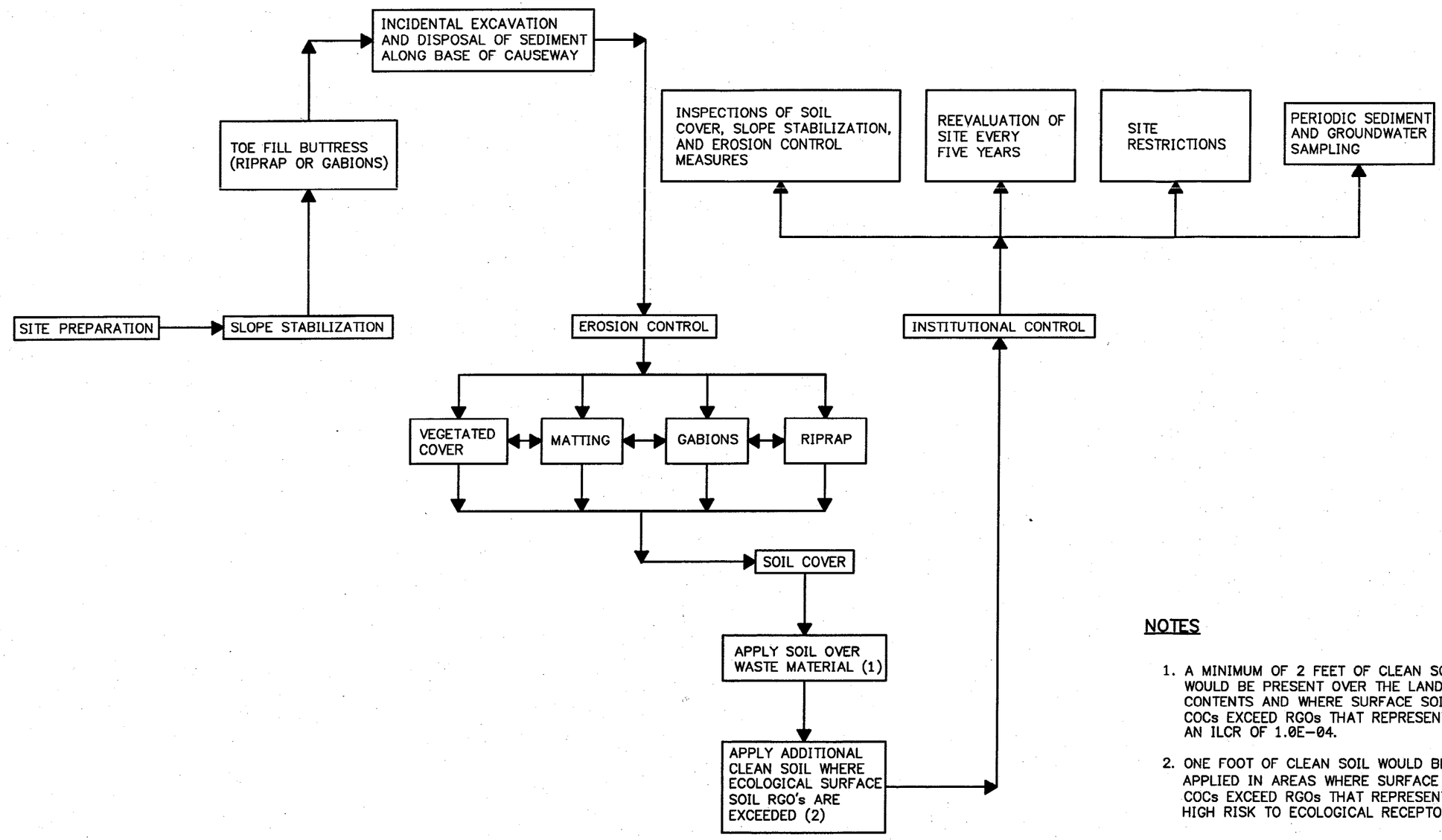

NOTES

1. A MINIMUM OF 2 FEET OF CLEAN SOIL WOULD BE PRESENT OVER THE LANDFILL CONTENTS AND WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT AN ILCR OF 1.0E–04.
2. ONE FOOT OF CLEAN SOIL WOULD BE APPLIED IN AREAS WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT A HIGH RISK TO ECOLOGICAL RECEPTORS.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY NJS DATE 7/12/99
CHECKED BY DATE
COST/SCHED–AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
SITE 3–ALTERNATIVE 2a
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4–1
REV. 0

FORM CADD NO. SOUTH-BH.DGN – REV 0 – 9/9/98

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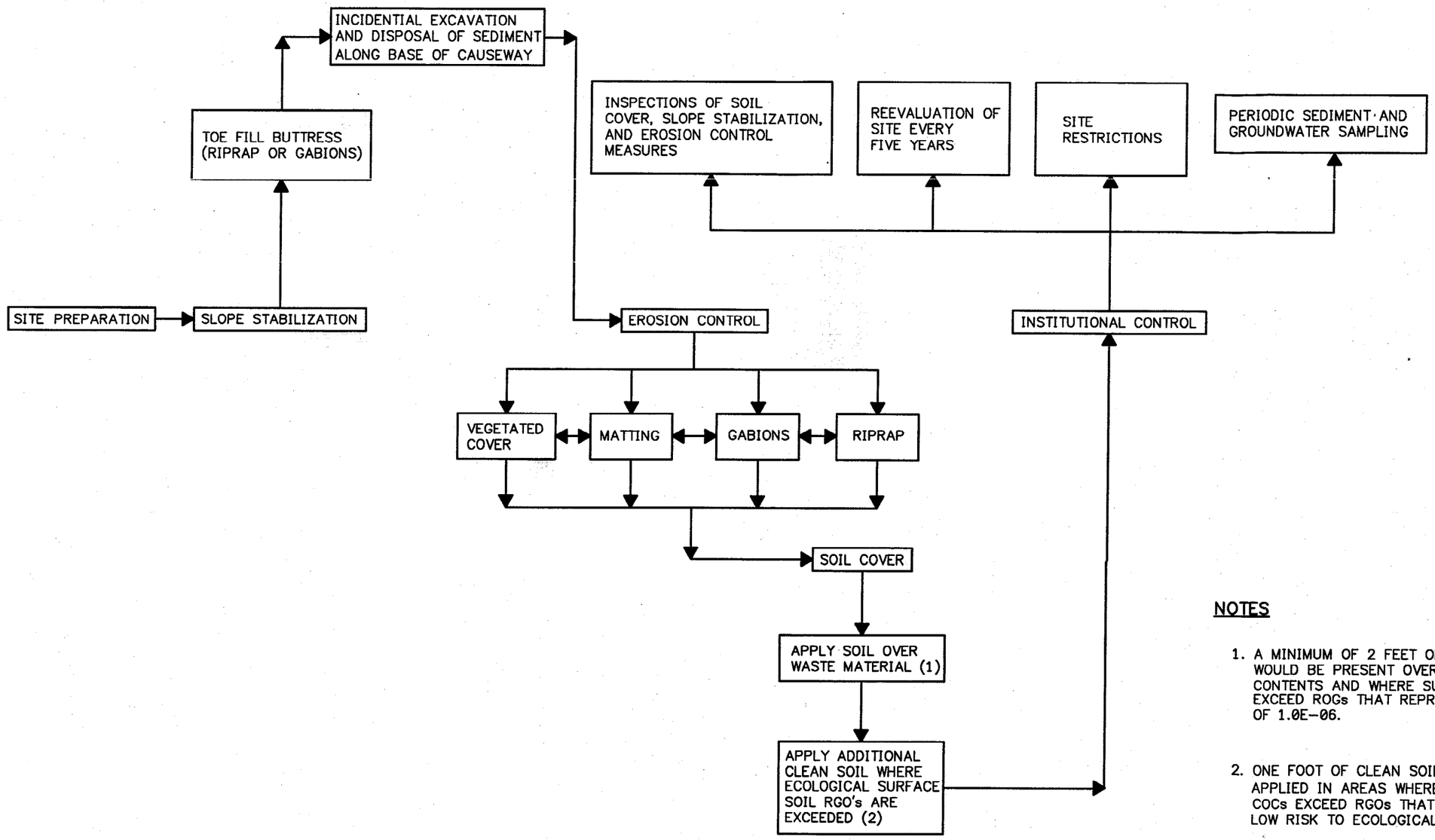

NOTES

1. A MINIMUM OF 2 FEET OF CLEAN SOIL WOULD BE PRESENT OVER THE LANDFILL CONTENTS AND WHERE SURFACE SOIL COCs EXCEED ROGs THAT REPRESENT AN ILCR OF 1.0E-06.

2. ONE FOOT OF CLEAN SOIL WOULD BE APPLIED IN AREAS WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT A LOW RISK TO ECOLOGICAL RECEPTORS.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY NJS DATE 7/12/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
SITE 3-ALTERNATIVE 2b
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-2
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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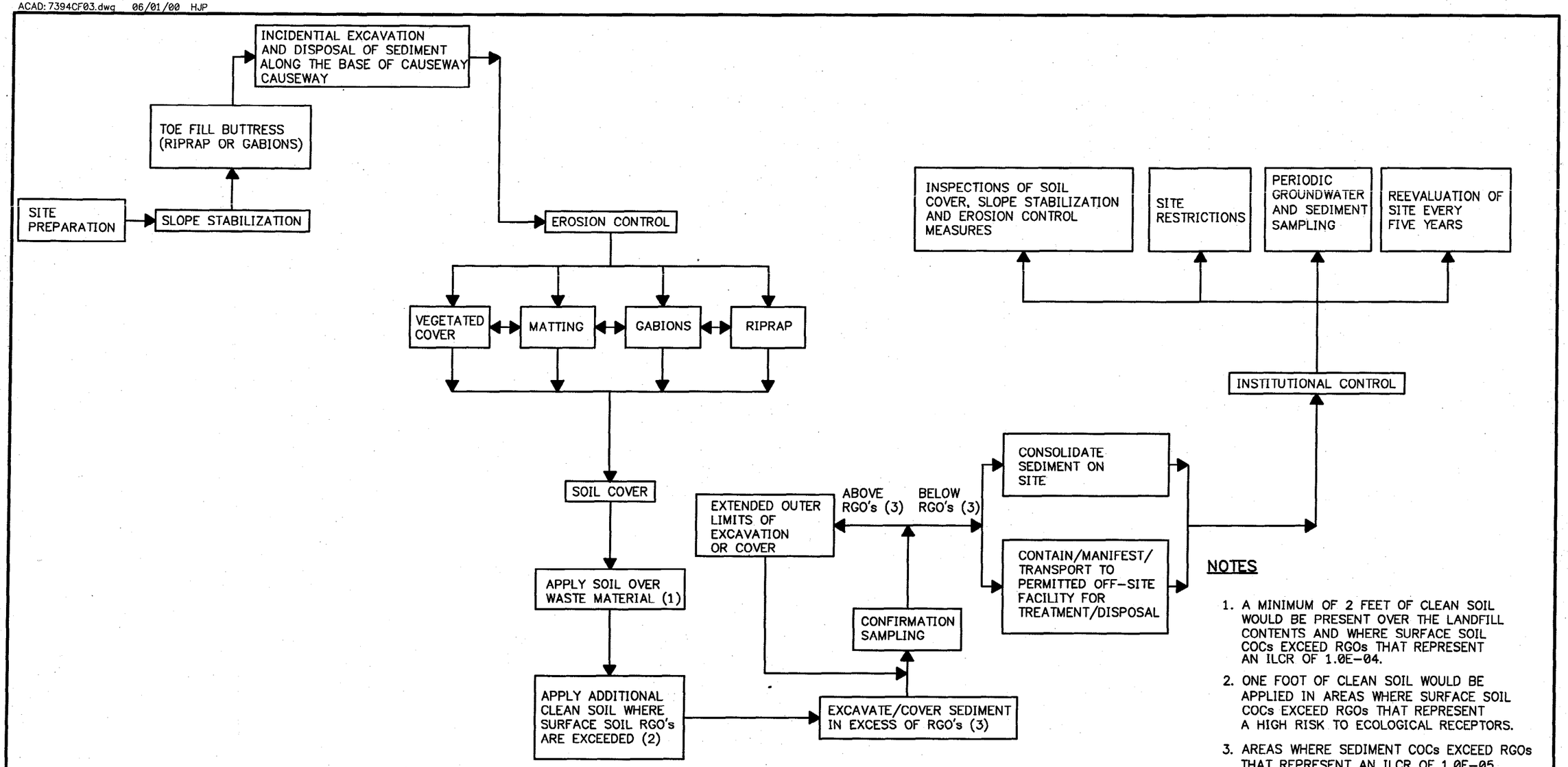

NOTES

1. A MINIMUM OF 2 FEET OF CLEAN SOIL WOULD BE PRESENT OVER THE LANDFILL CONTENTS AND WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT AN ILCR OF 1.0E-04.
2. ONE FOOT OF CLEAN SOIL WOULD BE APPLIED IN AREAS WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT A HIGH RISK TO ECOLOGICAL RECEPTORS.
3. AREAS WHERE SEDIMENT COCs EXCEED RGOs THAT REPRESENT AN ILCR OF 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS WOULD BE EXCAVATED/COVERED.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 5/24/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
SITE 3-ALTERNATIVE 3a
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-3
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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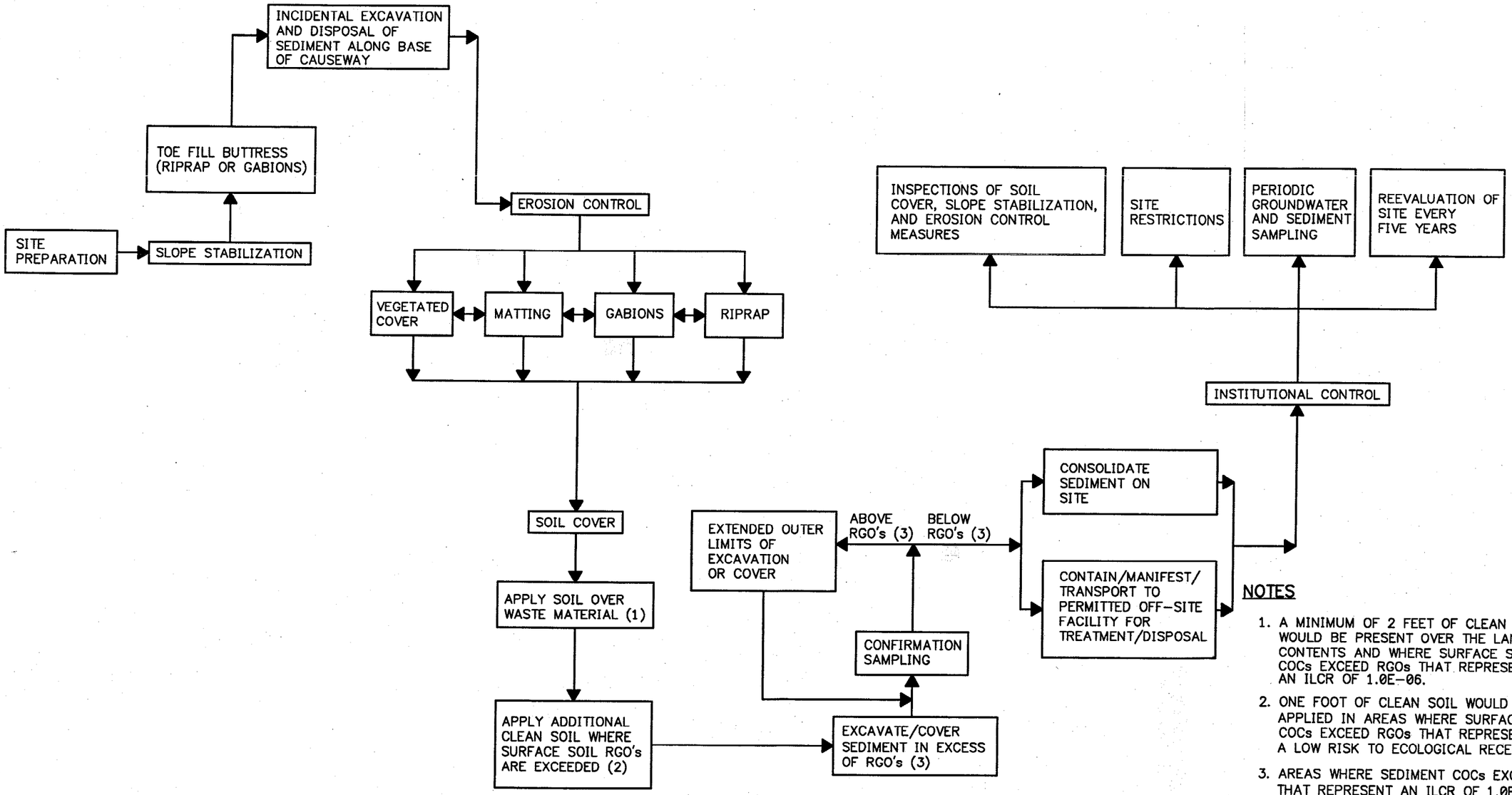

NOTES

1. A MINIMUM OF 2 FEET OF CLEAN SOIL WOULD BE PRESENT OVER THE LANDFILL CONTENTS AND WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT AN ILCR OF 1.0E-06.
2. ONE FOOT OF CLEAN SOIL WOULD BE APPLIED IN AREAS WHERE SURFACE SOIL COCs EXCEED RGOs THAT REPRESENT A LOW RISK TO ECOLOGICAL RECEPTORS.
3. AREAS WHERE SEDIMENT COCs EXCEED RGOs THAT REPRESENT AN ILCR OF 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS WOULD BE EXCAVATED/COVERED.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY NJS DATE 7/12/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
SITE 3-ALTERNATIVE 3b
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-4
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

5.0 EVALUATION OF REMEDIAL ACTION/CORRECTIVE MEASURES ALTERNATIVES

This section presents a detailed description of each remedial action/corrective measures alternative developed in Section 4.0, the rationale used in evaluating each alternative, and the results of the evaluation for each specific evaluation standard. The evaluation of alternatives is conducted in accordance with the U.S. EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988) and RCRA Corrective Action Plan (Final) (U.S. EPA, 1994).

5.1 REMEDIAL ACTION/CORRECTIVE MEASURES ALTERNATIVES

This section describes in detail the remedial action/correctives measure alternatives developed in Section 4.0. The following alternatives have been developed for Site/SWMU 3 (Site 3):

- Alternative 1 - No Action
- Alternative 2a – Partial Containment
- Alternative 2b – Full Containment
- Alternative 3a – Partial Containment with Further Sediment Evaluation
- Alternative 3b – Full Containment with Further Sediment Evaluation

These alternatives are described as follows.

5.1.1 Alternative 1 - No Action

The No Action alternative maintains the site at status quo. This alternative is retained to provide a baseline for comparison to other alternatives and, therefore, does not address the wastes present or impacted surface soil and sediment. There would be no reduction in toxicity, mobility, or volume of the COCs at Site 3 other than that which would result from natural dispersion, dilution, or other attenuating factors. Because of the physical characteristics of the site (long, narrow road with steep banks), the causeway's use as a residential area is unlikely.

5.1.2 Alternative 2a – Partial Containment

The purposes of Alternative 2a are to

- Minimize human exposure to impacted surface soil where concentrations of COCs exceed RGOs that represent a human health ILCR equal to 1.0E-04. Also, minimize ecological exposure to impacted

surface soil where concentrations of COCs exceed RGOs that represent a high risk to ecological receptors. Some risk to human health and potential risks to ecological receptors associated with sediment exposure would remain.

- Provide a minimum of 2 feet of soil cover over waste material consistent with federal and South Carolina regulations.
- Stabilize the sideslopes of the causeway to avoid further impacts to site sediment and surface water.
- Monitor the effectiveness of the remedy.

Alternative 2a consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring. The components of Alternative 2a are described as follows.

Soil Cover

A soil cover would be placed over approximately one-half the length of the causeway. The anticipated extent of the soil cover is illustrated in Figure 5-1. Figures 5-2, 5-3, and 5-4 present cross-sectional views of the causeway under this alternative. The cover would be placed so that a minimum of 2 feet of soil cover is present above waste material within the causeway. This remedy is consistent with South Carolina Sanitary Landfill Design, Construction, and Operation (R.61-70), which requires 2 feet of a compacted and well-graded soil over waste material. The 2-foot cover would generally consist of 6 inches of vegetated topsoil underlain by 18 inches of earthen material; however, in some areas, the cover may consist of granular material consistent for use as a road base for an asphalt road. Existing trees and shrubbery that would penetrate the cover or obstruct the installation of the cover would be removed from the site.

Additionally, in areas where contaminant concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-04 and/or a high risk to terrestrial ecological receptors, a minimum of 1 foot of soil cover would be placed over the impacted surface soil. The cover would be placed over impacted surface soil to eliminate the potential for human and ecological contact and to eliminate the migration of impacted surface soil to surface water and sediment due to surface water runoff and/or wind. The 1-foot cover would generally consist of 6 inches of vegetated topsoil underlain by 6 inches of earthen material; however, in some areas, the cover may consist of granular material consistent for use as a road base for an asphalt road. The upper 1 foot of soil represents the depth at which most soil macroinvertebrates live and vegetation roots extend.

This action has the additional benefit of protecting terrestrial ecological receptors from surface soil COC concentrations that exceed the most stringent ecological criteria.

After placement of the soil cover, an asphalt road will be constructed along the length of the causeway. To reduce infiltration, drainage ditches will be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope Stabilization and Erosion Control

Slope stabilization and erosion control measures would be implemented along the causeway to minimize the potential for failure of the causeway's sideslopes and to reduce the erosion rate of the cover due to surface water runoff, waves, and/or wind. On the sideslopes of the causeway, slope stabilization or erosion control measures may be used to supplement, or may be used in lieu of, the soil cover.

Slope stabilization measures would include providing riprap or gabions at the toe of slope to function as a toe fill buttress. The type and extent of slope stabilization measures implemented would be a function of site conditions, which include the shear strength of the materials comprising the causeway landfill, geometry, location (pond or marsh side), and water surface elevations. Conceptual details of slope stabilization measures are shown on Figures 5-3 and 5-4.

Erosion control measures would consist of providing a vegetated cover, erosion control matting, gabions, and/or riprap on the causeway landfill as required to control erosion. Grass would be planted on the flatter plateau and portions of the sideslopes. Erosion control matting, gabions, and riprap would be provided on the sideslopes as required to control erosion. Conceptual details of erosion control measures are shown on Figures 5-3 and 5-4.

Prior to the installation of the bank stabilization measures, the structural properties of the sediments at the existing toe of the slope would be evaluated to determine whether this material is suitable as a base for the new bank. Sediment not acceptable as a base material would be removed. This would result in incidental remediation of the most contaminated sediment.

Land Use Controls and Long-Term Monitoring

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. Site restrictions would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. The controls would be implemented through the MCRD Parris Island Master Plan and LUCAP and Site 3 LUCIP. Signs would be posted to warn of risk

associated with excessive fish ingestion and contact with sediment. Existing "No Swimming/Wading" signs would be maintained.

Annual sediment and groundwater sampling would be performed. Sampling would be performed annually for the first 5 years and every 5 years thereafter. This sampling would be performed to monitor changes in concentrations of the COCs and to determine whether potential impacts to human and ecological receptors diminish over time. Depot personnel would conduct periodic inspections of the soil cover to assess the integrity of the soil cover and slope stabilization and erosion control measures.

A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

5.1.3 Alternative 2b – Full Containment

The purposes of Alternative 2b are to

- Minimize human and ecological exposure to impacted surface soil where concentrations of COCs exceed RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors. Some risk to human health and potential risks to ecological receptors associated with exposure to impacted sediments would remain.

- Provide a minimum of 2 feet of soil cover over waste material consistent with federal and South Carolina regulations.

- Stabilize the sideslopes of the causeway to avoid further impacts to site sediment and surface water.

- Monitor the effectiveness of the remedy.

Alternative 2b consists of three components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, and 3) Land Use Controls and Long-term Monitoring. Alternative 2b is similar to Alternative 2a; however, with Alternative 2b, the soil cover is placed over the entire length of the causeway instead of the causeway's southeastern half. This action has the additional benefit of protecting terrestrial ecological receptors from surface soil COC concentrations that exceed the most stringent ecological criteria. The components of Alternative 2b are described as follows.

Soil Cover

A soil cover would be placed over the causeway as illustrated in Figure 5-5. Figures 5-6 and 5-7 present cross-sectional views of the causeway under this alternative. The cover would be placed so that a minimum of 2 feet of soil cover is present above waste material within the causeway. This remedy is consistent with South Carolina Sanitary Landfill Design, Construction, and Operation (R.61-70), which requires 2 feet of a compacted and well-graded soil over waste material. The 2-foot cover would consist of 6 inches of vegetated topsoil underlain by 18 inches of earthen material; however, in some areas, the cover may consist of granular material consistent for use as a road base for an asphalt road. Existing trees and shrubbery that would penetrate the cover or obstruct the installation of the cover would be removed from the site.

Additionally, in areas where contaminant concentrations in existing surface soil exceed RGOs that represent a human health ILCR equal to 1.0E-06 and/or a low risk to ecological receptors, a minimum of 1 foot of soil cover would be placed over impacted surface soil. The soil cover would be placed over impacted surface soil to eliminate the potential for human and ecological contact and to eliminate the migration of impacted surface soil to surface water and sediment due to surface water runoff and/or wind.

The 1-foot cover would generally consist of 6 inches of vegetated topsoil underlain by 6 inches of earthen material; however, in some areas, the cover may consist of granular material consistent for use as a road base for an asphalt road. The upper 1 foot of soil represents the depth at which most soil macroinvertebrates live and vegetation roots extend.

After placement of the soil cover, an asphalt road will be constructed along the length of the causeway. To reduce infiltration, drainage ditches will be installed along the side of the road to preferentially drain road runoff to the marsh and pond.

Slope Stabilization and Erosion Control

Slope stabilization and erosion control measures are identical to those proposed for Alternatives 2a, 3a, and 3b.

Land Use Controls and Long-term Monitoring

Land use controls and long-term monitoring are identical to those proposed for Alternative 2a.

5.1.4 Alternative 3a – Partial Containment with Further Sediment Evaluation

The purposes of Alternative 3a are to

- Minimize human exposure to impacted surface soil where concentrations of COCs exceed RGOs that represent a human health ILCR equal to 1.0E-04. Also, minimize ecological exposure to impacted surface soil where concentrations of COCs exceed RGOs that represent a high risk to ecological receptors.

- Minimize human and ecological exposure to impacted sediment where concentrations of COCs exceed RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors.

- Provide a minimum of 2 feet of soil cover over waste material consistent with federal and South Carolina regulations.

- Stabilize the sideslopes of the causeway to avoid further impacts to site sediment and surface water.

- Monitor the effectiveness of the remedy.

Alternative 3a consists of four components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, 3) Further Sediment Evaluation, and 4) Land Use Controls and Long-term Monitoring. Alternative 3a is similar to Alternative 2a; however, Alternative 3a includes further sediment evaluation as a remedial component. The extent of the soil cover and impacted sediment is illustrated in Figure 5-8. The components of Alternative 3a are described as follows.

Soil Cover

The soil cover is identical to the cover proposed for Alternative 2a.

Slope Stabilization and Erosion Control

Slope stabilization and erosion control measures are identical to those proposed for Alternatives 2a, 2b, and 3b.

Further Sediment Evaluation

As stated previously, the installation of slope stabilization and erosion control measures would result in incidental remediation of the most contaminated sediment. Consequently, after installation of these measures, sediment on the pond side of the causeway would be further delineated. Delineation would occur at four "hot spots" illustrated in Figure 3-8. At each "hot spot," three to 10 samples would be collected and analyzed for the COCs attributed to these areas. Based on current data, the affected volume of impacted sediment is approximately 7,100 cubic yards

Based on the concentrations and biodegradation rates of detected COCs and the volume of the impacted sediment, sediment would either be covered, excavated and consolidated on site, or allowed to naturally biodegrade in place. As required, federal and state permits would be obtained prior to any remedial action as the boundaries of the excavation would impact wetlands and/or endangered species. Biota testing may be conducted to refine the clean-up goals (RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors).

If the covering of sediments is chosen, the area of impacted sediment would first be covered with a geotextile layer, 12 to 18 inches of borrow soil, an additional geotextile layer, followed by a layer of rip rap.

Several options are available for excavating sediments. Under one option, the pond would be lowered by 1 to 3 feet to expose and dewater the contaminated sediments. Damp but largely water-free sediments would then be excavated and mixed in with existing causeway soils to stabilize the blend, covered with additional soil as needed, and then vegetated. Under another other option, sediment removal would occur while the sediments are under water. Confirmation sampling at the four "hot spot" areas would be performed after the excavation to assess that impacted sediment is removed. Debris, if encountered, may be taken off site for disposal.

Excavated sediment would be consolidated on site. Excavated sediment that is consolidated on site would not be used as the top 1 foot of cover material assuming that the consolidated sediment does not contain COCs at concentrations in excess of the soil RGOs that represent an ILCR greater than 1.0E-06. If the sediment does exceed these RGO values, the sediment would not be used as the top 2 feet of cover material. Excavated sediment or debris that is inherently waste-like would be loaded into suitable containers for transportation and disposal off site.

Land Use Controls and Long-Term Monitoring

Land use controls would be implemented to eliminate pathways of exposure to COCs at the site. These controls would be enacted to prohibit unauthorized intrusive activity within the causeway or the use of the groundwater as a drinking water supply. Site restrictions would be implemented through the MCRD Parris Island Master Plan and LUCAP and Site 3 LUCIP. Signs would be posted to warn of risk associated with high fish ingestion rates. Existing "No Swimming/Wading" signs would be maintained.

Annual groundwater and sediment sampling would be performed. Sampling would be performed annually for the first 5 years and every 5 years thereafter. Depot personnel would conduct periodic inspections of the soil cover to assess the integrity of the soil cover and slope stabilization and erosion control measures.

A re-evaluation of the site would be performed every 5 years to determine whether changes to the land use controls and monitoring would be required.

5.1.5 Alternative 3b – Full Containment with Further Sediment Evaluation

The purposes of Alternative 3b are to

- Minimize human and ecological exposure to impacted surface soil where concentrations of COCs exceed the RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors.

- Minimize human and ecological exposure to impacted sediment where concentrations of COCs exceed the RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors.

- Provide a minimum of 2 feet of soil cover over waste material consistent with federal and South Carolina regulations.

- Stabilize the sideslopes of the causeway to avoid further impacts to site sediment and surface water.

- Monitor the effectiveness of the remedy.

Alternative 3b consists of four components: 1) Soil Cover, 2) Slope Stabilization and Erosion Control, 3) Further Sediment Evaluation, and 4) Land Use Controls and Long-term Monitoring. Alternative 3b is similar to Alternative 2b; however, Alternative 3b includes further sediment evaluation as a remedial

component. The components of Alternative 3b are described as follows. The extent of the soil cover and impacted sediment is illustrated in Figure 5-9.

Soil Cover

The soil cover is identical to the cover proposed for Alternative 2b.

Slope Stabilization and Erosion Control Measures

Slope stabilization and erosion control measures are identical to those proposed for Alternatives 2a, 2b, and 3a.

Further Sediment Evaluation

Further sediment evaluation is identical to those proposed for Alternative 3a.

Land Use Controls and Long-Term Monitoring

Land use controls and long-term monitoring are identical to those proposed for Alternative 3a.

5.2 CRITERIA FOR DETAILED ANALYSIS

The following criteria will be used for the detailed analysis for each alternative:

1. Overall protection of human health and the environment
2. Compliance with ARARs/media clean-up standards
3. Source control
4. Waste management standards
5. Other factors (long-term reliability and effectiveness; reduction in toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost)
6. State and U.S. EPA acceptance
7. Community acceptance

The first five criteria are specifically addressed in this FS/CMS. State and U.S. EPA acceptance will be evaluated after the state of South Carolina and U.S. EPA Region IV have reviewed and commented on the draft FS/CMS report. Community acceptance will be addressed in the Record of Decision/Response To Comments that will be finalized after the public comment period for the FS/CMS and Proposed Plan/Statement of Basis. State, U.S. EPA, and community acceptance must be considered during remedy selection. The following contains a description of each of the evaluation criteria.

5.2.1 Overall Protection of Human Health and the Environment

The purpose of this evaluation criterion is to assess whether each alternative provides adequate protection of human health and the environment. Evaluation of the overall protectiveness of an alternative focuses on whether a specific alternative achieves adequate protection and should describe how site risks posed through each pathway being addressed by the FS/CMS are eliminated, reduced, or controlled through treatment, engineering, or institutional/land use controls. This evaluation also allows for consideration of whether an alternative poses any unacceptable short-term impacts. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs/media clean-up standards.

5.2.2 Compliance with ARARs/Media Clean-Up Standards

The purpose of this evaluation criterion is to assess whether each alternative will meet federal and state ARAR/media clean-up standards identified in Section 3.2. Each alternative will also be compared to the TBCs identified in Section 3.2. Compliance with ARARs/media clean-up standards is one of the statutory requirements for remedy selection. In the detailed analysis, requirements that are applicable or relevant and appropriate to an alternative will be summarized. Additionally, the detailed analysis will contain a description of how the alternative will meet ARARs/media clean-up standards and TBCs. Alternatives are developed and refined throughout the FS/CMS process to ensure that they will meet all of their respective ARARs/media clean-up standards or that there is good rationale for obtaining a variance or exemption.

5.2.3 Source Control

The purpose of this criterion is to evaluate how the alternative addresses the source of the release, so as to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment. This criterion addresses whether source control measures are necessary and what type of source control actions would be appropriate. In addition, for any source control measure proposed, a discussion is provided on how well the method is expected to work given the site situation and previous experiences of the specific technology.

5.2.4 Waste Management Standards

The purpose of this criterion is to evaluate how the alternative will comply with applicable standards for the management of wastes. This includes a description of how the specific waste management activities would be conducted in order to maintain compliance with all applicable state and federal regulations.

5.2.5 Other Factors

In addition to the first four standards, there are five general factors that are to be addressed as part of the evaluation of alternatives. The five general decision factors to be considered under this standard are

- Long-term reliability and effectiveness
- Reduction in toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

5.2.5.1 Long-Term Reliability and Effectiveness

The purpose of this criterion is to ensure protection of human health and the environment in the future, as well as in the near term. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis should focus on the residual risks that will remain at the site after the completion of the remedial action. This analysis should include consideration of the following:

- Degree of threat posed by treatment residuals or untreated waste remaining at the site.
- Adequacy and reliability of any controls (e.g., engineering and institutional controls) used to manage the hazardous substances remaining at the site.
- Potential impacts on human health and the environment should the remedy fail.
- Whether the alternative would have the flexibility to address uncontrollable changes at the site (e.g., heavy rain storms, seismic tremors, etc.)
- The overall useful life of the alternative.

5.2.5.2 Reduction in Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element by ensuring that the relative performance of the various treatment alternatives in reducing toxicity, mobility, or volume will be assessed. Specifically, the analysis examines the

- Treatment process and remedy
- Amount of hazardous material destroyed or treated

- Reduction in toxicity, mobility, or volume
- Irreversibility of the treatment
- Type and quantity of treatment residual
- Statutory preference for treatment as a principal element

There may be some situations (e.g., large, municipal-type landfills) where achieving substantial reductions in toxicity, mobility, or volume may not be practical or desirable (U.S. EPA, 1993 and 1994).

5.2.5.3 Short-Term Effectiveness

This purpose of this criterion is to examine the short-term impacts of the alternatives (i.e., impacts of the implementation) on the neighboring community, the on-site workers, or the surrounding environment, including the potential threat to human health and the environment associated with excavation, treatment, and transportation of hazardous substances. The time to achieve protection of human health and the environment is also evaluated.

5.2.5.4 Implementability

Implementability considerations include the technical and administrative feasibility of the alternatives, as well as the availability of the goods and services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementability considerations often affect the timing of various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of materials-handling steps that must be followed, the need to obtain permits for off-site activities, and the need to secure technical services such as well drilling and excavation).

5.2.5.5 Cost

Cost encompasses all capital costs and operation and maintenance costs incurred over the life of the project. The focus during the detailed analysis is on the net present value of these costs. Costs were used to select the least expensive (or most cost-effective) alternative that will achieve the remedial action objectives. For purposes of calculating the present worth for the annual operating and maintenance costs, a 30-year maintenance life and a 7 percent annual discount factor are used.

5.2.6 State and U.S. EPA Acceptance

This criterion, which is an ongoing concern throughout the remediation process, reflects the statutory requirement to provide for substantial and meaningful state involvement.

5.2.7 Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include all interested parties. These comments are taken into account throughout the FS/CMS process. However, only preliminary assessment of community acceptance can be conducted during the development of the FS/CMS, since formal public comment will not be received until after the public comment period for the preferred alternative is held.

5.3 EVALUATION OF ALTERNATIVES

This section presents the results of the evaluation conducted for each alternative based on the specific standards described in Section 5.2.

5.3.1 Alternative 1 - No Action

5.3.1.1 Overall Protection of Human Health and the Environment

The no-action alternative is not protective of human health and the environment. The existing maintenance and future construction worker would be exposed to surface soil and sediment where COC concentrations are greater than the RGOs that represent a human health ILCR equal to 1.0E-06; however, the estimated risks fall within the U.S. EPA acceptable ILCR risk range of 1.0E-06 to 1.0E-04. Also, the HQ for both receptors is less than 1, indicating that non carcinogenic effects would not be expected for the construction and maintenance worker. The risks posed to the adult recreational user from fish consumption using very conservative fish ingestion assumptions exceed an ILCR of 1.0E-04 and an HQ of 1. However, using site-specific fish ingestion assumptions, the risks fall within the U.S. EPA acceptable ILCR risk range. Signs will soon be placed at Site 3 recommending limited fish consumption which would reduce the estimated risk associated with higher fish consumption rates.

Terrestrial and aquatic ecological receptors (macroinvertebrates, site-specific food-chain receptors, and vegetation) would continue to be exposed to surface soil and sediment contaminants at levels where some adverse effects would be anticipated. However, the maximum detected metal concentrations are generally within a factor of two of background concentrations and most of the pesticide concentrations at Site 3 are similar to typical concentrations found at the Depot. Additionally, the total forage area at Site 3 is a small percentage of the home range area of most receptors. As shown in Appendix E, when home range is taken into consideration for the raccoon, heron, and bald eagle, the HQs (based on LOAELs) resulting from exposure to the individual sediment "hot spot" areas are less than 1.0 for each receptor. As a result, the ecological RGOs may overstate the actual site-related risk posed to ecological receptors.

The primary COCs are PAHs, PCBs, and inorganics in surface soil and PAHs, PCBs, and pesticides, in sediment. An ongoing release of wastes and contaminants through erosion would be expected under this alternative. Pesticides and PCBs are relatively persistent and would remain for an extended period of time. PAH concentrations would be expected to decrease over time; however, because PAHs are associated with motor vehicles and roadways, non-site-related deposition would continue to occur.

5.3.1.2 Compliance with ARARs /Media Clean-up Standards

Alternative 1 attains all chemical-specific ARARs/media clean-up standards with two exceptions. In surface water, AWQCs promulgated under the Clean Water Act and Surface Water Standards promulgated under the South Carolina Regulation 61-68 are exceeded. Also, several soil, sediment, surface water, and groundwater chemical-specific TBCs would not be met, including the Dutch Soil Clean-up Act ecological soil screening values, risk-based concentrations (RBCs) for soil and groundwater, and U.S. EPA's ecological screening values for soil, sediment, and surface water.

Under current conditions, location-specific ARARs are attained; however, the causeway sideslopes may not be adequately stable. The failure of the sideslopes would result in the release of landfill contents into the nearby sediment of the marsh and pond. This occurrence would result in non-attainment of several location-specific ARARs including Executive Orders regarding Floodplain Management and Protection of Wetlands, the Endangered Species Act, Fish and Wildlife Coordination Act, and Coastal Zone Management Act.

Lastly, under the no-action alternative, the southeastern half of the causeway would not meet federal and State regulations regarding the final cover requirements of landfills. These ARARs consist of final cover regulations under RCRA Subtitle C and D and South Carolina Regulations regarding Solid Waste Management: Construction, Demolition, and Land Clearing Debris Landfills (R.61-107.11), Solid Waste Management: Municipal Solid Waste Landfills (R.61-107.258), and Sanitary Landfill Design, Construction, and Operation (R.61-70).

5.3.1.3 Source Control

Alternative 1 does not involve source control.

5.3.1.4 Waste Management Standards

There are no actions to be implemented for Alternative 1 and, therefore, no waste would be generated.

5.3.1.5 Other Factors

Long-Term Reliability and Effectiveness

In the long term, this alternative would not be reliable and may not be effective. The potential risks would not be reduced through removal or treatment. Risks would only be reduced through natural processes. Risks that remain are attributed to

- The potential failure of the sideslopes of the causeway. This occurrence would result in a release of landfill material into the surrounding sediment and surface water.
- The migration of surface soil COCs to nearby sediment and surface water and sediment COCs to surface water.

There are no long-term management controls; therefore, the adequacy and reliability of controls are not applicable.

Reduction in Toxicity, Mobility, and Volume

Alternative 1 involves no reduction in toxicity, mobility, or volume of the COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed and therefore no materials are treated or destroyed.

Short-term Effectiveness

Alternative 1 involves no action; therefore, there would not be short-term risks to the nearby community and on-site workers attributable to remedial actions. Similarly, environmental impacts would not result from remedial actions.

The following RAOs/CAOs would be achieved under Alternative 1.

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of	X	X	
Control macroinvertebrate and site-specific food chain receptor exposure to COC concentrations in surface soil in excess of			
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of	X	X	

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of	X		
Control macroinvertebrate and site-specific food chain receptor exposure to COC concentrations in sediment in excess of	X		

X = RAO/CAO achieved. A blank space indicates the RAO/CAO is not achieved.

Alternative 1 would not eliminate the migration of COCs from the fill material to groundwater, surface water, and sediment and would not comply with ARARs.

Implementability

Since no actions would occur, this alternative is readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost Analysis

There are no costs associated with the no-action alternative.

5.3.2 Alternative 2a – Partial Containment

5.3.2.1 Overall Protection of Human Health and the Environment

Alternative 2a features components that are protective of human health and the environment. Under Alternative 2a, a soil cover would be placed over one-half the length of the causeway. This action would minimize exposure of the existing maintenance and future construction worker to surface soil where COC concentrations are greater than RGOs that represent a human health ILCR equal to 1.0E-04. In addition, the cover would also reduce the risk to human health to 1.0E-06. The soil cover would also prevent the exposure of terrestrial ecological receptors (macroinvertebrates, site-specific food-chain receptors, and terrestrial plants) to surface soil where concentrations of COCs are in excess of the RGOs that represent a high risk to ecological receptors. The protective layer of soil cover would minimize uptake of COCs through the roots of terrestrial plants and macroinvertebrate contact with COCs. This action would then prevent potential bioaccumulation of COCs through the food chain to higher receptors.

Under Alternative 2a, aquatic macroinvertebrates would continue to be exposed to sediment contaminants at levels where some adverse effects would be anticipated, although these risks would be expected to diminish over time. For aquatic food-chain receptors, exposure risks to sediment are minimal when home range considerations are taken into account. For the raccoon, heron, and eagle, the area of

impacted sediment shown in Figure 3-4 represents a small portion of the total forage area typically used by these receptors. Appendix E presents revised food-chain modeling HQs that factor in this consideration. For the raccoon, heron, and eagle, the revised modeling indicates that the resulting HQ from exposure to each sediment "hot spot" is less than 1.0.

The use of slope stabilization and erosion control measures would eliminate the transport of waste and impacted surface soil to the sediment and allow existing sediment contaminants to attenuate. Additionally, the implementation of these measures would result in excavating and/or covering the most impacted sediment (sediment closest to the causeway) which would prevent exposure and migration pathways attributable to this sediment. The primary COCs in sediment would consist of PAHs, pesticides, and PCBs. Residual concentrations of PAHs in sediment would be expected to be reduced through biodegradation. Half-lives for the PAHs of concern in sediment are estimated to range up to 20.8 years (Howard, 1991). Pesticides and PCBs in sediment would also biodegrade, but at a much slower rate where half-lives for several pesticides are reported to range up to 15.6 years (Howard, 1991).

The risks posed to the adult recreational user from fish consumption would also be expected to decrease over time. In the long term, concentrations of COCs in the sediment would gradually diminish and would eventually result in a decreased concentration of COCs in fish tissue. In the short term, signs recommending limited fish consumption would minimize the estimated risk associated with higher fish consumption rates.

Sampling of sediment and groundwater is included to determine the effectiveness of the remedy and assess any impacts to human and ecological receptors. Periodic review of the site would be necessary to determine that the concentrations of COCs are not increasing.

5.3.2.2 Compliance with ARARs/Media Clean-Up Standards

In the short term, Alternative 2a attains all chemical-specific ARARs/media clean-up standards with two exceptions. In surface water, AWQCs promulgated under the Clean Water Act and Surface Water Standards promulgated under South Carolina Regulation 61-68 are exceeded. However, the soil cover and erosion control measures are expected to eliminate the transport of impacted surface soil to sediment and surface water, which is expected to reduce the concentration of chemicals in surface water that exceed AWQCs. Also, several soil, sediment, surface water, and groundwater chemical-specific TBCs would not be met, including RBCs for residential soil and tapwater, ER-L and ER-M sediment values, and U.S. EPA's ecological screening values for soil, sediment, and surface water.

All location-specific and action-specific ARARs/media clean-up standards and TBCs would be attained.

5.3.2.3 Source Control

The source control measures employed consist of the following actions:

- A minimum of 2 feet of soil cover would be used to minimize human and ecological contact with the waste contents of the causeway.

- A minimum of 1 foot of soil cover would be used to decrease human contact with surface soil where COC concentrations exceed RGOs that represent a human health ILCR equal to 1.0E-04 (1.0E-06). Also, the cover would be used to decrease ecological contact with surface soil where COC concentrations exceed RGOs that represent a high risk to ecological receptors.

- Slope stabilization and erosion control measures would be utilized to minimize the potential failure of the sideslopes of the causeway and prevent the contents of the causeway from impacting nearby sediment and surface water. Additionally, these measures would result in excavating/covering the most impacted sediment.

- The construction of an asphalt road along the length of the causeway would minimize rainwater infiltration into the causeway. Drainage ditches constructed on the sides of the road would further reduce infiltration by preferentially draining road runoff to the marsh and pond.

- Site restrictions would be implemented prohibiting unauthorized intrusive activity and the use of the groundwater as a drinking water source.

- Signs would be posted warning of potential hazards associated with high fish consumption.

5.3.2.4 Waste Management Standards

Minimal waste would be expected to be generated during remedial activities and any inherently waste-like material would be taken off site for disposal. This alternative would comply with ARARs under federal and South Carolina regulations concerning final covers for landfills.

5.3.2.5 Other Factors

<u>Long-Term Reliability and Effectiveness</u>

In the long term, this alternative would be reliable and effective. Slope stabilization and erosion control measures would minimize the potential failure of the sideslopes of the causeway and continued release of

the causeway's contents into the surrounding sediment and surface water. The soil cover would prevent concentrations of COCs in surface soil from migrating to nearby sediment and surface water. In the long-term, minimal repair to slope stabilization and erosion control measures would be expected. Such repair needs would be identified during periodic inspections of these measures.

Risks that remain are attributed to

- Ecological contact with surface soil containing COCs at concentrations greater than the RGOs that represent a moderate risk but less than the RGOs that represent a high risk to ecological receptors.

- Potential human contact with sediment containing COCs at concentrations less than the RGOs that represent a human health ILCR equal to 1.0E-04 but greater than the RGOs that represent a human health ILCR equal to 1.0E-06. The risk from remaining sediments would be less than current conditions, but would not be well defined.

- Potential ecological contact with sediment containing COCs at concentrations less than the RGOs that represent a high risk to ecological receptors but greater than the RGOs that represent a low risk to ecological receptors. The risk from remaining sediments would be less than current condition, but would not be well defined.

The controls used in this alternative are adequate and reliable. Containment and slope stabilization and erosion control measures are commonly used as components of remedies.

The reliability and effectiveness of the remedy would be assessed through the long-term media monitoring program, inspection of slope stabilization and erosion control measures, site restrictions, and 5-year reviews. If it should be discovered during these actions that control measures have failed, actions to correct the remedy (i.e., replace an eroded portion of a soil cover) would be easily implemented.

Additional geotechnical study would be required to determine whether the slope stabilization measures would be adequate in the long term to avoid failure of the sideslopes of the causeway due to factors such as normal storm events, hurricane-like weather patterns, the additional weight of the soil cover, and minor seismic events that occasionally occur in the area. These issues would be addressed during the remedial design.

Reduction in Toxicity, Mobility, and Volume

The containment components that comprise Alternative 2a prevent the migration of the contents of the landfill. This alternative does not reduce the toxicity or volume of the surface soil COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed. Approximately 375,000 cubic yards of landfill material would be contained with this remedy.

Although a statutory preference for treatment exists for CERCLA Remedial Actions, the Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable.

This alternative does not reduce the toxicity, mobility, or volume of the sediment COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed.

Short-term Effectiveness

Alternative 2a would be effective in the short term. There would be no short-term effects to the neighboring off-base community (Beaufort, Port Royal, etc.). There would be some short-term effects to the on-base community. This alternative would require that the causeway, an alternative vehicular route to Malecon Drive, be closed during the implementation of the alternative. Although this would disrupt traffic flow, this temporary road closure would have the benefit of preventing on-base personal and guests from coming within the vicinity of remedial actions. Work areas would be marked and monitored to prevent entry by unauthorized personnel. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation.

During implementation of the alternative, vegetation along the sideslopes of the causeway and within the area of the soil cover would be removed. Additionally, the implementation of slope stabilization measures would encroach on wetlands. Measures would be conducted to either minimize the reduction of wetlands or to create wetland areas elsewhere on the Depot. An active bald eagle nest is near Site 3. Actions would be conducted to minimize disturbance to the bald eagles associated with this nest.

Prior to the installation of the bank stabilization measures, the structural properties of the sediments at the existing toe of the slope would be evaluated to determine whether this material is suitable as a base for the new bank. Soft materials (muds and silts) in this area are not acceptable as a base material and

would have to be removed. This concern is more significant in areas where rock fills (rip rap or gabions) would be used to stabilize relatively high banks. Two options considered for removing the sediments are lowering the pond by several feet and bulk excavating the sediments and dredging the sediments.

Lowering of the pond by several feet followed by excavation would be safest and most efficient way to remove the sediments. However, this action could essentially drain the entire pond and there would be a moderate to high short-term impact on the existing ecological system in the area. After completion and refilling, the pond ecosystem would recover.

Use of dredging techniques would also be relatively efficient at removing sediments. Because only small areas of the pond would be affected at any one time, dredging would result in less short-term ecological impacts than discussed under the lowering of the pond option. However during the dredging, some migration of the clays and silts from the base of the causeway would occur. The impacts would be most significant in areas where the sediments are more contaminated and with increasing distance from the causeway, where the sediments are more predominately silts and clays.

The time needed to complete remedial actions is anticipated to be 1 to 2 years. The following RAOs/CAOs would be achieved:

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of	X	X	X
Control ecological exposure (terrestrial receptors) to COC concentrations in surface soil in excess of	X		
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of	X	X	*
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of	X	*	*
Control ecological exposure (aquatic receptors) to COC concentrations in sediment in excess of	X		

X = RAO/CAO achieved. A blank space indicates the RAO/CAO is not achieved.
* = RAO/CAO will also be achieved through land use controls and natural attenuation of site contaminants, although long periods of time would be required.

Additionally, Alternative 2a would eliminate the migration of COCs from the fill material to groundwater, surface water, and sediment and would comply with ARARs.

Because slope stabilization and erosion control measures would prevent the transport of waste materials and COCs to sediment, existing COCs in sediment may attenuate to levels that would achieve RGOs that represent a human health ILCR equal to 1.0E-05 or 1.0E-06 and a moderate or low risk to ecological receptors. Due to the conservative nature of these sediment RGOs, supplemental testing could be

conducted to refine the RGOs and more accurately depict the risk posed to human and ecological receptors.

Implementability

Alternative 2a would be implementable. Contractors and equipment are readily available for conducting soil-moving activities and installing slope stabilization and erosion control measures. In the long-term, minimal repair to slope stabilization and erosion control measures may be required; however, such repair actions would be easy to implement.

Existing exposure pathways of residual risks can be monitored easily. Four groundwater wells currently exist on the causeway and could be used to monitor the surficial aquifer. Sediment samples could be easily collected.

This alternative is administratively feasible. The MCRD Parris Island Partnering Team consists of representatives of the U.S. EPA, SCDHEC, South Carolina Department of Natural Resources (SCDNR), National Oceanic and Atmospheric Administration (NOAA), and USFWS, as well as the U.S. Navy and Marine Corps. Regulatory approval/permitting requirements could be coordinated via this partnering mechanism.

Cost Analysis

The following costs are estimated for Alternative 2a. The cost estimate is provided in Appendix D.

Estimated capital costs:	$4,090,000
Estimated O&M costs:	$58,700 to $74,700 per year
Estimated 30-year present worth:	$4,880,000

5.3.3 Alternative 2b – Full Containment

5.3.3.1 Overall Protection of Human Health and the Environment

Alternative 2b features components that are protective of human health and the environment. Under Alternative 2b, a soil cover would be placed over the entire length of the causeway. This action would minimize exposure of the existing maintenance and future construction worker to surface soil where COC concentrations are greater than the RGOs that represent a human health ILCR equal to 1.0E-06. The soil cover would also prevent the exposure of terrestrial ecological receptors (macroinvertebrates, site-specific food-chain receptors, and terrestrial plants) to surface soil where concentrations of COCs are in excess of

the RGOs that represent a low risk to ecological receptors. The protective layer of soil cover would minimize uptake of COCs through the roots of terrestrial plants and macroinvertebrate contact with COCs. This action would then prevent potential bioaccumulation of COCs through the food chain to higher receptors.

Under Alternative 2b, aquatic macroinvertebrates would continue to be exposed to sediment contaminants at levels where some adverse effects would be anticipated, although these risks would be expected to diminish over time. For aquatic food-chain receptors, exposure risks to sediment are minimal when home range considerations are taken into account. For the raccoon, heron, and eagle, the area of impacted sediment shown in Figure 3-4 represents a small portion of the total forage area typically used by these receptors. Appendix E presents revised food-chain modeling HQs that factor in this consideration. For the raccoon, heron, and eagle, the revised modeling indicates that the resulting HQ from exposure to each sediment "hot spot" is less than 1.0.

The use of slope stabilization and erosion control measures would eliminate the transport of waste and impacted surface soil to the sediment and allow existing sediment contaminants to attenuate. Additionally, the implementation of these measures would result in excavating and/or covering the most impacted sediment (sediment closest to the causeway) which would prevent exposure and migration pathways attributable to this sediment. The primary COCs in sediment would consist of PAHs, pesticides, and PCBs. Residual concentrations of PAHs in sediment would be expected to be reduced through biodegradation. Half-lives for the PAHs of concern in sediment are estimated to range up to 20.8 years (Howard, 1991). Pesticides and PCBs in sediment would also biodegrade but at a much slower rate where half-lives for several pesticides are reported to range up to 15.6 years (Howard, 1991).

The risks posed to the adult recreational user from fish consumption would also be expected to decrease over time. In the long term, concentrations of COCs in the sediment would gradually diminish and would eventually result in a decreased concentration of COCs in fish tissue. In the short term, signs recommending limited fish consumption would minimize the estimated risk associated with higher fish consumption rates.

Sampling of sediment and groundwater is included to determine the effectiveness of the remedy and assess any impacts to human and ecological receptors. Periodic review of the site would be necessary to determine that the concentrations of COCs are not increasing.

5.3.3.2 Compliance with ARARs/Media Clean-Up standards

In the short term, Alternative 2b attains all chemical-specific ARARs/media clean-up standards with two exceptions. In surface water, AWQCs promulgated under the Clean Water Act and Surface Water

Standards promulgated under South Carolina Regulation 61-68 are exceeded. However, the soil cover and erosion control measures are expected to eliminate the transport of impacted surface soil to sediment and surface water, which is expected to reduce the concentration of chemicals in surface water that exceed AWQCs. Also, several soil, sediment, surface water, and groundwater chemical-specific TBCs would not be met, including RBCs for soil and tapwater, ER-L and ER-M sediment values, and U.S. EPA's ecological screening values for sediment and surface water.

All location-specific and action-specific ARARs/media clean-up standards and TBCs would be attained.

5.3.3.3 Source Control

The source control measures employed consist of the following actions:

- A minimum of 2 feet of soil cover would be used to minimize human and ecological contact with the waste contents of the causeway.

- A minimum of 1 foot of soil cover would be placed over the causeway to decrease human and ecological contact with surface soil where COC concentrations exceed RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors.

- Slope stabilization and erosion control measures would be utilized to minimize the potential failure of the sideslopes of the causeway and prevent the contents of the causeway from impacting nearby sediment and surface water. Additionally, these measures would result in excavating/covering the most impacted sediment.

- The construction of an asphalt road along the length of the causeway would minimize rainwater infiltration into the causeway. Drainage ditches constructed on the sides of the road would further reduce infiltration by preferentially draining road runoff to the marsh and pond.

- Site restrictions would be implemented prohibiting unauthorized intrusive activity and the use of the groundwater as a drinking water source.

- Signs would be posted warning of potential hazards associated with higher fish consumption rates.

5.3.3.4 Waste Management Standards

Minimal waste would be expected to be generated during remedial activities and any inherently waste-like material would be taken off site for disposal. This alternative would comply with ARARs under federal and South Carolina regulations concerning final covers for landfills.

5.3.3.5 Other Factors

Long-Term Reliability and Effectiveness

In the long term, this alternative would be reliable and effective. Slope stabilization and erosion control measures would minimize the potential failure of the sideslopes of the causeway and continued release of the causeway's contents into the surrounding sediment and surface water. The soil cover would prevent concentrations of COCs in surface soil in excess of the RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors from migrating to nearby sediment and surface water. In the long-term, minimal repair to slope stabilization and erosion control measures would be expected. Such repair needs would be identified during periodic inspections of these measures.

Risks that remain are attributed to human and ecological contact with sediment containing COCs at concentrations less than the RGOs that represent a human health ILCR equal to 1.0E-04 and a high risk to ecological receptors. These risks still exceed the human health ILCR equal to 1.0E-06 and the low risk to ecological receptors. The risks from remaining sediments would be less than current conditions, but would not be well defined.

The controls used in this alternative are adequate and reliable. Containment and slope stabilization and erosion control measures are commonly used as components of remedies.

The reliability and effectiveness of the remedy would be assessed through the long-term media monitoring program, inspection of slope stabilization and erosion control measures, site restrictions, and 5-year reviews. If it should be discovered during these actions that control measures have failed, actions to correct the remedy (i.e., replace an eroded portion of a soil cover) would be easily implemented.

Additional geotechnical study would be required to determine whether the slope stabilization measures would be adequate in the long term to avoid failure of the sideslopes of the causeway due to factors such as normal storm events, hurricane-like weather patterns, the additional weight of the soil cover, and minor seismic events that occasionally occur in the area. These issues would be addressed during the remedial design.

Reduction in Toxicity, Mobility, and Volume

The containment components that comprise Alternative 2b prevent the migration of the contents of the landfill. This alternative does not reduce the toxicity or volume of the surface soil COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed. Approximately 375,000 cubic yards of landfill material would be contained with this remedy.

Although a statutory preference for treatment exists for CERCLA remedial actions, the Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable.

This alternative does not reduce the toxicity, mobility, or volume of the sediment COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed.

Short-Term Effectiveness

Alternative 2b would be effective in the short term. There would be no short-term effects to the neighboring off-base community (Beaufort, Port Royal, etc.). There would be some short-term effects to the on-base community. This alternative would require that the causeway, an alternative vehicular route to Malecon Drive, be closed during the implementation of the alternative. Although this would disrupt traffic flow, this temporary road closure would have the benefit of preventing on-base personal and guests from coming within the vicinity of remedial actions. Work areas would be marked and monitored to prevent entry by unauthorized personnel. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation.

During implementation of the alternative, vegetation along the sideslopes of the causeway and within the area of the soil cover would be removed. Additionally, the implementation of slope stabilization measures would encroach on wetlands. Measures would be conducted to either minimize the reduction of wetlands or to create wetland areas elsewhere on the Depot. An active bald eagle nest is near Site 3. Actions would be conducted to minimize disturbance to the bald eagles associated with this nest.

Prior to the installation of the bank stabilization measures, the structural properties of the sediments at the existing toe of the slope would be evaluated to determine whether this material is suitable as a base for the new bank. Soft materials (muds and silts) in this area are not acceptable as a base material and

would have to be removed. This concern is more significant in areas where rock fills (rip rap or gabions) would be used to stabilize relatively high banks. Two options considered for removing the sediments are lowering the pond by several feet and bulk excavating the sediments and dredging the sediments.

Lowering of the pond by several feet followed by excavation would be safest and most efficient way to remove the sediments. However, this action could essentially drain the entire pond and there would be a moderate to high short-term impact on the existing ecological system in the area. After completion and refilling, the pond ecosystem would recover.

Use of dredging techniques would also be relatively efficient at removing sediments. Because only small areas of the pond would be affected at any one time, dredging would result in less short-term ecological impacts than discussed under the lowering of the pond option. However during the dredging, some migration of the clays and silts from the base of the causeway would occur. The impacts would be most significant in areas where the sediments are more contaminated and with increasing distance from the causeway, where the sediments are more predominately silts and clays.

The time needed to complete remedial actions is anticipated to be 1 to 2 years. The following RAOs/CAOs would be achieved:

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of	X	X	X
Control ecological exposure (terrestrial receptors) to COC concentrations in surface soil in excess of	X	X	X
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of	X	X	*
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of	X	*	*
Control ecological exposure (aquatic receptors) to COC concentrations in sediment in excess of	X		

X = RAO/CAO achieved. A blank space indicates the RAO/CAO is not achieved.
* = RAO/CAO will also be achieved through land use controls and natural attenuation of site contaminants, although long periods of time would be required.

Additionally, Alternative 2b would eliminate the migration of COCs from the fill material to groundwater, surface water, and sediment and would comply with ARARs.

Because slope stabilization and erosion control measures would prevent the transport of waste materials and COCs to sediment, existing COCs in sediment may attenuate to levels that would achieve RGOs that represent a human health ILCR equal to 1.0E-05 or 1.0E-06 and a moderate or low risk to ecological receptors. Due to the conservative nature of these sediment RGOs, supplemental testing could be

conducted to refine the RGOs and more accurately depict the risk posed to human and ecological receptors.

Implementability

Alternative 2b would be implementable. Contractors and equipment are readily available for conducting soil-moving activities and installing slope stabilization and erosion control measures. In the long-term, minimal repair to slope stabilization and erosion control measures may be required; however, such repair actions would be easy to implement.

Existing exposure pathways of residual risks can be monitored easily. Four groundwater wells currently exist on the causeway and could be used to monitor the surficial aquifer. Sediment samples could be easily collected.

This alternative is administratively feasible. The MCRD Parris Island Partnering Team consists of representatives of the U.S. EPA, SCDHEC, SCDNR, NOAA, and USFWS as well as the U.S. Navy and Marine Corps. Regulatory approval/permitting requirements could be coordinated via this partnering mechanism.

Cost Analysis

The following costs are estimated for Alternative 2b. The cost estimate is provided in Appendix D.

Estimated capital costs:	$4,530,000
Estimated O&M costs:	$58,700 to $74,700 per year
Estimated 30-year present worth:	$5,310,000

5.3.4 Alternative 3a – Partial Containment with Sediment Excavation

5.3.4.1 Overall Protection of Human Health and the Environment

Alternative 3a features components that are protective of human health and the environment. Under Alternative 3a, a soil cover would be placed over one-half the length of the causeway. This action would minimize exposure of the existing maintenance and future construction worker to surface soil where COC concentrations are greater than the RGOs that represent a human health ILCR equal to 1.0E-04. In addition, the cover would also reduce the risk to human health to 1.0E-06. The soil cover would also prevent the exposure of terrestrial ecological receptors (invertebrates, site-specific food-chain receptors, and terrestrial plants) to surface soil where concentrations of COCs are in excess of the RGOs that

represent a high risk to ecological receptors. The protective layer of soil cover would minimize uptake of COCs through the roots of terrestrial plants and macroinvertebrate contact with COCs. This action would then prevent potential bioaccumulation of COCs through the food chain to higher receptors.

Under Alternative 3a, aquatic macroinvertebrates would continue to be exposed to sediment COCs at concentrations greater than RGOs that represent a low ecological risk but less than RGOs that represent a moderate ecological risk. Concentrations of remaining sediment COCs would be at levels where some adverse effects would be anticipated, although these risks would be expected to diminish over time. Based on the revised food-chain modeling and that the most contaminated sediment would be excavated or covered, the risk posed to aquatic food-chain receptors would be expected to be minimal.

The use of slope stabilization and erosion control measures would eliminate the transport of waste and impacted surface soil to the sediment and allow remaining sediment contaminants to attenuate. Additionally, the implementation of these measures would result in excavating/covering the most impacted of the remaining sediment (sediment closest to the causeway) which would prevent exposure and migration pathways attributable to this sediment.

After sediment excavation or covering, the remaining COCs in exposed sediment would consist of PAHs, PCBs, and inorganics. Residual concentrations of PAHs in sediment would be expected to decrease through biodegradation. Half-lives for the PAHs of concern in sediment are estimated to range up to 20.8 years (Howard, 1991). Pesticides and PCBs in sediment would also biodegrade but at a much slower rate where half-lives for several pesticides are reported to range up to 15.6 years (Howard, 1991). Concentrations of inorganics in sediment would diminish over time due to natural processes such as advection and dispersion.

The risks posed to the adult recreational user from fish consumption would also be expected to decrease over time. The concentration of sediment COCs available for bioaccumulation into fish would be decreased as a result of the sediment excavation/covering. Erosion control measures would also eliminate the transport of soil COCs to sediment and surface water. In the long term, concentrations of remaining COCs in the sediment would gradually diminish and would eventually result in a decreased concentration of COCs in fish tissue. In the short term, signs recommending limited fish consumption would minimize the estimated risk associated with higher fish consumption rates.

Sampling of sediment and groundwater is included to determine the effectiveness of the remedy. Periodic review of the site would be necessary to determine that the concentrations of COCs are not increasing.

5.3.4.2 Compliance with ARARs/Media Clean-Up Standards

In the short term, Alternative 3a attains all chemical-specific ARARs/media clean-up standards with two exceptions. In surface water, AWQCs promulgated under the Clean Water Act and Surface Water Standards promulgated under South Carolina Regulation 61-68 are exceeded. However, the soil cover and erosion control measures are expected to eliminate the transport of impacted surface soil to sediment and surface water, which is expected to eliminate the concentration of chemicals in surface water that exceed AWQCs. Also, several soil, sediment, surface water, and groundwater chemical-specific TBCs would not be met, including RBCs for residential soil and tapwater, ER-L sediment values, and U.S. EPA's ecological screening values for soil, sediment, and surface water.

All location-specific and action-specific ARARs/media clean-up standards and TBCs would be attained.

5.3.4.3 Source Control

The source control measures employed consist of the following actions:

- A minimum of 2 feet of soil cover would be used to minimize human and ecological contact with the waste contents of the causeway.

- A minimum of 1 foot of soil cover would decrease human contact with surface soil where COC concentrations exceed RGOs that represent an human health ILCR equal to 1.0E-04 (1.0E-06). Additionally, the 1 foot of soil cover would decrease ecological contact with surface soil where COC concentrations exceed RGOs that represent a high risk to ecological receptors.

- Sediment containing COC concentrations in excess of the RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors would be excavated or covered.

- Slope stabilization and erosion control measures would be utilized to minimize the potential failure of the sideslopes of the causeway and prevent the contents of the causeway from impacting nearby sediment and surface water. Additionally, these measures would result in excavating/covering over the most impacted of the remaining sediment.

- The construction of an asphalt road along the length of the causeway would minimize rainwater infiltration into the causeway. Drainage ditches constructed on the sides of the road would further reduce infiltration by preferentially draining road runoff to the marsh and pond.

- Site restrictions would be implemented prohibiting unauthorized intrusive activity and the use of the groundwater as a drinking water source.

- Signs would be posted warning of potential hazards associated with higher fish consumption rates.

5.3.4.4 Waste Management Standards

A majority of the excavated sediment would be consolidated on site and covered with clean soil; however, any inherently waste-like material would be taken off site for disposal. This alternative would comply with ARARs under federal and South Carolina regulations concerning final covers for landfills.

5.3.4.5 Other Factors

Long-Term Reliability and Effectiveness

In the long term, this alternative would be reliable and effective. Slope stabilization and erosion control measures would minimize the potential failure of the sideslopes of the causeway and continued release of the causeway's contents into the surrounding sediment and surface water. The soil cover would prevent concentrations of COCs in surface soil from migrating to nearby sediment and surface water. In the long-term, minimal repair to slope stabilization and erosion control measures would be expected. Such repair needs would be identified during periodic inspections of these measures. Sediment containing COC concentrations in excess of the RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors would be excavated or covered.

Risks that remain are attributed to:

- Ecological contact with surface soil containing COCs at concentrations greater than RGOs that represent a moderate risk but less than a high risk to ecological receptors.

- Human contact with sediment containing COCs at concentrations between RGOs that represent a human health ILCR of 1.0E-06 and 1.0E-05.

- Ecological contact with sediment containing COCs at concentrations greater than RGOs that represent a low risk but less than a moderate risk to ecological receptors.

The controls used in this alternative are adequate and reliable. Containment, excavation, and slope stabilization and erosion control measures are commonly used as components of remedies.

The reliability and effectiveness of the remedy would be assessed through the long-term media monitoring program, inspection of slope stabilization and erosion control measures, site restrictions, and 5-year reviews. If it should be discovered during these actions that control measures have failed, actions to correct the remedy (i.e., replace an eroded portion of a soil cover) would be easily implemented.

Additional geotechnical study would be required to determine whether the slope stabilization measures would be adequate in the long term to avoid failure of the sideslopes of the causeway due to factors such as normal storm events, hurricane-like weather patterns, the additional weight of the soil cover, and minor seismic events that occasionally occur in the area. These issues would be addressed during the remedial design.

Reduction in Toxicity, Mobility, and Volume

The containment components that comprise Alternative 3a prevent the migration of the contents of the landfill. Additionally, sediment in excess of the RGOs that represent a human health ILCR equal to 1.0E-05 and moderate risks to ecological receptors would be removed. This alternative does not reduce the toxicity or volume of the surface soil COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed. Approximately 375,000 cubic yards of landfill material would be contained with this remedy. Additionally, approximately 7,100 cubic yards of sediment would be excavated or covered.

Although a statutory preference for treatment exists for CERCLA remedial actions, the Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable.

Short-Term Effectiveness

Alternative 3a would be effective in the short term. There would be no short-term effects to the neighboring off-base community (Beaufort, Port Royal, etc.). There would be some short-term effects to the on-base community. This alternative would require that the causeway, an alternative vehicular route to Malecon Drive, be closed during the implementation of the alternative. Although this would disrupt traffic flow, this temporary road closure would have the benefit of preventing on-base personal and guests from coming within the vicinity of remedial actions. Work areas would be marked and monitored to prevent entry by unauthorized personnel. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation.

During implementation of the alternative, vegetation along the sideslopes of the causeway and within the area of the soil cover would be removed. Additionally, the implementation of slope stabilization measures would encroach on wetlands. Measures would be conducted to either minimize the reduction of wetlands or to create wetland areas elsewhere on the Depot. An active bald eagle nest is near Site 3. Actions would be conducted to minimize disturbance to the bald eagles associated with this nest.

Prior to the installation of the bank stabilization measures, the structural properties of the sediments at the existing toe of the slope would be evaluated to determine whether this material is suitable as a base for the new bank. Soft materials (muds and silts) in this area are not acceptable as a base material and would have to be removed. This concern is more significant in areas where rock fills (rip rap or gabions) would be used to stabilize relatively high banks. Two options considered for removing the sediments are lowering the pond by several feet and bulk excavating the sediments and dredging the sediments. Covering of the sediments is another remedial option.

Lowering of the pond by several feet followed by excavation would be safest and most efficient way to remove the sediments. However, this action could essentially drain the entire pond and there would be a moderate to high short-term impact on the existing ecological system in the area. After completion and refilling, the pond ecosystem would recover.

Use of dredging techniques would also be relatively efficient at removing sediments. Because only small areas of the pond would be affected at any one time, dredging would result in less short-term ecological impacts than discussed under the lowering of the pond option. However during the dredging, some migration of the clays and silts from the base of the causeway would occur. The impacts would be most significant in areas where the sediments are more contaminated and with increasing distance from the causeway, where the sediments are more predominately silts and clays.

The time needed to complete remedial actions is anticipated to be less than 1 to 2 years. The following RAOs/CAOs would be achieved:

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of	X	X	X
Control ecological exposure (terrestrial receptors) to COC concentrations in surface soil in excess of	X		
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of	X	X	*
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of	X	X	*

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control ecological exposure (aquatic receptors) to COC concentrations in sediment in excess of	X	X	*

X = RAO/CAO achieved. A blank space indicates the RAO/CAO is not achieved.
* = RAO/CAO will also be achieved through land use controls and natural attenuation of site contaminants. However, additional time beyond 1 to 2 years is likely.

Additionally, Alternative 3a would reduce the migration of COCs from the fill material to groundwater, surface water, and sediment and would comply with ARARs.

Because slope stabilization and erosion control measures would reduce the transport of waste materials and COCs to sediment, existing COCs in sediment may attenuate to levels that would achieve RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors. Due to the conservative nature of these sediment RGOs, supplemental testing could be conducted to refine the RGOs and more accurately depict the risk posed to human and ecological receptors.

Implementability

Alternative 3a would be implementable. Contractors and equipment are readily available for conducting soil-moving/excavation activities and installing slope stabilization and erosion control measures. In the long-term, minimal repair to slope stabilization and erosion control measures may be required; however, such repair actions would be easy to implement.

Existing exposure pathways of residual risks can be monitored easily. Four groundwater wells currently exist on the causeway and could be used to monitor the surficial aquifer. This alternative is administratively feasible. The MCRD Parris Island Partnering Team consists of representatives of the U.S. EPA, SCDHEC, SCDNR, NOAA, and USFWS as well as the U.S. Navy and Marine Corps. Regulatory approval/permitting requirements could be coordinated via this partnering mechanism.

Cost Analysis

The following costs are estimated for Alternative 3a. The cost estimate is provided in Appendix D.

Estimated capital costs:	$4,700,000
Estimated O&M costs:	$58,700 to $74,700 per year
Estimated 30-year present worth:	$5,480,000

5.3.5 Alternative 3b – Full Containment with Further Sediment Evaluation

5.3.5.1 Overall Protection of Human Health and the Environment

Alternative 3b features components that are protective of human health and the environment. Under Alternative 3b, a soil cover would be placed over the entire length of the causeway. This action would minimize exposure of the existing maintenance and future construction worker to surface soil where COC concentrations are greater the RGOs that represent a human health ILCR equal to 1.0E-06. The soil cover would also prevent the exposure of terrestrial ecological receptors (macroinvertebrates, site-specific food-chain receptors, and terrestrial plants) to surface soil where concentrations of COCs are in excess of the RGOs that represent a low risk to ecological receptors. The protective layer of clean soil cover would minimize uptake of COCs through the roots of terrestrial plants and macroinvertebrate contact with COCs. This action would then prevent potential bioaccumulation of COCs through the food chain to higher receptors.

Under Alternative 3b, aquatic macroinvertebrates would continue to be exposed to sediment COCs at concentrations greater than RGOs that represent a low ecological risk but less than RGOs that represent a moderate ecological risk. Concentrations of remaining sediment COCs would be at levels where some adverse effects would be anticipated, although these risks would be expected to diminish over time. Based on the revised food-chain modeling and that the most contaminated sediment would be excavated/covered, the risk posed to aquatic food-chain receptors would be expected to be minimal.

The use of slope stabilization and erosion control measures would eliminate the transport of waste and impacted surface soil to the sediment and allow remaining sediment contaminants to attenuate. Additionally, the implementation of these measures would result in excavating/covering the most impacted of the remaining sediment (sediment closest to the causeway) which would prevent exposure and migration pathways attributable to this sediment.

After sediment excavation or covering, the remaining COCs in exposed sediment would consist of PAHs, PCBs, and inorganics. Residual concentrations of PAHs in sediment would be expected to decrease through biodegradation. Half-lives for the PAHs of concern in sediment are estimated to range up to 20.8 years (Howard, 1991). Pesticides and PCBs in sediment would also biodegrade but at a much slower rate where half-lives for several pesticides are reported to range up to 15.6 years (Howard, 1991). Concentrations of inorganics in sediment would diminish over time due to natural processes such as advection and dispersion.

The risks posed to the adult recreational user from fish consumption would also be expected to decrease over time. The concentration of sediment COCs available for bioaccumulation into fish would be

decreased as a result of the sediment excavation/covering. Erosion control measures would also eliminate the transport of soil COCs to sediment and surface water. In the long term, concentrations of COCs in the sediment would gradually diminish and would eventually result in a decreased concentration of COCs in fish tissue. In the short term, signs recommending limited fish consumption would minimize the estimated risk associated with higher fish consumption rates.

Sampling of sediment and groundwater is included to determine the effectiveness of the remedy. Periodic review of the site would be necessary to determine that the concentrations of COCs are not increasing.

5.3.5.2 Compliance with ARARs/Media Clean-Up Standards

In the short term, Alternative 3b attains all chemical-specific ARARs/media clean-up standards with two exceptions. In surface water, AWQCs promulgated under the Clean Water Act and Surface Water Standards promulgated under South Carolina Regulation 61-68 are exceeded. However, the soil cover and erosion control measures are expected to eliminate the transport of impacted surface soil to sediment and surface water which is expected to reduce the concentration of chemicals in surface water that exceed AWQCs. Also, soil, several sediment, surface water, and groundwater chemical-specific TBCs would not be met including RBCs for soil and tapwater, ER-L sediment values, and U.S. EPA's Ecological Screening Values for sediment and surface water.

All location-specific and action-specific ARARs/media clean-up standards and TBCs would be attained.

5.3.5.3 Source Control

The source control measures employed consist of the following actions:

- A minimum of 2 feet of soil cover would be used to minimize human and ecological contact with the waste contents of the causeway.

- A minimum of 1 foot of soil cover would be placed over the causeway to decrease human and ecological contact with surface soil where COC concentrations exceed RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors.

- Sediment containing COC concentrations in excess of the RGOs that represent an human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors would be excavated or covered.

- Slope stabilization and erosion control measures would be utilized to minimize the potential failure of the sideslopes of the causeway and prevent the contents of the causeway from impacting nearby sediment and surface water. Additionally, these measures would result in excavating/covering over the most impacted of the remaining sediment.

- The construction of an asphalt road along the length of the causeway would minimize rainwater infiltration into the causeway. Drainage ditches constructed on the sides of the road would further reduce infiltration by preferentially draining road runoff to the marsh and pond.

- Site restrictions would be implemented prohibiting unauthorized intrusive activity and the use of the groundwater as a drinking water source.

- Signs would be posted warning of potential hazards associated with higher fish consumption rates.

5.3.5.4 Waste Management Standards

A majority of the excavated sediment would be consolidated on site and covered with clean soil; however, any inherently waste-like material would be taken off site for disposal. This alternative would comply with ARARs under federal and South Carolina regulations concerning final covers for landfills.

5.3.5.5 Other Factors

Long-Term Reliability and Effectiveness

In the long term, this alternative would be reliable and effective. Slope stabilization and erosion control measures would minimize the potential failure of the sideslopes of the causeway and the continued release of the causeway's contents into the surrounding sediment and surface water. The soil cover would prevent concentrations of COCs in surface soil in excess of the RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors from migrating to nearby sediment and surface water. In the long-term, minimal repair to slope stabilization and erosion control measures would be expected. Such repair needs would be identified during periodic inspections of these measures. Sediment containing COC concentrations in excess of the RGOs that represent a human health ILCR equal to 1.0E-05 and a moderate risk to ecological receptors would be excavated or covered.

Risks that remain are attributed to:

- Human contact with sediment where COC concentrations are between RGOs that represent a human health ILCR of 1.0E-06 and 1.0E-05.

- Ecological contact with sediment where COC concentrations are greater than RGOs that represent a low risk but less than a moderate risk to ecological receptors.

The controls used in this alternative are adequate and reliable. Containment, excavation, and slope stabilization and erosion control measures are commonly used as components of remedies.

The reliability and effectiveness of the remedy would be assessed through the long-term media monitoring program, inspection of slope stabilization and erosion control measures, site restrictions, and 5-year reviews. If it should be discovered during these actions that control measures have failed, actions to correct the remedy (i.e., replace an eroded portion of a soil cover) would be easily implemented.

Additional geotechnical study would be required to determine whether the slope stabilization measures would be adequate in the long term to avoid failure of the sideslopes of the causeway due to factors such as normal storm events, hurricane-like weather patterns, the additional weight of the soil cover, and minor seismic events that occasionally occur in the area. These issues would be addressed during the remedial design.

Reduction in Toxicity, Mobility, and Volume

The containment components that comprise Alternative 3b prevent the migration of the contents of the landfill. Additionally, sediment in excess of the RGOs that represent a human health ILCR equal to 1.0E-05 and moderate risks to ecological receptors would be removed. This alternative does not reduce the toxicity or volume of the surface soil COCs other than that which would result from natural dispersion, dilution, or other attenuating factors. There are no treatment processes employed, and therefore no materials are treated or destroyed. Approximately 375,000 cubic yards of landfill material would be contained with this remedy. Additionally, approximately 7,100 cubic yards of sediment would be excavated or covered.

Although a statutory preference for treatment exists for CERCLA remedial actions, the Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable.

Short-Term Effectiveness

Alternative 3b would be effective in the short term. There would be no short-term effects to the neighboring off-base community (Beaufort, Port Royal, etc.). There would be some short-term effects to the on-base community. This alternative would require that the causeway, an alternative vehicular route to Malecon Drive, be closed during the implementation of the alternative. Although this would disrupt traffic flow, this temporary road closure would have the benefit of preventing on-base personal and guests from coming within the vicinity of remedial actions. Work areas would be marked and monitored to prevent entry by unauthorized personnel. Site workers would receive the appropriate health and safety training and would wear the required PPE during implementation.

During implementation of the alternative, vegetation along the sideslopes of the causeway and within the area of the soil cover would be removed. Additionally, the implementation of slope stabilization measures would encroach on wetlands. Measures would be conducted to either minimize the reduction of wetlands or to create wetland areas elsewhere on the Depot. An active bald eagle nest is near Site 3. Actions would be conducted to minimize disturbance to the bald eagles associated with this nest.

Prior to the installation of the bank stabilization measures, the structural properties of the sediments at the existing toe of the slope would be evaluated to determine whether this material is suitable as a base for the new bank. Soft materials (muds and silts) in this area are not acceptable as a base material and would have to be removed. This concern is more significant in areas where rock fills (rip rap or gabions) would be used to stabilize relatively high banks. Two options considered for removing the sediments are lowering the pond by several feet and bulk excavating the sediments and dredging the sediments. Covering of the sediments is another remedial option.

Lowering of the pond by several feet followed by excavation would be safest and most efficient way to remove the sediments. However, this action could essentially drain the entire pond and there would be a moderate to high short-term impact on the existing ecological system in the area. After completion and refilling, the pond ecosystem would recover.

Use of dredging techniques would also be relatively efficient at removing sediments. Because only small areas of the pond would be affected at any one time, dredging would result in less short-term ecological impacts than discussed under the lowering of the pond option. However during the dredging, some migration of the clays and silts from the base of the causeway would occur. The impacts would be most significant in areas where the sediments are more contaminated and with increasing distance from the causeway, where the sediments are more predominately silts and clays.

The time needed to complete remedial actions is anticipated to be 1 to 2 years. The following RAOs/CAOs would be achieved:

RAO/CAO	RGOs: ILCR = 1.0E-04 and High Risk to Eco.	RGOs: ILCR = 1.0E-05 and Moderate Risk to Eco.	RGOs: ILCR = 1.0E-06 and Low Risk to Eco.
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of	X	X	X
Control ecological exposure (terrestrial receptors) to COC concentrations in surface soil in excess of	X	X	X
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of	X	X	*
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of	X	X	*
Control ecological exposure (aquatic receptors) to COC concentrations in sediment in excess of	X	X	*

X = RAO/CAO achieved. A blank space indicates the RAO/CAO is not achieved.
* = RAO/CAO will also be achieved through land use controls and natural attenuation of site contaminants. However, additional time beyond 1 to 2 years is likely.

Additionally, Alternative 3b would eliminate the migration of COCs from the fill material to groundwater, surface water, and sediment and would comply with ARARs.

Because slope stabilization and erosion control measures would prevent the transport of waste materials and COCs to sediment, existing COCs in sediment may attenuate to levels that would achieve RGOs that represent a human health ILCR equal to 1.0E-06 and a low risk to ecological receptors. Due to the conservative nature of these sediment RGOs, supplemental testing could be conducted to refine the RGOs and more accurately depict the risk posed to human and ecological receptors.

Implementability

Alternative 3b would be implementable. Contractors and equipment are readily available for conducting soil-moving/excavation activities and installing slope stabilization and erosion control measures. In the long-term, minimal repair to slope stabilization and erosion control measures may be required; however, such repair actions would be easy to implement.

Existing exposure pathways of residual risks can be monitored easily. Four groundwater wells currently exist on the causeway and could be used to monitor the surficial aquifer.

This alternative is administratively feasible. The MCRD Parris Island Partnering Team consists of representatives of the U.S. EPA, SCDHEC, SCDNR, NOAA, and USFWS as well as the U.S. Navy and Marine Corps. Regulatory approval/permitting requirements could be coordinated via this partnering mechanism.

Cost Analysis

The following costs are estimated for Alternative 3b. The cost estimate is provided in Appendix D.

Estimated capital costs:	$5,130,000
Estimated O&M costs:	$58,700 to $74,700 per year
Estimated 30-year present worth:	$5,910,000

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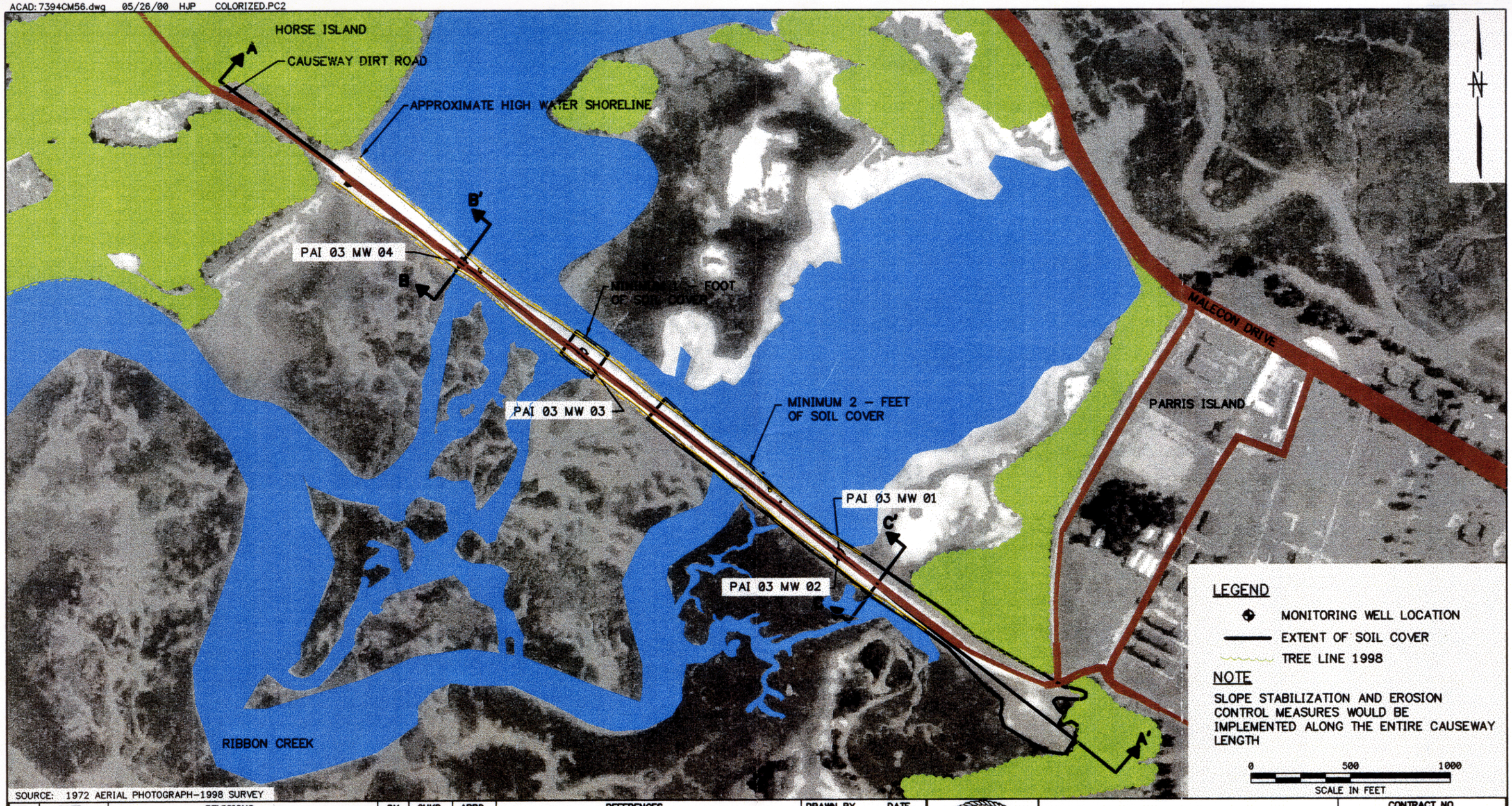

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/29/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

ALTERNATIVE 2a
PARTIAL CONTAINMENT - AERIAL VIEW
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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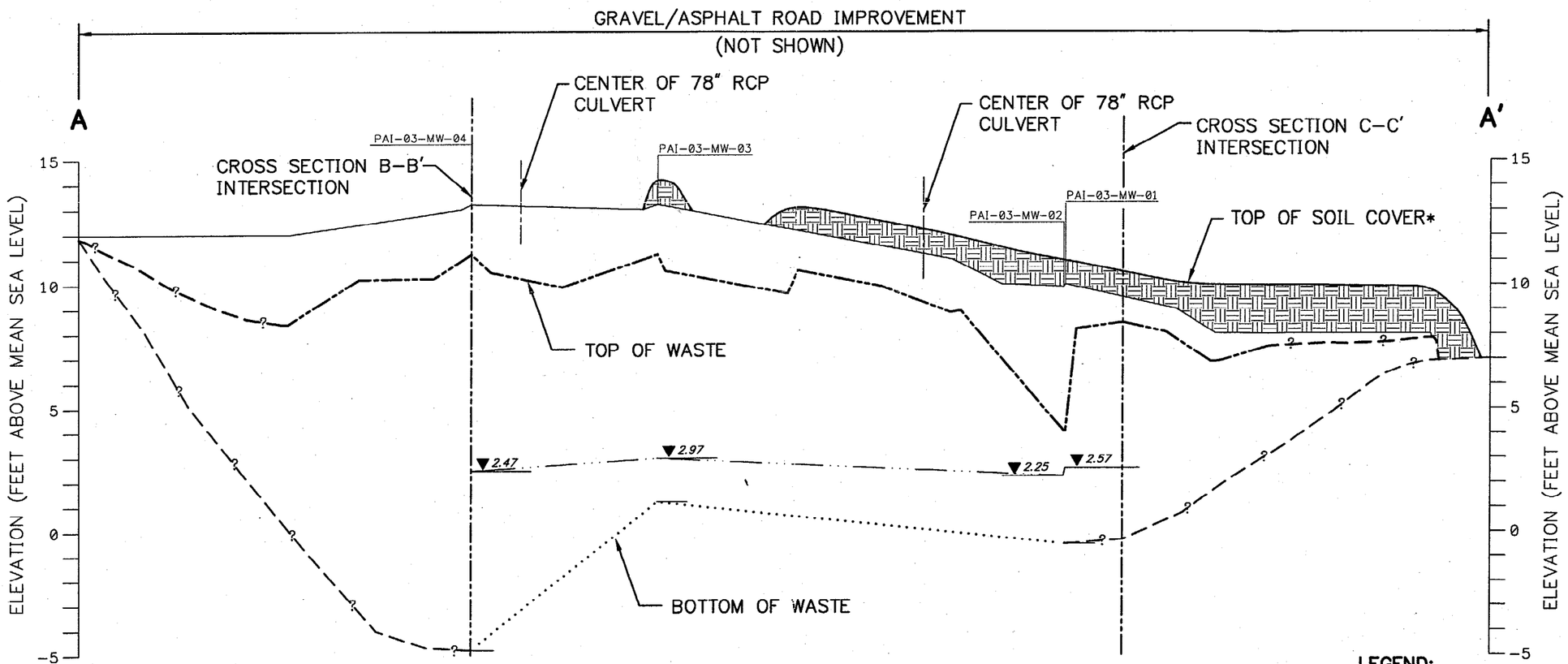

LEGEND:

PAI-03-MW-04 — MONITORING WELL

EXISTING GROUND SURFACE

TOP OF WASTE (DASHED WHERE INFERRED)

2.47 ▼ — GROUNDWATER ELEVATION

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 500 1000
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NOTE:

* COVER TO CONSIST OF 1' TO 2' OF SOIL OR GRAVEL/ASPHALT ROAD. SEE FIGURES 5-3 & 5-4.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 5/24/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION A-A'
ALTERNATIVES 2a AND 3a - PARTIAL CONTAINMENT
SITE/SWMU 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-2 REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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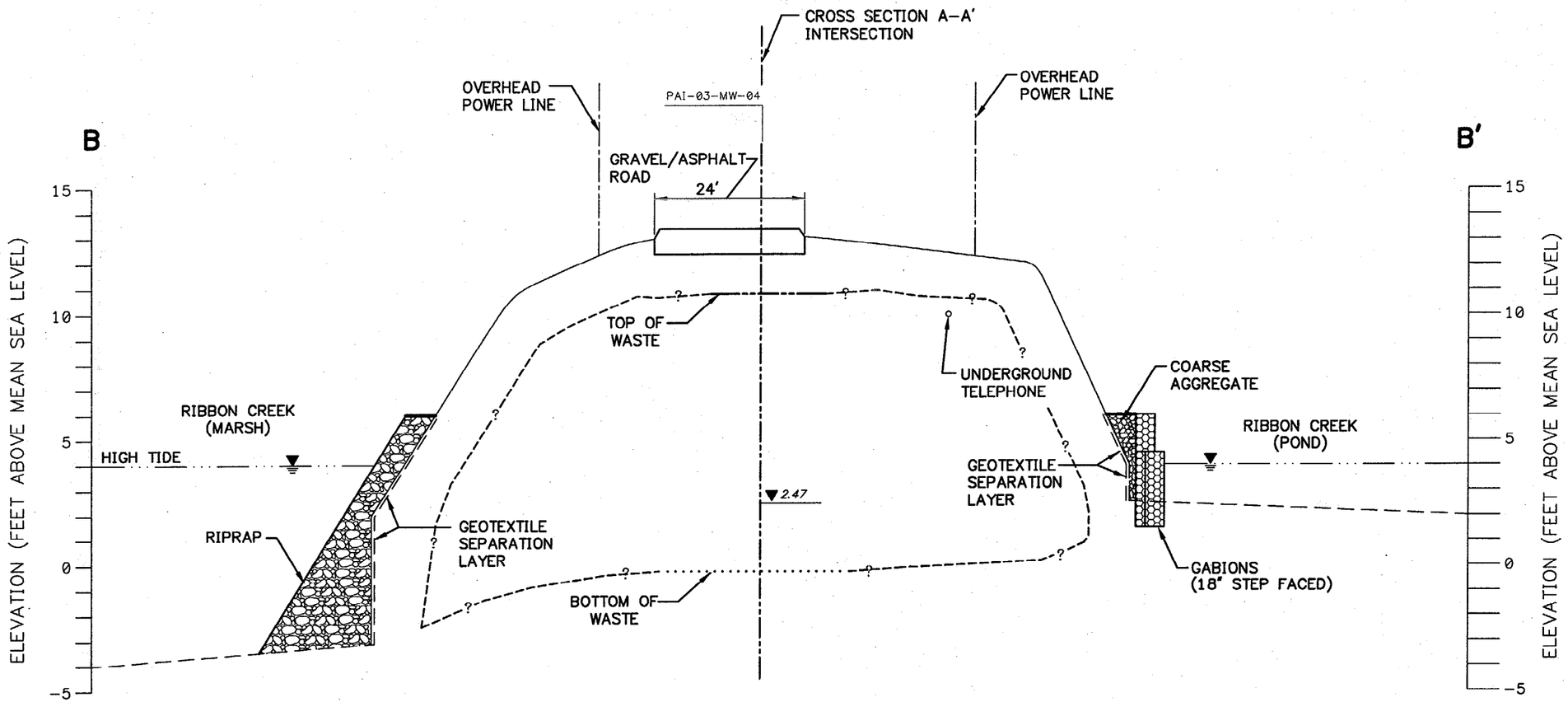

LEGEND:

PAI-03-MW-04 — MONITORING WELL

EXISTING GROUND SURFACE (DASHED WHERE INFERRED)

TOP OF WASTE (DASHED WHERE INFERRED)

2.47 ▼ — GROUNDWATER ELEVATION

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 20 40
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 7/22/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION B–B'
ALTERNATIVES 2a AND 3a – PARTIAL CONTAINMENT
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-3
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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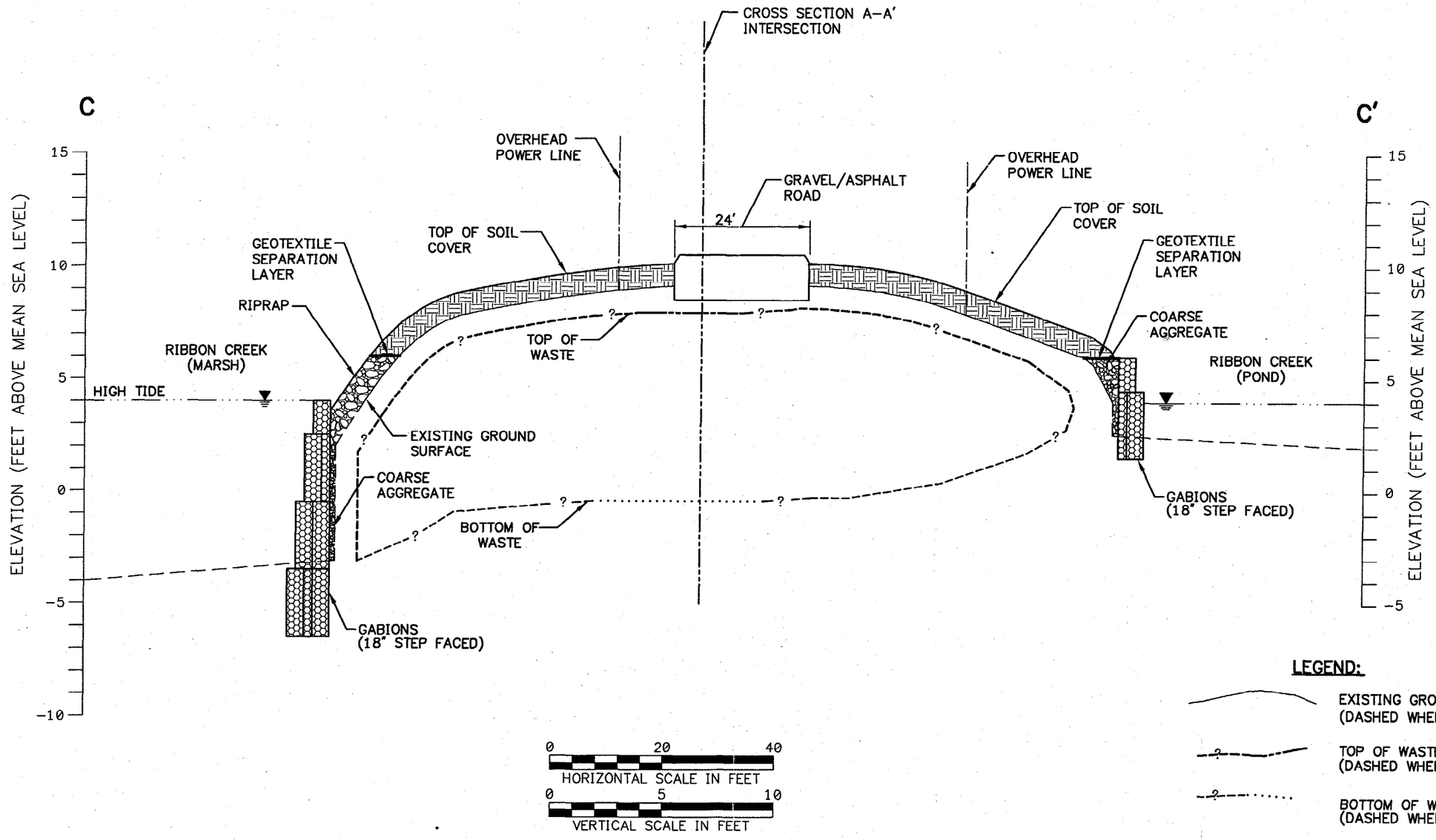

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 7/22/99
CHECKED BY DATE
COST/SCHED–AREA
SCALE AS NOTED

CROSS SECTION C–C'
ALTERNATIVES 2a, 2b, 3a AND 3b – PARTIAL AND FULL CONTAINMENT
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5–4
REV. 0

FORM CADD NO. SOUTH-BH.DGN - REV 0 - 9/9/98

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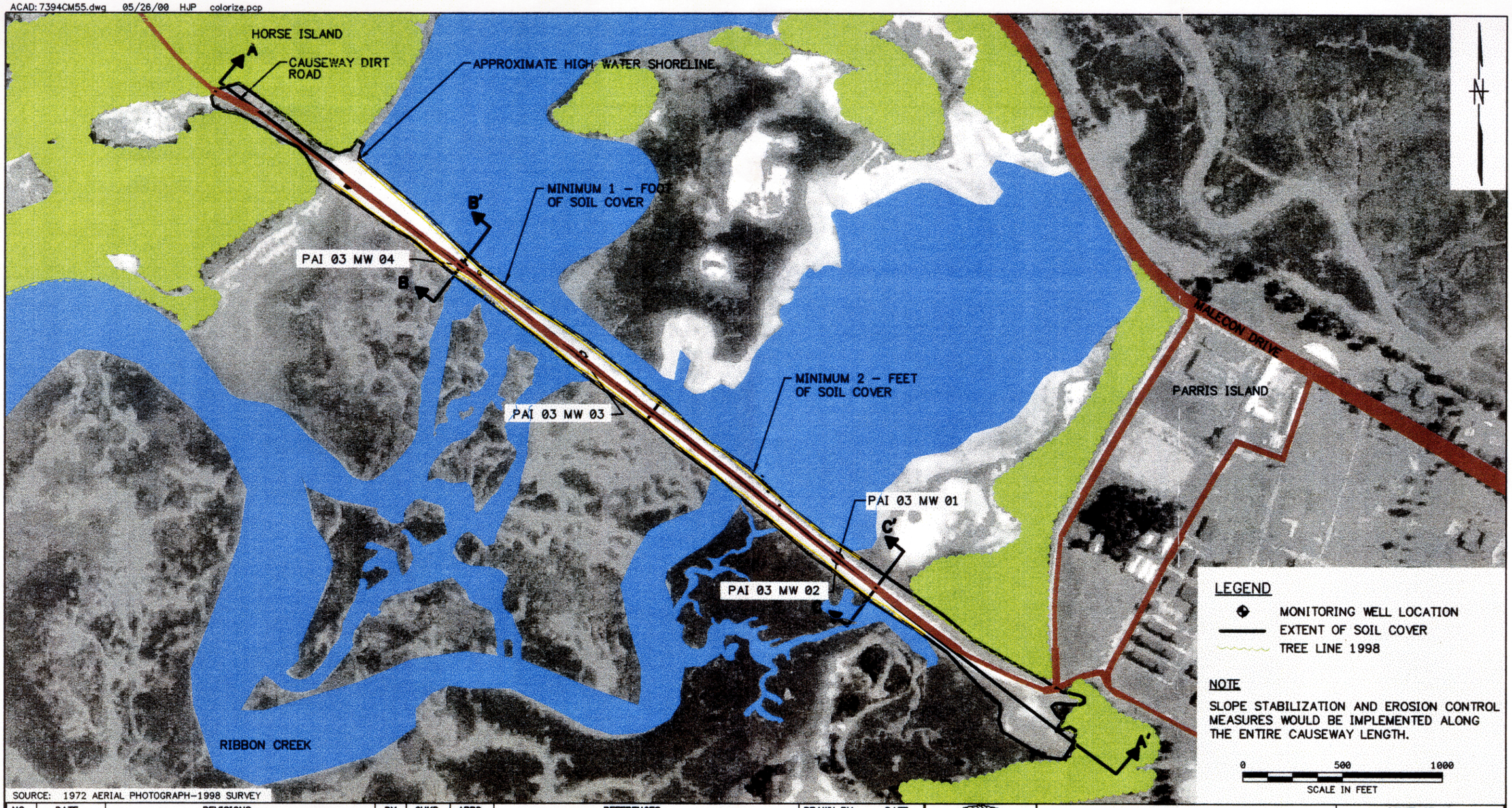

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/29/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

ALTERNATIVE 2b
FULL CONTAINMENT - AERIAL VIEW
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-5
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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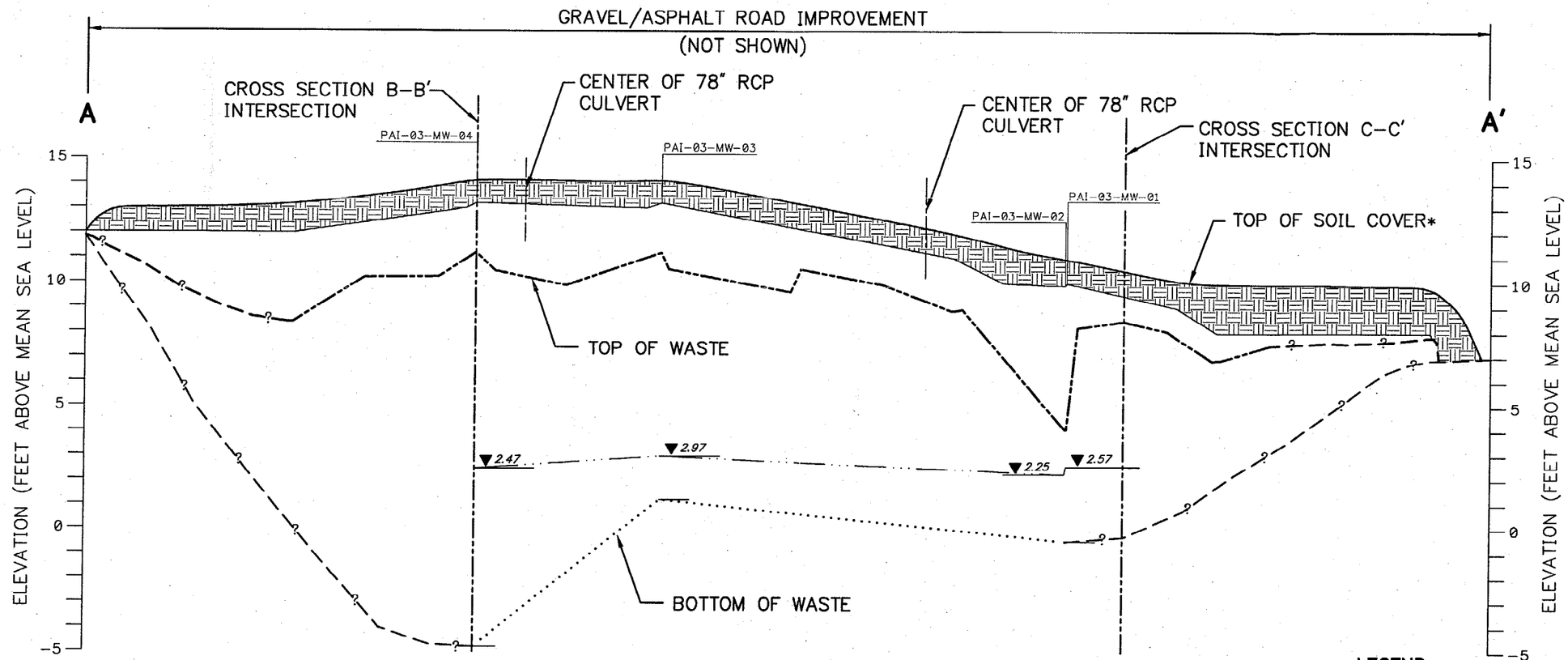
ACAD:7394cx07.dwg 10/13/99 HJP



LEGEND:

PAI-03-MW-04 — MONITORING WELL

EXISTING GROUND SURFACE

TOP OF WASTE (DASHED WHERE INFERRED)

2.47 ▼ — GROUNDWATER ELEVATION

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 500 1000
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NOTE:

* COVER TO CONSIST OF 1' TO 2' OF SOIL OR GRAVEL/ASPHALT ROAD. SEE FIGURES 5-3 & 5-4.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 5/24/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

CROSS SECTION A–A'
ALTERNATIVES 2b AND 3b – FULL CONTAINMENT
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-6
REV. 0

FORM CADD NO. SOUTH-BH.DGN – REV 0 – 9/9/98

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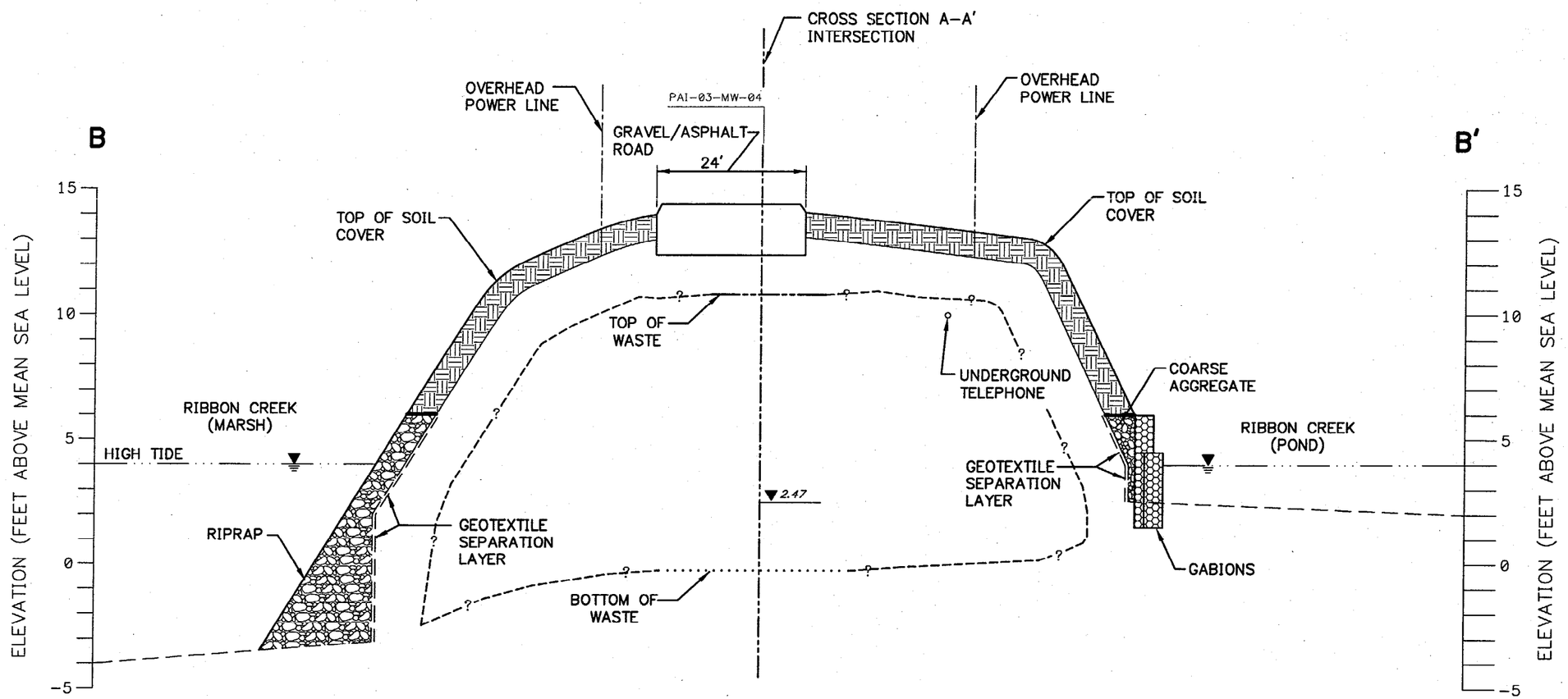
ACAD: 7394CX08.dwg 10/14/99 HJP



LEGEND:

PAI–03–MW–04 — MONITORING WELL

EXISTING GROUND SURFACE (DASHED WHERE INFERRED)

TOP OF WASTE (DASHED WHERE INFERRED)

2.47 ▼ — GROUNDWATER ELEVATION

BOTTOM OF WASTE (DASHED WHERE INFERRED)

0 20 40
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DLT DATE 7/22/99
CHECKED BY DATE
COST/SCHED–AREA
SCALE AS NOTED

CROSS SECTION B–B'
ALTERNATIVES 2b AND 3b – FULL CONTAINMENT
SITE/SWMU 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5–7
REV. 0

FORM CADD NO. SOUTH-BH.DGN – REV 0 – 9/9/98

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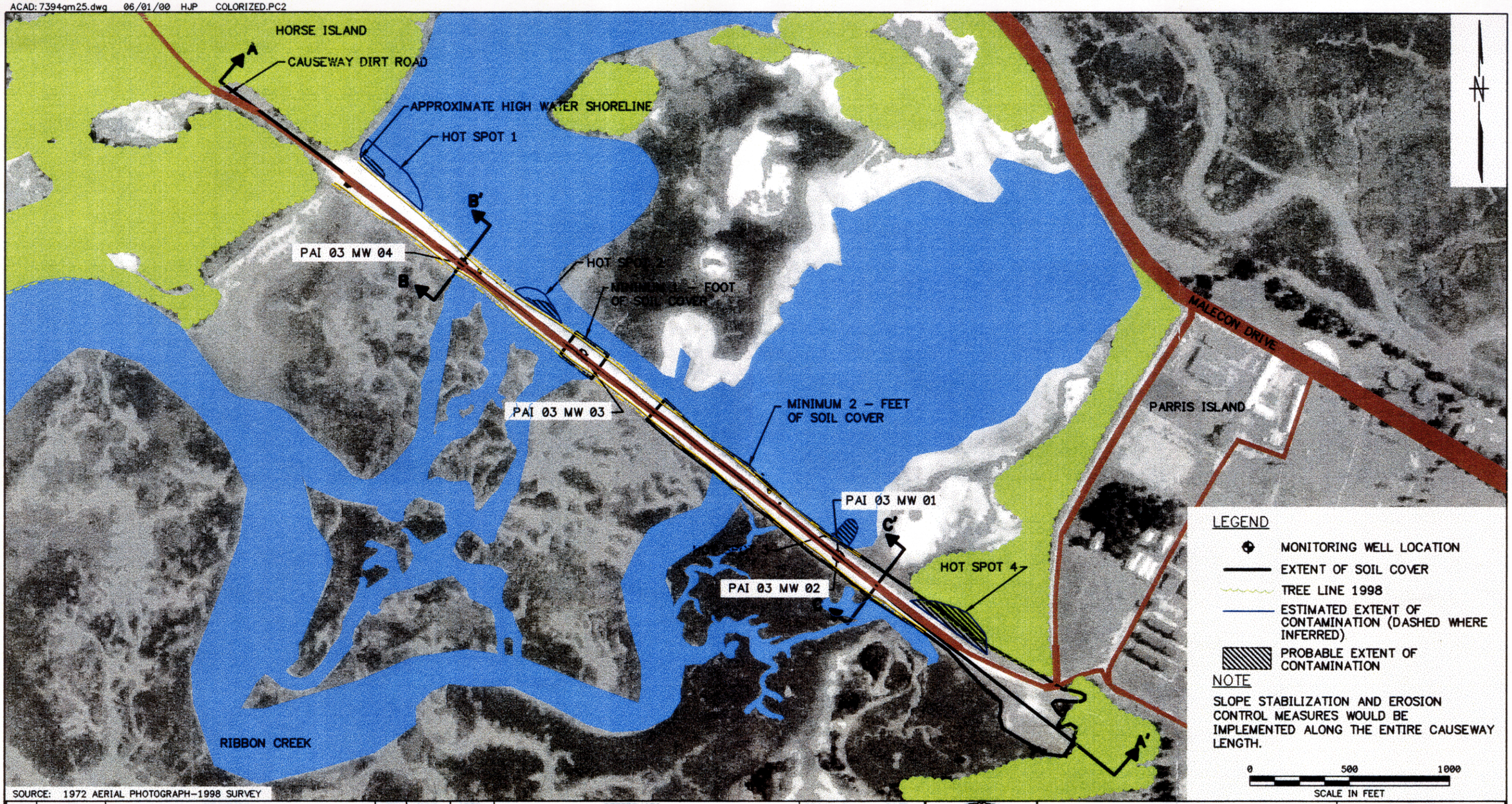

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 5/25/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

ALTERNATIVE 3a
PARTIAL CONTAINMENT WITH
SEDIMENT EVALUATION – AREAL VIEW
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 5-8
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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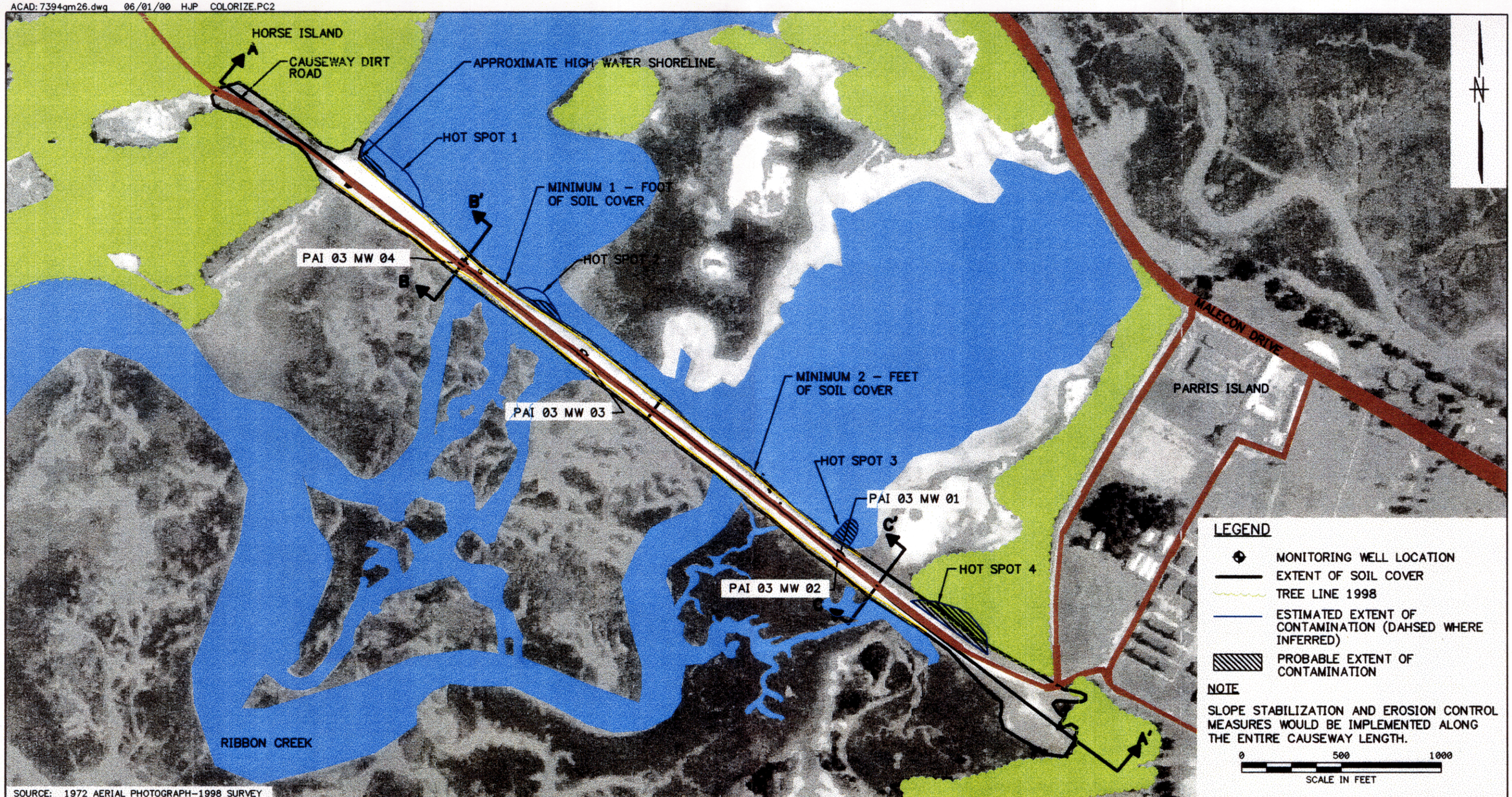

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 5/25/00
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

ALTERNATIVE 3b
FULL CONTAINMENT WITH SEDIMENT
EVALUATION - AERIAL VIEW
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
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DRAWING NO. FIGURE 5-9
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

6.0 COMPARATIVE ANALYSIS OF REMEDIAL ACTION/CORRECTIVE MEASURES ALTERNATIVES

6.1 INTRODUCTION

This section presents a comparison of the remedial action/corrective measures alternatives to each evaluation criterion. The criteria used for comparison are identical to those used for the detailed analysis of individual alternatives.

The following alternatives are compared in this section:

- Alternative 1 - No Action: This alternative is developed per the NCP to provide a baseline for comparison to other alternatives.

- Alternative 2a – Partial Containment: This alternative is developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection would be achieved by assuring that a minimum of two feet of clean soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. In addition, in areas where a concern to only terrestrial ecological receptors is present under the *high*-risk scenario, a minimum of 1 foot of soil cover would be placed. The soil cover described in this alternative would be placed over the southeast half of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway). Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

- Alternative 2b – Full Containment: This alternative is also developed to protect humans from exposure to contaminated soil and the contents of the landfill. This protection is achieved by assuring that a minimum of two feet of soil cover is present over waste material and that the sideslopes of the causeway are stable. Land use controls would be used to ensure protection of human health. Alternative 2b provides equal protection to human health as Alternative 2a; however, Alternative 2b is more protective of terrestrial ecological receptors. In areas where a concern to only terrestrial ecological receptors is present under the *low*-risk scenario, a minimum of 1 foot of soil cover would be placed. As a result of the evaluation, the soil cover described in this alternative would be placed over the entire length of the causeway. As part of the bank stabilization, incidental remediation of the sediments found to be the most contaminated would occur (sediments adjacent to the causeway).

Remaining contaminated sediments would be addressed through monitoring and natural attenuation. However, potential risks to aquatic ecological receptors may not be fully addressed in the near term.

- Alternative 3a – Partial Containment with Further Sediment Evaluation: Alternative 3a consists of all the components of Alternative 2a; however, Alternative 3a also contains components for the intentional delineation and excavating/covering of the more contaminated sediment found on the pond side of the causeway. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

- Alternative 3b – Full Containment with Further Sediment Evaluation: Alternative 3b consists of all the components of Alternative 2b; however, Alternative 3b also contains components for the intentional delineation and excavating/covering of the more contaminated sediment found on the pond side of the causeway. The sediment component would be the same as proposed in Alternative 3a. Remaining contaminated sediments would be addressed through monitoring and natural attenuation. As a result, potential risks to aquatic ecological receptors would be fully addressed.

6.2 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a comparative discussion of the alternatives versus the evaluation criteria presented in Section 5.0. A summary of this comparative analysis is presented in Table 6-1.

6.2.1 Overall Protection of Human Health and the Environment

Protection of the existing maintenance and future construction worker

- Alternative 1 would be somewhat protective of the existing maintenance and future construction worker. The estimated risks fall within the U.S. EPA acceptable ILCR risk range of 1.0E-06 to 1.0E-04. Also, the HQ for both receptors is less than 1, indicating that unacceptable non carcinogenic effects would not be expected. Risks could increase as currently contained wastes are exposed.

- With regard to surface soil exposure, Alternatives 2a, 2b, 3a, and 3b would be equally more protective of the existing maintenance and future construction worker than Alternative 1. The soil cover would decrease exposure to surface soil to less than an ILCR of 1.0E-06.

- With regard to sediment exposure, since some of the contaminated sediments would be excavated or covered under Alternatives 2a and 2b, Alternatives 2a and 2b would be more protective of the existing maintenance and future construction worker than Alternative 1. In the short-term, residual risk

attributed to sediment exposure would still exceed an ILCR of 1.0E-06 under all three alternatives (1, 2a, and 2b). The associated HQ would be less than 1. In the long term, under Alternatives 2a and 2b, existing concentrations of COCs in sediment would attenuate and associated risks would decrease. Under Alternative 1, sediment exposure risks could increase as more wastes are eroded into the sediment. The soil cover and slope stabilization and erosion control measures would eliminate the transport of waste material and impacted surface soil to sediment. Additionally, the implementation of these measures would result in excavating/covering the most impacted sediment (sediment closest to the causeway) which would prevent exposure and migration pathways attributable to this sediment.

- With regard to sediment exposure, Alternatives 3a and 3b would be more protective of the existing maintenance and future construction worker than Alternatives 2a and 2b. The sediment excavation/covering would further minimize the residual risk attributed to sediment exposure to less than an ILCR of 1.0E-06. The associated HQ would be less than 1.

Protection of the adult recreational user

- Alternative 1 may not be protective of the adult recreational user. The risks posed to the adult recreational user from fish consumption using very conservative fish ingestion assumptions exceed an ILCR of 1.0E-04 and a HQ of 1. However, using site-specific fish ingestion assumptions, the risks fall within the U.S. EPA acceptable ILCR risk range and HQ less than 1.

- Alternative 2a is more protective of the adult recreational user than Alternative 1. To eliminate the transport of surface soil and waste material to the surrounding sediment and surface water, Alternative 2a utilizes slope stabilization and erosion control measures in conjunction with a soil cover over the southeastern half of the causeway. The cover would provide a minimum of 1 foot of soil cover over areas of surface soil where COC concentrations exceed the RGOs that represent an ILCR equal to 1.0E-06 and a minimum of 2 feet of soil cover over waste material. These actions would eliminate the migration of COCs to sediment. In addition, some of the most contaminated sediments would be excavated or covered under this alternative. Ultimately, through attenuation, potential bioaccumulation of COCs from sediment to fish would decrease, thereby reducing the risks to the adult recreation user from fish consumption.

- Alternative 2b is more protective of the adult recreational user than Alternative 2a. In addition to the measures used in Alternative 2a, Alternative 2b utilizes a soil cover over the entire length of the causeway to further prevent the migration of soil COCs to sediment and surface water.

- Alternatives 3a and 3b are more protective of the adult recreational user than Alternatives 2a and 2b, especially in the short term. In addition to the measures used in Alternatives 2a and 2b, Alternatives

3a and 3b include excavation or covering of the most contaminated sediment (i.e., sediment where COC concentrations exceed RGOs that represent an ILCR of 1.0E-05). These actions would further prevent the bioaccumulation of COCs from sediment to fish and thereby minimize risks to the adult recreational user through fish consumption.

Protection of terrestrial ecological receptors (macroinvertebrates and site-specific food-chain receptors)

- Alternative 1 may not be protective of terrestrial ecological receptors. Terrestrial ecological receptors would continue to be exposed to COC concentrations in surface soil in excess of the RGOs that represent low, moderate, and high risk to ecological receptors.

- Alternatives 2a and 3a would be more protective of terrestrial ecological receptors than Alternative 1. A soil cover would be placed over the most contaminated surface soil to prevent terrestrial ecological contact with surface soil where COC concentrations exceed RGOs that represent a high risk to ecological receptors.

- Alternatives 2b and 3b would be more protective than Alternatives 2a and 3a. A soil cover would be placed over the most contaminated surface soil to prevent terrestrial ecological contact with surface soil where COC concentrations exceed RGOs that represent a low risk to ecological receptors.

Protection of aquatic ecological receptors (macroinvertebrates and site-specific food-chain receptors)

- Alternative 1 may not be protective of aquatic ecological receptors. Aquatic ecological receptors would continue to be exposed to COC concentrations in sediment in excess of the RGOs that represent a low and moderate risk to ecological receptors. However, none of the COCs observed in the sediment exceed concentrations in excess of the RGOs that represent a high risk to ecological receptors. Under Alternative 1, an ongoing release of contaminants through erosion would occur and, because of the type of waste present, sediment may become more contaminated over time.

- Alternatives 2a, 2b, 3a, and 3b would be more protective of aquatic ecological receptors than Alternative 1. The use of slope stabilization and erosion control measures and the soil cover over all or the southeastern half of the causeway would eliminate the transport of waste and impacted surface soil to nearby sediment and surface water and allow existing sediment contaminants to attenuate. Additionally, the implementation of slope stabilization and erosion control measures would result in excavating/covering the most impacted sediment (sediment closest to the causeway) which would minimize exposure and migration pathways attributable to this sediment. The COCs currently present

in sediment consist of PAHs, pesticides, PCBs, and inorganics. PAHs in sediment would be reduced through biodegradation over moderate periods of time; however, because PAHs are associated with motor vehicles and roadways, non-site-related deposition would likely continue to occur. Pesticides and PCBs in sediment would biodegrade but at a much slower rate than the PAHs. Concentrations of inorganics would decrease through processes such as advection and dispersion. Food-chain modeling indicates the risks posed to aquatic food-chain receptors from exposure to sediment are minimal when home range considerations are taken into account.

- Alternatives 3a and 3b are more protective of aquatic ecological receptors than Alternatives 2a and 2b, respectively. In addition to the measures used in Alternatives 2a and 2b, Alternatives 3a and 3b include excavation or covering of the most contaminated sediment, which would minimize ecological contact with COC concentrations in sediment in excess of the RGOs that represent moderate risk to ecological receptors.

- Alternative 3b would be more protective of aquatic ecological receptors than Alternative 3a. Because Alternative 3b includes a soil cover over the entire length of the causeway, transport of soil COCs to surface water and sediment would be further minimized than what would be observed with the partial soil cover of Alternative 3a.

6.2.2 Compliance with ARARs/Media Clean Up Standards

This criterion considers whether the alternative will achieve ARARs/media clean-up standards (ARARs).

Chemical-Specific ARARs

- In the short term, Alternative 1 would not attain AWQCs promulgated under the CWA and Surface Water Standards promulgated under the South Carolina Regulation 61-68. With Alternative 1, no action is taken to reduce the release of the causeway's contents into surrounding sediment and surface water; consequently, this alternative may not attain AWQCs, in the long term.

- In the short term, Alternatives 2a, 2b, 3a, and 3b do not attain AWQCs; however, these alternatives include actions to eliminate the release of the causeway's contents into the surrounding sediment and surface water through containment measures. Furthermore, Alternatives 3a and 3b include sediment excavation or covering to eliminate the transport of the highest concentrations of COCs from sediment to surface water. In the long term, Alternatives 2a, 2b, 3a, and 3b are anticipated to attain all chemical-specific ARARs.

- Alternative 1 does not attain various TBC criteria for soil, sediment, groundwater, and surface water. However, Alternatives 2a and 3a would comply with soil RBCs for industrial settings and CCME Soil Quality Guidelines. In addition to these two TBCs, Alternatives 2b and 3b would comply with Dutch Soil Clean Up Act Ecological Soil Screening Values, Dutch Ministry of Housing Intervention Values and Target Values – Soil Quality Standards, and Oak Ridge National Laboratory Toxicity Benchmarks for Soil. Furthermore, Alternatives 3a and 3b would comply with ER-M and PEL values for sediment.

Location-Specific ARARs

- In the short term, Alternative 1 attains location-specific ARARs; however, the causeway sideslopes may not be adequately stable. The failure of the sideslopes would result in the release of landfill contents into the nearby sediment of the marsh and pond. This occurrence would result in non-attainment of several location-specific ARARs including Executive Orders regarding Floodplain Management and Protection of Wetlands, the Endangered Species Act, Fish and Wildlife Coordination Act, and Coastal Zone Management Act.

- Alternatives 2a, 2b, 3a, and 3b would attain all location-specific ARARs.

Action-Specific ARARs

- Under Alternative 1, the southeastern half of the causeway would not meet federal and state regulations regarding the final cover requirements of landfills. These ARARs consist of final cover regulations under RCRA Subtitle C and D and South Carolina Regulations regarding Solid Waste Management: Construction, Demolition, and Land Clearing Debris Landfills (R.61-107.11), Solid Waste Management: Municipal Solid Waste Landfills (R.61-107.258), and Sanitary Landfill Design, Construction, and Operation (R.61-70).

- Alternatives 2a, 2b, 3a, and 3b would attain all action-specific ARARs.

6.2.3 Source Control

This criterion evaluates the alternatives for control of the source of contamination so as to eliminate further releases that may pose a threat to human health and the environment, to the furthest extent possible. This criterion addresses what source control actions are implemented with each alternative.

- Alternative 1 does not include source control measures.

- Alternatives 2a, 2b, 3a, and 3b utilize slope stabilization and erosion control measures to minimize the potential failure of the sideslopes of the causeway and eliminate the transport of waste materials and impacted surface soil to nearby sediment and surface water. Additionally, these measures would result in excavating/covering over the most impacted sediment (sediment closest to the causeway).

- Alternatives 2a, 2b, 3a, and 3b reduce rainwater infiltration into the causeway through construction of an asphalt road and drainage ditches.

- Alternatives 2a, 2b, 3a, and 3b provide a minimum of 2 feet of soil cover to minimize human and ecological contact with the waste contents of the causeway.

- Alternatives 2a, 2b, 3a, and 3b provide 2 feet of soil cover to minimize human contact with surface soil where COC concentrations exceed the RGOs that represent an ILCR equal to 1.0E-06.

- Alternatives 2a and 3a provide a minimum of 1 foot of soil cover to minimize ecological contact with surface soil where COC concentrations exceed RGOs that represent a *high* risk to ecological receptors.

- Alternatives 2b and 3b provide a minimum of 1 foot of soil cover to minimize ecological contact with surface soil where COC concentrations exceed RGOs that represent a *low* risk to ecological receptors.

- Alternatives 2a, 2b, 3a, and 3b include site restrictions prohibiting unauthorized intrusive activity and the use of the groundwater as a drinking water source. Under these alternatives, signs would also be posted warning of potential hazards associated with higher fish consumption rates until test results indicate that unrestricted consumption of fish meets appropriate requirements. Existing "No Swimming/Wading" signs would be maintained.

- Under Alternatives 3a and 3b, concentrations of COCs in sediment in excess of the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk to ecological receptors would be excavated or covered.

6.2.4 Waste Management Standards

The alternative must comply with applicable standards for the management of wastes. This criterion includes a description of how the specific waste management activities will be conducted in order to maintain compliance with all applicable federal and state regulations.

- Alternative 1 does not include removal of any waste materials; therefore, the management of waste material ARARs does not apply. Final cover requirements of several federal and state of South Carolina regulations are not met.

- With Alternatives 2a, 2b, 3a, and 3b minimal waste would be generated during bank stabilization activities; however, any inherently waste-like material would be taken off site for disposal in accordance with federal and South Carolina regulatory requirements.

- Alternatives 3a and 3b include the excavation or covering of COCs in sediment that exceed the RGOs that represent an ILCR of 1.0E-05 for human receptors and moderate risk to ecological receptors. Excavated sediment would be consolidated on site and covered over with clean soil. Additionally, any inherently waste-like material would be taken off site for disposal in accordance with federal and South Carolina regulatory requirements.

- Alternatives 2a, 2b, 3a, and 3b would comply with ARARs under federal and South Carolina Regulations concerning final covers for landfills.

6.2.5 Long-Term Reliability and Effectiveness

The evaluation of the long-term reliability and effectiveness of the alternatives include an assessment of useful life, operation and maintenance requirements, and demonstration of reliability.

- Alternative 1 would not be reliable and effective in the long term. Residual risks are attributed to human and ecological exposure to surface soil where COCs exceed RGOs that represent an ILCR equal to 1.0E-06 for human receptors and high risk to ecological receptors. Additionally, human and ecological receptors would be exposed to sediment containing COCs at concentrations greater than the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk for ecological receptors. Alternative 1 would allow for the human health and ecological residual risks to remain in the long term. Additionally, a continued release of the causeway's contents is likely.

- Under Alternative 2a, residual risks are attributed to ecological exposure to surface soil where COC concentrations exceed the RGOs that represent a moderate risk, but less than a high risk to ecological receptors. Additionally, residual risks are attributed to human and ecological exposure to sediment containing COCs at concentrations greater than the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk for ecological receptors.

- Under Alternative 2b, residual risks are attributed to human and ecological exposure to sediment containing COCs at concentrations greater than the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk for ecological receptors.

- Under Alternative 3a, residual risks are attributed to ecological exposure to surface soil where COC concentrations exceed the RGOs that represent a moderate risk, but less than a high risk to ecological receptors. Additionally, residual risks are attributed to human and ecological exposure to sediment containing COCs at concentrations less than the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk for ecological receptors.

- Under Alternative 3b, residual risks are attributed to human and ecological exposure to sediment containing COCs at concentrations less than the RGOs that represent an ILCR equal to 1.0E-05 for human receptors and moderate risk for ecological receptors.

- Due to the conservative nature of the RGOs that represent an ILCR equal to 1.0E-05 an moderate risk to ecological receptors, it may not be feasible to achieve these goals in sediment. Supplemental testing could be conducted to refine RGOs and more accurately depict residual risk posed to human and ecological receptors.

- Alternatives 2a, 2b, 3a, and 3b comprise remedial components that are reliable and readily available. The controls (e.g., long-term monitoring, groundwater restrictions, and inspection programs) would be adequate in determining and ensuring the reliability and effectiveness of the remedy.

6.2.6 Reduction in the Toxicity, Mobility, or Volume

This criterion evaluates the ability of alternative to reduce the toxicity, mobility, and/or volume of the contaminated media through treatment.

- Alternatives 1, 2a, 2b, 3a, and 3b do not include treatment. Although a statutory preference for treatment exists for CERCLA remedial actions, the Presumptive Remedy for CERCLA Municipal Landfill Sites (U.S. EPA, 1993) establishes containment as the presumptive remedy for CERCLA municipal landfills because the volume and heterogeneity of the waste in municipal landfills generally make treatment impracticable. These alternatives do not reduce the toxicity, mobility, or volume of the surface soil or sediment COCs other than that which would result from natural dispersion, dilution, or other attenuating factors.

- Alternatives 2a, 2b, 3a, and 3b would eliminate the migration of the contents of the landfill through soil cover placement and slope stabilization and erosion control measures. Approximately 375,000 cubic yards of landfill material would be contained with these measures.

- Under Alternatives 3a and 3b, approximately 7,100 cubic yards of sediment would be excavated or covered.

6.2.7 Short-Term Effectiveness

This criterion evaluates of the potential effects to the site workers and community (off base and on base) during implementation of the alternative. This criterion is not applicable to Alternative 1- No Action.

- Alternatives 2a, 2b, 3a, and 3b would not pose environmentally significant short-term effects to the neighboring off-base community. These alternatives would require the closure of the causeway during remedial activities that would disrupt traffic patterns on base; however, the temporary road closure would have the benefit of averting on-base personnel and guests from the vicinity of remedial actions. The time required to complete remedial actions under these alternatives is anticipated to be 1 to 2 years. Health and safety training and proper PPE usage would minimize any effects to site workers during implementation of these alternatives.

- Under Alternatives 2a, 2b, 3a, and 3b, vegetation along the sideslopes of the causeway and within the area of the soil cover would be removed. Additionally, the implementation of slope stabilization measures would encroach on wetlands. Measures would be conducted to either minimize the reduction of wetlands or to create wetland areas elsewhere on the Depot. No endangered species are known to live within the boundaries of Site 3; however, a bald eagle nest is located within the vicinity of Site 3. Actions would be conducted to minimize disturbance to the bald eagle.

- Under Alternatives 3a and 3b, aquatic receptors that inhabit the area of impacted sediment would be subject to short-term effects resulting from excavation or covering; however, these areas would be expected to re-establish to natural conditions after implementation.

- Table 6-2 illustrates which RAOs/CAOs would and would not be met under the various alternatives.

6.2.8 Implementability

This section includes consideration of the relative ease of implementation, availability of equipment and services, and the ability to obtain required permits. The time needed to complete each alternative is also provided. This criterion is not applicable to Alternative 1 - No Action.

- The implementation of Alternatives 2a, 2b, 3a, and 3b is technically feasible and easy to implement. Contractors, equipment, and materials are readily available for conducting soil-moving/excavation activities and installing slope stabilization and erosion control measures. Existing exposure pathways of residual risks can be monitored easily.

- The implementation of Alternatives 2a, 2b, 3a, and 3b is administratively feasible. The MCRD Parris Island Partnering Team consists of representatives of the U.S. EPA, SCDHEC, SCDNR, NOAA, and USFWS as well as the U.S. Navy and Marine Corps. Regulatory approval/permitting requirements could be coordinated via this partnering mechanism.

6.2.9 Cost

A cost estimate of each alternative includes both capital and operation and maintenance costs. Capital costs include both direct and indirect costs. Operation and maintenance costs are post-construction activities that are necessary to ensure the continued effectiveness of the alternative.

Alternative	Capital ($)	Operating ($/year)	30-Year Present Worth ($)
1	0	0	0
2a	4,090,000	58,700 to 74,700	4,880,000
2b	4,530,000	58,700 to 74,700	5,310,000
3a	4,700,000	58,700 to 74,700	5,480,000
3b	5,130,000	58,700 to 74,700	5,910,000

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TABLE 6-1

COMPARATIVE ANALYSIS OF ALTERNATIVES
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
PAGE 1 OF 2

Criterion	Alternative 1: No Action	Alternative 2a: Partial Containment[1]	Alternative 2b: Full Containment[2]	Alternative 3a: Partial Containment With Further Sediment Evaluation[1]	Alternative 3b: Full Containment With Further Sediment Evaluation[2]
Overall Protection of Human Health and the Environment					
• Protective of existing maintenance and future construction worker (surface soil exposure)?	Somewhat protective. Estimated risks fall within the U.S. EPA acceptable risk range of 1.0E-06 to 1.0E-04. HQs are less than 1.	Yes. Implementation of soil cover achieves the RGOs that represent an ILCR of 1.0E-06, 1.0E-05, and 1.0E-04 for this receptor.	Yes. Implementation of soil cover achieves the RGOs that represent an ILCR of 1.0E-06, 1.0E-05, and 1.0E-04 for this receptor.	Yes. Implementation of soil cover achieves the RGOs that represent an ILCR of 1.0E-06, 1.0E-05, and 1.0E-04 for this receptor.	Yes. Implementation of soil cover achieves the RGOs that represent an ILCR of 1.0E-06, 1.0E-05, and 1.0E-04 for this receptor.
• Protective of existing maintenance and future construction worker (sediment exposure)?	Somewhat protective. Estimated risks fall within the U.S. EPA acceptable risk range of 1.0E-06 to 1.0E-04. HQs are less than 1.	Yes/No. Through partial containment, transport of soil COCs to sediment would be reduced. Residual risk from sediment exposure would decrease in the future as sediment COCs attenuate, but residual risk would remain the same in the near term. Sediment in excess of the RGOs that represent an ILCR of 1.0E-06, but less than an ILCR of 1.0E-05, would remain.	Yes/No. More protective than Alternative 2a. Through full containment, transport of soil COCs to sediment would be further reduced. Residual risk from sediment exposure would decrease in the future as sediment COCs attenuate, but residual risk would remain the same in the near term. Sediment in excess of the RGOs that represent an ILCR of 1.0E-06, but less than an ILCR of 1.0E-05, would remain.	Yes/No. More protective than Alternative 2a. Utilizes sediment excavation/covering to reduce residual risk in the near term. However, sediment in excess of the RGOs that represent an ILCR of 1.0E-06, but less than an ILCR of 1.0E-05, would remain. Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment would be reduced through partial containment.	Yes/No. More protective than Alternatives 2a, 2b, and 3a. Utilizes sediment excavation/covering to reduce residual risk in the near term. However, sediment in excess of the RGOs that represent an ILCR of 1.0E-06, but less than an ILCR of 1.0E-05, would remain. Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment would be further reduced through full containment.
• Protective of adult recreational user	May not be protective. Does not achieve the RGOs that represent an ILCR of 1.0E-06 and 1.0E-05 for this receptor.[3]	Yes/No. Through partial containment, transport of soil COCs to sediment would be reduced. Residual risk would decrease in the future as sediment COCs attenuate, but residual risk would remain the same in the near term (RGOs that represent an ILCR of 1.0E-06 and 1.0E-05 are not achieved).[3]	Yes/No. More protective than Alternative 2a. Through full containment, transport of soil COCs to sediment would further decrease. Residual risk would be reduced in the future as sediment COCs attenuate, but residual risk would remain the same in the near term (RGOs that represent an ILCR of 1.0E-06 and 1.0E-05 are not achieved).[3]	Yes/No. More protective than Alternative 2a. Utilizes sediment excavation/covering to reduce residual risk in the near term. However, sediment in excess of RGOs that represent an ILCR of 1.0E-06, but less than 1.0E-05, would remain.[3] Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment would decrease through partial containment.	Yes/No. More protective than Alternatives 2a, 2b, and 3a. Utilizes sediment excavation/covering to reduce residual risk in the near term. However, sediment in excess of RGOs that represent an ILCR of 1.0E-06, but less than 1.0E-05, would remain.[3] Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment would further decrease through full containment.
• Protective of terrestrial ecological receptors (surface soil exposure)?	May not be protective. Does not achieve the RGOs that represent low, moderate, and high risk to ecological receptors.	Yes/No. Soil cover achieves the RGOs that represent high risk to this receptor. Does not achieve the RGOs that represent low and moderate risk to this receptor.	Yes. More protective than Alternative 2a and 3a. Soil cover achieves RGOs that represent low, moderate, and high risk to this receptor.	Yes/No. Soil cover achieves the RGOs that represent high risk to this receptor. Does not achieve the RGOs that represent low and moderate risk to this receptor.	Yes. More protective than Alternative 2a and 3a. Soil cover achieves RGOs that represent low, moderate, and high risk to this receptor.
• Protective of aquatic ecological receptors (sediment exposure)?	May not be protective. Does not achieve the RGOs that represent low and moderate risk to ecological receptors.[3] When home range considerations are taken into account, risk to aquatic food-chain receptors are minimal.	Yes/No. Through partial containment, transport of soil COCs to sediment would be reduced. Residual risk from sediment exposure would decrease in the future as sediment COCs attenuate, but residual risk would remain the same in the near term (RGOs that represent low and moderate risk to ecological receptors are not achieved).[3] When home range considerations are taken into account, risk to aquatic food-chain receptors are minimal.	Yes/No. More protective than Alternative 2a. Through full containment, transport of soil COCs to sediment would be further reduced. Residual risk would be reduced in the future as sediment COCs attenuate, but residual risk would remain the same in the near term (RGOs that represent low and moderate risk to ecological receptors are not achieved).[3] When home range considerations are taken into account, risk to aquatic food-chain receptors are minimal.	Yes/No. More protective than Alternative 2a. Utilizes sediment excavation/covering to reduce residual risk in the near term; however, sediment in excess of the RGOs that represent low risk, but less than moderate risk to ecological receptors, would remain.[3] Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment is reduced through partial containment.[3] When home range considerations are taken into account, risk to aquatic food-chain receptors are minimal.	Yes/No. More protective than Alternatives 2a, 2b, and 3a. Utilizes sediment excavation/covering to reduce residual risk in the near term; however, sediment in excess of the RGOs that represent low risk, but less than moderate risk to ecological receptors, would remain.[3] Residual risk from exposure to sediment would decrease in the future as sediment COCs attenuate and soil COC migration to sediment is further reduced through full containment.[3] When home range considerations are taken into account, risk to aquatic food-chain receptors are minimal.
Compliance with ARARs/Media Clean-Up Standards					
• Attains Chemical-Specific ARARs?	No. Does not attain AWQCs under the CWA.	Yes/No. AWQCs would not be attained in the near future. Partial containment would reduce transport of soil COCs to surface water. AWQCs are anticipated to be attained in the future.	Yes/No. AWQCs would not be attained in the near future. Full containment would further reduce transport of soil COCs to surface water. AWQCs are anticipated to be attained in the future in a faster time period than Alternative 2a.	Yes/No. AWQCs would not be attained in the near future. Sediment excavation/covering would remove/contain the more contaminated sediment. In combination with partial containment, AWQCs are anticipated to be attained in the future in a faster time period than Alternative 2a.	Yes/No. AWQCs would not be attained in the near future. Sediment excavation/covering would remove/contain the more contaminated sediment. In combination with full containment, AWQCs are anticipated to be attained in the future in a faster time period than Alternatives 2a, 2b, and 3a.
• Attains Location-Specific ARARs?	No. Potential failure of the causeway's sidewalls could cause non attainment of several location-specific ARARs.	Yes	Yes	Yes	Yes
• Attains Action-Specific ARARs?	No. Final cover requirements under federal and state regulations for landfills are not met.	Yes	Yes	Yes	Yes

TABLE 6-1

COMPARATIVE ANALYSIS OF ALTERNATIVES
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
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Criterion	Alternative 1: No Action	Alternative 2a: Partial Containment[1]	Alternative 2b: Full Containment[2]	Alternative 3a: Partial Containment With Further Sediment Evaluation[1]	Alternative 3b: Full Containment With Further Sediment Evaluation[2]
Source Control					
• Slope Stabilization and Erosion Control Measures	No	Yes. The measures also would cover the most impacted sediment (sediment closest to the causeway).	Yes. The measures also would cover the most impacted sediment (sediment closest to the causeway).	Yes. The measures also would cover the most impacted sediment (sediment closest to the causeway).	Yes. The measures also would cover the most impacted sediment (sediment closest to the causeway).
• Soil Cover	No	Placed over the southeastern half of the causeway.	Placed over the full length of the causeway.	Placed over the southeastern half of the causeway.	Placed over the full length of the causeway.
• Site Restrictions	No	Yes	Yes	Yes	Yes
• Sediment Excavation/Covering	No	Yes (Along the base of the causeway)	Yes (Along the base of the causeway)	Yes	Yes
• Reduced Infiltration (Through roadway and drainage ditch construction)	No	Yes	Yes	Yes	Yes
Waste Management Standards	Final cover requirements of Federal and state regulations are not met.	Meets waste management standards.	Meets waste management standards.	Meets waste management standards.	Meets waste management standards.
Long-term Reliability and Effectiveness					
• Magnitude of Residual Risk/CAO/RAO adherence	See Table 6-2	See Table 6-2	See Table 6-2	See Table 6-2	See Table 6-2
• Adequacy and Reliability of Controls	Not applicable	Controls adequate and reliable.	Controls adequate and reliable.	Controls adequate and reliable.	Controls adequate and reliable.
Reduction in Toxicity, Mobility, and Volume	No reduction in toxicity, mobility, and volume.	No reduction in toxicity, mobility, and volume. Migration of COCs in soil is reduced.	No reduction in toxicity, mobility, and volume. Migration of COCs in soil is reduced.	No reduction in toxicity, mobility, and volume. Migration of COCs in soil and sediment is reduced.	No reduction in toxicity, mobility, and volume. Migration of COCs in soil and sediments reduced.
Short-term Effectiveness					
• Protective of community?	Not Applicable	Yes	Yes	Yes	Yes
• Protective of Site Workers?	Not Applicable	Yes	Yes	Yes	Yes
• Environmental Impacts	Not Applicable	Vegetation along causeway sideslopes and in area of soil cover would be removed. Installation of slope stabilization measures would destroy wetlands; however, new wetlands would be created elsewhere on Parris Island to replace destroyed wetlands. Other impacts would be minimal.	Vegetation along causeway sideslopes and in area of soil cover would be removed. Installation of slope stabilization measures would destroy wetlands; however, new wetlands would be created elsewhere on Parris Island to replace destroyed wetlands. Other impacts would be minimal.	Vegetation along causeway sideslopes and in area of soil cover would be removed. Installation of slope stabilization measures would destroy wetlands; however, new wetlands would be created elsewhere on Parris Island to replace destroyed wetlands. Other impacts would be minimal.	Vegetation along causeway sideslopes and in area of soil cover would be removed. Installation of slope stabilization measures would destroy wetlands; however, new wetlands would be created elsewhere on Parris Island to replace destroyed wetlands. Other impacts would be minimal.
• Time to Complete Remedial Activities	Not Applicable	1 to 2 years	1 to 2 years	1 to 2 years	1 to 2 years
Implementability					
• Is the alternative technically feasible?	Not Applicable	Yes	Yes	Yes	Yes
• Is the alternative administratively feasible?	Not Applicable	Yes	Yes	Yes	Yes
Cost					
• Capital Cost ($)	0	4,090,000	4,530,000	4,700,000	5,130,000
• O&M Cost ($/year)	0	58,700 to 74,700	58,700 to 74,700	58,700 to 74,700	58,700 to 74,700
• Present Worth Cost ($)	0	4,880,000	5,310,000	5,480,000	5,910,000
State and U.S. EPA Acceptance	To be determined.	To be determined.	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.	To be determined.	To be determined.

1 Partial containment consists of slope stabilization and erosion control measures along the entire length of the causeway and a soil cover placed over the southeastern half of the causeway.
2 Full containment consists of slope stabilization and erosion control measures and a soil cover placed along the entire length of the causeway.
3 Due to the conservative nature of the RGOs, it may not be feasible to achieve these goals. Supplemental testing could be conducted to refine the RGOs and more accurately depict risk posed to receptors.

TABLE 6-2

COMPARATIVE ANALYSIS OF RAO/CAOs
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

RAO/CAO	Alternative 1: No Action	Alternative 2a: Partial Containment	Alternative 2b: Full Containment	Alternative 3a: Partial Containment With Sediment Excavation	Alternative 3b: Full Containment With Sediment Excavation
Control maintenance/construction worker exposure to COC concentrations in surface soil in excess of					
• RGOs: ILCR = 1.0E-06		X	X	X	X
• RGOs: ILCR = 1.0E-05	X	X	X	X	X
• RGOs: ILCR = 1.0E-04	X	X	X	X	X
Control maintenance/construction worker exposure to COC concentrations in sediment in excess of					
• RGOs: ILCR = 1.0E-06		(1)	(1)	(1)	(1)
• RGOs: ILCR = 1.0E-05	X	X	X	X	X
• RGOs: ILCR = 1.0E-04	X	X	X	X	X
Protect the adult recreational user by controlling concentrations of COCs in sediment in excess of					
• RGOs: ILCR = 1.0E-06		(1)(2)	(1)(2)	(1)(2)	(1)(2)
• RGOs: ILCR = 1.0E-05		(1)(2)	(1)(2)	X	X
• RGOs: ILCR = 1.0E-04	X	X	X	X	X
Control ecological exposure (aquatic receptors) to COC concentrations in sediment in excess of					
• Low Risk RGOs		(1)(2)	(1)(2)	(1)(2)	(1)(2)
• Moderate Risk RGOs		(1)(2)	(1)(2)	X	X
• High Risk RGOs	X	X	X	X	X
Reduce Migration of COCs from the fill material to groundwater, surface water, and sediment		X	X	X	X
Comply with ARARs		X	X	X	X
Control ecological exposure (terrestrial receptors) to COC concentrations in surface soil in excess of					
• Low Risk RGOs			X		X
• Moderate Risk RGOs			X		X
• High Risk RGOs		X	X	X	X

X = RAO/CAO achieved. A blank space indicates that the RAO/CAO is not achieved.

1 Slope stabilization and erosion control measures would reduce the transport of waste materials and COCs to sediment. In the long-term, this RAO could be achieved through the reduced contaminant transport to sediment in conjunction with attenuation of existing COCs in sediment.

2 Selection of sediment COCs and RGOs are based on conservative assumptions. Supplemental testing could be conducted to refine the RGOs and more accurately depict risk posed to receptors.

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Appendix A

Comparison of Surface Water and Groundwater Preliminary COCs to ARARs and Site-specific RGOs

APPENDIX A

COMPARISON OF SURFACE WATER AND GROUNDWATER PRELIMINARY COCS TO CHEMICAL-SPECIFIC CRITERIA.

Surface water

Preliminary COCs in surface water consist of several PAHs and inorganics. Surface water preliminary COCs for human health were identified as those chemicals that exceeded either a incremental lifetime cancer risk (ILCR) of 1.0E-06 or an individual hazard quotient (HQ) of 1 as calculated in the HHRA. No chemicals exceeded an HQ of 1. Surface water preliminary COCs for ecological receptors (site-specific food-chain receptors) were identified as those chemicals that exceeded a no observed adverse effect level (NOAEL) HQ of 1 as calculated in the ERA food-chain modeling. Also, surface water preliminary COCs for protection of ecological receptors (macroinvertebrates) are selected from COPCs from the Site 3 ERA for which an ecological screening value exists.

Preliminary COCs in surface water were compared against the following surface water criteria:

- Ambient Water Quality Criteria
- Human Health RGOs based on Ingestion of Fish (Conservative Ingestion Rates) for the Adult Recreational User
- Human Health RGOs based on Ingestion of Fish (Site-Specific Ingestion Rates) for the Adult Recreational User
- Human Health RGOs based on Dermal Contact by the future Construction Worker or Maintenance Worker
- U.S. EPA Region IV Salt Water Ecological Screening Values
- NOAELs and LOAELs based on HQs of 1 for the Protection of Aquatic Receptors
- South Carolina Water Quality Criteria for the Protection of Human Health

The comparison is provided in Tables A-1 and A-2.

Groundwater

Preliminary COCs in groundwater consist of the human health and ecological COPCs from the Site 3 HHRA and ERA. Preliminary COCs in groundwater were compared against the following groundwater criteria:

- Federal MCLs and MCLGs
- U.S. EPA Region III Tap Water RBCs
- South Carolina MCLs and SMCLs
- U.S. EPA Region IV Salt Water Ecological Screening Values
- South Carolina Water Quality Standards

The comparison is provided in Tables A-3 and A-4.

TABLE A-1

SURFACE WATER RGOS FOR PROTECTION OF HUMAN HEALTH
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Preliminary COCs	Concentration Range	Frequency of Detection	Background[1]	Ambient Water Quality Criteria- Human Health for Consumption of[2]		Human Health RGOs Based on Ingestion of Fish - Conservative Inputs[3]			Human Health RGOs Based on Ingestion of Fish - Site-Specific Inputs[3]			Site-Specific Human Health RGOs Based on Dermal Contact[4]			South Carolina Water Quality Criteria for Protection of Human Health[8]
						ILCR			ILCR			ILCR			
				Water + Organisms	Organisms Only	1.00E-04	1.00E-05	1.00E-06	1.00E-04	1.00E-05	1.00E-06	1.00E-04	1.00E-05	1.00E-06	
Carcinogenic PAHs[3] (µg/L)															
Benzo(a)pyrene	0.075 - 0.72	2/20	ND	**0.0044**	**0.049**	(5)	(5)	(5)	(5)	(5)	(5)	9.1	0.91	**0.091**	**0.31**
Benzo(a)anthracene	0.66	2/20	ND	**0.0044**	**0.049**	(5)	(5)	(5)	(5)	(5)	(5)	91	9.1	0.91	**0.31**
Benzo(b)fluoranthene	0.06 - 0.67	1/20	ND	**0.0044**	**0.049**	(5)	(5)	(5)	(5)	(5)	(5)	91	9.1	0.91	**0.31**
Benzo(k)fluoranthene	0.025 - 0.25	2/20	ND	**0.0044**	**0.049**	(5)	(5)	(5)	(5)	(5)	(5)	910	91	9.1	0.31
Chrysene	0.09 - 1.2	2/20	ND	**0.0044**	**0.049**	(5)	(5)	(5)	(5)	(5)	(5)	9100	910	91	**0.31**
Dibenzo(a,h)anthracene	ND	0/20	ND	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	0.31
Indeno(1,2,3-cd)pyrene	0.075 - 0.39	2/20	2.6	*0.0044*	*0.049*	(5)	(5)	(5)	(5)	(5)	(5)	91	9.1	0.91	**0.31**
Inorganics (filtered) (µg/L)															
Arsenic	2.3 - 12.9	2/20	4.3	*0.018*	*0.14*	17.2[6]	**5.59[6]**	**4.43[6]**	183[6]	**22.2[6]**	**6.09[6]**	-	-	-	**1.4**

1 Background is calculated as 2 times the average background concentration. For non-detected chemicals, one-half the detection limit was used.
2 63 FR 68354 - 68364, December 10, 1998.
3 Calculated for the adult recreational user.
4 Calculated for the construction/maintenance worker.
5 For In the HHRA, ingestion risks from organics were evaluated using the sediment to fish tissue pathway. The surface water to fish tissue pathway was not evaluated.
6 Criterion is equal to the RGO corresponding to the ICR plus background.
7 Carcinogenic PAHs were retained aspreliminary COCs based on the Site 3 RI/RFI HHRA; however, this specific PAH was not detected in sediment. Therefore, it will not be retained as a COC for sediment.
8 South Carolina Regulation 61-68, Appendix 2
- = Not applicable or not available
ND = Non-Detected Value
Shaded and bold values indicate that the criterion has been exceeded.
Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background.

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TABLE A-2

SURFACE WATER RGOS FOR PROTECTION OF ECOLOGICAL RECEPTORS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Preliminary COCs	Maximum Concentration	Background[7]	Ambient Water Quality Criteria - Saltwater[1]		U.S. EPA Salt Water Eco. Screening Values[2] (acute/chronic)	NOAELs - Aquatic Receptors[3]		LOAELs - Aquatic Receptors[4]	
			Criterion Max. Conc.	Criterion Continuous Conc.		HQ = 1	Receptor	HQ = 1	Receptor
Organics (µg/L)									
AROCLOR-1254	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
4,4'-DDD	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
4,4'-DDE	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
4,4'-DDT	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
FLUORANTHENE	1.9	ND	-	-	4/1.6	(8)	(8)	(8)	(8)
Inorganics (filtered) (µg/L)									
ALUMINUM	650	ND	**340**	**150**	-	**104**	Raccoon	1043	Raccoon
ARSENIC	12.9	4.3	69	36	69/36[6]	37.6	Raccoon	376	Raccoon
BARIUM	279	256	-	-	-	6217	Raccoon	55196	Heron
CHROMIUM	ND	2	(5)	(5)	(5)	(8)	(8)	(8)	(8)
COBALT	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
COPPER	1.7	13	4.8	3.1	2.9/2.9	(8)	(8)	(8)	(8)
IRON	549	48	-	-	-	**95.3**	Raccoon	953	Raccoon
LEAD	ND	11	(5)	(5)	(5)	(5)	(5)	(5)	(5)
MERCURY	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
NICKEL	ND	ND	(5)	(5)	(5)	(8)	(8)	(8)	(8)
SELENIUM	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
SILVER	0.71	ND	1.9	-	2.3/0.23	(8)	(8)	(8)	(8)
THALLIUM	ND	ND	(5)	(5)	(5)	(5)	(5)	(5)	(5)
VANADIUM	11	15	-	-	-	4687	Raccoon	46874	Raccoon
ZINC	84.8	66	9100	69000	95/86	1708	Heron	15428	Heron

1 63 FR 68354 - 68364

2 U.S. EPA (United States Environmental Protection Agency), 1998.

3 Minimum no observable adverse effects level calculated for the Raccoon, Heron, Mummichog, Red Drum, and Eagle. The receptor that corresponds to this value is also listed.

4 Minimum low observable adverse effects level calculated for the Raccoon, Heron, Mummichog, Red Drum, and Eagle. The receptor that corresponds to this value is also listed.

5 This compound was retained as a preliminary COC based on the RI food chain modelling which considered both sediment and surface water; however, this chemical was not detected in surface water. Therefore, it will not be retained as a preliminary COC for surface water.

6 Criterion for arsenic(III).

7 Background concentration is calculated as 2 times the average background concentration. For non-detected chemicals, one-half detection limit was used.

8 This chemical is not a preliminary COC for the protection of site-specific food chain receptors

9 Criterion for chromium(III).

"-" = Not Applicable or Not Available

ND = Non Detected Value

Shaded and bold values indicate that the criterion has been exceeded.

Shaded and italicized values indicate that the criterion has been exceeded; however, the criterion is less than background.

TABLE A-3

COMPARISON OF GROUNDWATER HUMAN HEALTH COPCS TO FEDERAL AND STATE GROUNDWATER CRITERIA
SITE 3- CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Human Health COPCs	Maximum Concentration	Detection Frequency	Federal Criteria			State Criteria			
			MCLs[1]	MCLG[1]	Tap Water RBCs[2]	MCLs[3]	SMCLs[3]	Water Quality Criteria [4]	
								MCL	Taste and Odor
VOCs (ug/L)									
Benzene	21	2/4	**5**	**0**	**0.36**	**5**	-	**5**	**20**
Chlorobenzene	130	2/4	-	-	**35**	-	-	**100**	-
Chloroform	0.3	1/4	100	**0**	**0.15**	-	-	100	-
SVOCs (ug/L)							-		
1,4-Dichlorobenzene	10	1/4	75	75	**0.47**	-	-	75	-
4-Methylphenol	73	1/4	-	-	180	-	-	-	-
PESTICIDES/PCBs (ug/L)									
alpha-BHC	0.12	1/4	-	-	**0.011**	-	-	0.13	-
INORGANICS (UNFILTERED) (ug/L)									
Arsenic	34.5	4/4	50	-	**0.045**	50	-	-	-
Barium	854	4/4	2000	2000	2600	2000	-	-	-
Iron	32600	3/3	-	-	**11000**	-	**300**	-	-
Manganese	708	3/3	-	-	730	-	**50**	-	-
Thallium	2.6	1/4	2	5	2.6	**2**	-	**2**	-
INORGANICS (FILTERED) (ug/L)									
Arsenic	31.1	4/4	50	-	**0.045**	50	-	-	-
Barium	901	4/4	2000	2000	2600	2000	-	-	-
Iron	31500	3/3	-	-	**11000**	-	**300**	-	-
Manganese	711	3/3	-	-	730	-	**50**	-	-
Thallium	3.8	1/4	**2**	5	**2.6**	**2**	-	**2**	-

1 U.S. EPA Drinking Water Regulations and Health Advisories, October 1996.
2 U. S. EPA, 1999. Risk-Based Concentration Table, U. S. EPA Region III, April.
3 South Carolina State Drinking Water Regulations. Chapter 61-58.
4 South Carolina Water Quality Standards. Chapter 61-68.
"-" = Not applicable or not available
ND = Non Detected Value
RBC = Risk-Based Concentration
Shaded and bold values indicate that the criterion has been exceeded.

TABLE A-4

COMPARISON OF GROUNDWATER ECOLOGICAL COPCS TO SURFACE WATER CRITERIA
SITE 3- CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

Ecological COPC	Frequency of Detection	Maximum Concentration	U.S.EPA Region 4 Screening Level (Saltwater)[1]
VOLATILE ORGANIC COMPOUNDS (µg/L)			
Carbon Disulfide	1/4	0.3	NA
Chlorobenzene	2/4	**130**	105
Xylenes, Total	1/4	0.3	NA
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)			
2-Methylnaphthalene	1/4	1	NA
4-Methylphenol	1/4	73	NA
Bis(2-Ethylhexyl)phthalate	3/4	1	NA
METALS AND INORGANIC COMPOUNDS (mg/L)			
Barium	4/4	901	NA
Iron	3/3	32600	NA
Manganese	3/3	711	NA

1 U.S. EPA (United States Environmental Protection Agency), 1995. U.S. EPA Region IV Surface Water Screening Values, Supplemental Guidance to RAGS – Bulletin Number 2, U. S. EPA Region IV, November.

Shaded and bold values indicate that the criterion has been exceeded.

Appendix B

Derivation of Remedial Goal Options

Appendix B-1

Derivation of Human Health RGOs For Soil, Sediment and Surface Water

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on carcinogenic and noncarcinogenic risks from ingestion of Finfish/Shellfish by the adult recreational user			
Based On: MCRD Parris Island Site 3 RI Human Health Risk Assessment			
By: J. Brown	**Checked By:** R Jupi		**Date:** May 27, 1999

Purpose: To calculate sediment RGOs based on carcinogenic and noncarcinogenic risks from ingestion of Finfish/Shellfish by the adult recreational user as determined from the Site 3 RI human health risk assessment using both conservative and site-specific inputs. RGOs are calculated for preliminary COCs from the Site 3 RI which are chemicals that exceed an ICR of 1.0E-06 or a hazard quotient of 1.0.

Equations:

$TBP_{rgo} = (TBP_{exp} \times ICR_{rgo})/ICR_{exp}$ for carcinogenic risks

$TBP_{rgo} = (TBP_{exp} \times HQ_{rgo})/HQ_{exp}$ for noncarcinogenic risks

$Sed_{rgo} = (TBP_{rgo} \times f_{oc})/(BSAF \times f_l)$

Where:

BSAF = biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)

C_{sed} = Exposure concentration in sediment (ug/kg)

f_l = organism lipid content expressed as a decimal fraction

f_{oc} = Total organic carbon (TOC) content of sediment expressed as a decimal fraction

TBP_{exp} = Theoretical bioaccumulation potential in fish tissue corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment (ug/kg)

TBP_{rgo} = Theoretical bioaccumulation potential in fish tissue corresponding to the desired RGO (ug/kg)

HQ_{exp} = Hazard Quotient (unitless) corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment

HQ_{rgo} = Hazard Quotient (unitless) corresponding to the desired RGO

ICR_{exp} = Incremental Cancer Risk (unitless) corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment

ICR_{rgo} = Incremental Cancer Risk (unitless) corresponding to the desired RGO

Sed_{rgo} = Sediment remedial goal option corresponding a desired ICR (ug/kg)

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on carcinogenic and noncarcinogenic risks from ingestion of Finfish/Shellfish by the adult recreational user			
Based On: MCRD Parris Island Site 3 RI Human Health Risk Assessment			
By: J. Brown	**Checked By:**		**Date:** May 27, 1999

Assumptions for Aroclor 1254:

TBP_{exp} = 330 ug/kg (From Table 6-11 of the Site 3 RI)
BSAF = 1.85
f_l = 0.01
f_{oc} = 0.014

Conservative Inputs
HQ_{exp} = 12 (From Table 7.9, Appendix E of the Site 3 RI)
ICR_{exp} = 2.1E-04 (From Table 8.9, Appendix E of the Site 3 RI)

Site-Specific Inputs
HQ_{exp} = 4.2 (From Table 7.11, Appendix E of the Site 3 RI)
ICR_{exp} = 1.4E-05 (From Table 8.11, Appendix E of the Site 3 RI)

Example Carcinogenic Calculation for ICR = 1.0E-06 using Conservative Inputs

TBP_{rgo} = (330 ug/kg x 1.0E-06)/2.1E-04 = 1.57 ug/kg

Sed_{rgo} = (1.57 ug/kg x 0.014)/(1.85 x 0.01) = 1.19 ug/kg

Example Carcinogenic Calculation for ICR = 1.0E-06 using Site-Specific Inputs

TBP_{rgo} = (330 ug/kg x 1.0E-06)/1.4E-05= 23.6 ug/kg

Sed_{rgo} = (23.6 ug/kg x 0.014)/(1.85 x 0.01) = 17.8 ug/kg

Example Non-Carcinogenic Calculation for HQ = 1.0 using Conservative Inputs

TBP_{rgo} = (330 ug/kg x 1)/12 = 27.5 ug/kg

Sed_{rgo} = (27.5 ug/kg x 0.014)/(1.85 x 0.01) = 20.8 ug/kg

Example Non-Carcinogenic Calculation for HQ = 1.0 using Site-Specific Inputs

TBP_{rgo} = (330 ug/kg x 1)/4.2 = 78.6 ug/kg

Sed_{rgo} = (78.6 ug/kg x 0.014)/(1.85 x 0.01) = 59.5 ug/kg

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks from ingestion of Finfish/Shellfish by the adult recreational user.			
Based On: MCRD Parris Island Site 3 RI Human Health Risk Assessment			
By: J. Brown	**Checked By:** R Jupi		**Date:** May 28, 1999

Purpose: To calculate surface water RGOs based on carcinogenic and noncarcinogenic risks from ingestion of Finfish/Shellfish by the adult recreational receptor as determined from the Site 3 RI human health risk assessment using both conservative and site-specific inputs. RGOs are calculated for preliminary COCs from the Site 3 RI which are chemicals that exceed an ICR of 1.0E-06 or a hazard quotient of 1.0. No chemicals in surface water exceeded an HQ of 1.0.

Equations:

$TBP_{rgo} = (TBP_{exp} \times ICR_{rgo})/ICR_{exp}$

$SW_{rgo} = TBP_{rgo}/BCF_{fish}$

Where:

BCF = bioconcentration factor for fish (L/kg)
C_{sw} = Exposure concentration in surface water (ug/L)
TBP_{exp} = Theoretical bioaccumulation potential in fish tissue corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment (ug/L)
TBP_{rgo} = Theoretical bioaccumulation potential in fish tissue corresponding to the desired RGO (ug/L)
ICR_{exp} = Incremental Cancer Risk (unitless) corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment
ICR_{rgo} = Incremental Cancer Risk (unitless) corresponding to the desired remedial goal option
SW_{rgo} = Surface water remedial goal option corresponding a desired ICR (ug/L)

Assumptions (for arsenic):

TBP_{exp} = 0.219 mg/kg (From Table 6-11 of the Site 3 RI)
BCF_{fish} = 17 L/kg

Conservative Inputs
ICR_{exp} = 1.0E-04 (From Table 8.9, Appendix E of the Site 3 RI)

Site-Specific Inputs
ICR_{exp} = 7.2E-06 (From Table 8.11, Appendix E of the Site 3 RI)

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks from ingestion of Finfish/Shellfish by the adult recreational user.			
Based On: MCRD Parris Island Site 3 RI Human Health Risk Assessment			
By: J. Brown	**Checked By:** RJ Lupi		**Date:** May 28, 1999

Example Carcinogenic Calculation for ICR = 1.0E-06 using Conservative Inputs

TBP_{rgo} = (0.219 mg/kg x 1.0E-06)/ 1.0E-04 = 0.00219 mg/kg

SW_{rgo} = 0.00219 mg/kg /17 kg/L = 0.000129 mg/L = 0.129 ug/L

Example Carcinogenic Calculation for ICR = 1.0E-06 using Site-Specific Inputs

TBP_{rgo} = (0.219 mg/kg x 1.0E-06)/ 7.2E-06 = 0.0304 mg/kg

SW_{rgo} = 0.0304 mg/kg /17 kg/L = 0.00178 mg/L = 1.79 ug/L

SURFACE WATER AND SEDIMENT RGOS FOR INGESTION OF FISH - CONSERVATIVE INPUTS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

f_{loc} = 0.014
f_l = 0.01

Preliminary Chemical of Concern	TBP_{exp} (1)(4)	ICR_{exp} (2)(5)	BSAF	BCF (fish)	ICR = 1E-06		ICR = 1.0E-5		ICR = 1.0E-4	
					Sed RGO	SW RGO	Sed RGO	SW RGO	Sed RGO	SW RGO
Carcinogenic PAHs (ug/kg)										
Benzo(a)pyrene	308	7.10E-04	0.29	-	2.09	-	20.9	-	209	-
Benzo(a)anthracene	(3)	(3)	(3)	(3)	20.9	-	209	-	2094	-
Benzo(b)fluoranthene	(3)	(3)	(3)	(3)	20.9	-	209	-	2094	-
Benzo(k)fluoranthene	(3)	(3)	(3)	(3)	209	-	2094	-	20942	-
Chrysene	(3)	(3)	(3)	(3)	2094	-	20942	-	209422	-
Dibenzo(a,h)anthracene	(3)	(3)	(3)	(3)	2.09	-	20.9	-	209	-
Indeno(1,2,3-cd)pyrene	(3)	(3)	(3)	(3)	20.9	-	209	-	2094	-
Pesticides/PCBs (ug/kg)										
Carbazole	407	2.60E-06	1	-	219	-	2192	-	21915	-
4,4'-DDD	58	4.40E-06	0.28	-	66	-	659	-	6591	-
4,4'-DDE	248	2.70E-05	7.7	-	1.67	-	16.7	-	167	-
4,4'-DDT	41	4.40E-06	1.67	-	7.81	-	78.1	-	781	-
alpha-chlordane	95	1.10E-05	4.77	-	2.53	-	25.3	-	253	-
gamma-chlordane	44.4	4.90E-06	2.22	-	5.71	-	57.1	-	571	-
Aroclor-1254	330	2.10E-04	1.85	-	1.19	-	11.9	-	119	-
Aroclor-1260	92.5	5.90E-05	1.85	-	1.19	-	11.9	-	119	-
Dieldrin	0.98	5.00E-06	-	-	0.196	-	1.96	-	19.6	-
Inorganics (TBP in mg/kg and RGOs in ug/L)										
Arsenic	0.219	1.00E-04	-	17	-	0.129	-	1.29	-	12.9

Preliminary Chemical of Concern	TBP_{exp} (1)	HI(2)	BSAF	BCF (fish)	RGO HI=1
					Sed RGO
Pesticides/PCBs (ug/kg)					
Aroclor-1254	330.357	1.20E+01	1.85	-	20.8

Notes:
1 - From Table 6-11 of the Site 3 RI
2 - ICR or HI as calcuated in the HHRA corresponding to the maximum concentration (See Tables 7.9 and 8.9 in App. E of the Site 3 RI).
3 - Calculated based on benzo(a)pyrene equivalents
4 - Because a BASF is not available for Dieldrin, fish tissue concentration is assumed to equal the sediment concentration.
5- ICR for Dieldrin obtained from Table 8.7 in Appendix E of the Site 3 RI.
"-" - Not applicable.

SURFACE WATER AND SEDIMENT RGOS FOR INGESTION OF FISH - SITE-SPECIFIC INPUTS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

f_{loc} = 0.014
f_l = 0.01

Preliminary Chemical of Concern	TBP_{exp} (1)(4)	ICR_{exp} (2)(5)	BSAF	BCF (fish)	ICR = 1E-06		ICR = 1.0E-5		ICR = 1.0E-4	
					Sed RGO	SW RGO	Sed RGO	SW RGO	Sed RGO	SW RGO
Carcinogenic PAHs (ug/kg)										
Benzo(a)pyrene	308	4.90E-05	0.29	-	30.3	-	303	-	3034	-
Benzo(a)anthracene	(3)	(3)	(3)	(3)	303	-	3034	-	30345	-
Benzo(b)fluoranthene	(3)	(3)	(3)	(3)	303	-	3034	-	30345	-
Benzo(k)fluoranthene	(3)	(3)	(3)	(3)	3034	-	30345	-	303448	-
Chrysene	(3)	(3)	(3)	(3)	30345	-	303448	-	3034483	-
Dibenzo(a,h)anthracene	(3)	(3)	(3)	(3)	30.3	-	303	-	3034	-
Indeno(1,2,3-cd)pyrene	(3)	(3)	(3)	(3)	303	-	3034	-	30345	-
Pesticides/PCBs (ug/kg)										
Carbazole	407	1.80E-07	1	-	3166	-	31656	-	316556	-
4,4'-DDD	58	3.00E-07	0.28	-	967	-	9667	-	96667	-
4,4'-DDE	248	1.80E-06	7.7	-	25.1	-	251	-	2505	-
4,4'-DDT	41	3.00E-07	1.67	-	114.6	-	1146	-	11457	-
alpha-chlordane	95	7.30E-07	4.77	-	38.2	-	382	-	3820	-
gamma-chlordane	44.4	3.40E-07	2.22	-	82.4	-	824	-	8235	-
Aroclor-1254	330	1.40E-05	1.85	-	17.8	-	178	-	1784	-
Aroclor-1260	92.5	4.00E-06	1.85	-	17.5	-	175	-	1750	-
Dieldrin	0.98	5.00E-06	-	-	0.196	-	1.96	-	19.6	-
Inorganics (TBP in mg/kg and RGOs in ug/L)										
Arsenic	0.219	7.20E-06	-	17	-	1.79	-	17.9	-	179

Preliminary Chemical of Concern	TBP_{exp} (1)	HI (2)	BSAF	BCF (fish)	RGO HI=1
					Sed RGO
Pesticides/PCBs (ug/kg)					
Aroclor-1254	330.357	4.20E+00	1.85	-	59.5

Notes:
1 - From Table 6-11 of the Site 3 RI
2 - ICR or HI as calcuated in the HHRA corresponding to the maximum concentration (See Tables 7.9 and 8.9 in App. E of the Site 3 RI).
3 - Calculated based on benzo(a)pyrene equivalents
4 - Because a BASF is not available for Dieldrin, fish tissue concentration is assumed to equal the sediment concentration.
5- ICR for Dieldrin obtained from Table 8.7 in Appendix E of the Site 3 RI.
"-" - Not applicable.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks from dermal contact of surface water			
Based On: MCRD Parris Island Site 3 RI Human Health Risk Assessment			
By: J. Brown	**Checked By:**		**Date:** May 24, 1999

Purpose: To calculate surface water RGOs based on dermal contact of surface water as determined from the Site 3 RI human health risk assessment. RGOs are calculated for preliminary COCs from the Site 3 RI. Preliminary COCs are are chemicals that exceed an ICR of 1.0E-06 or a hazard quotient of 1.0. No chemicals in surface water exceeded an HQ of 1.0. Carcinogenic PAHs are the only chemicals that exceed an ICR of 1.0E-06.

Equations:

$SW_{rgo} = (C_{sw} \times ICR_{rgo})/ICR_{exp}$

Where:

C_{sw} = Exposure concentration in surface water (ug/L)
ICR_{exp} = Incremental Cancer Risk (unitless) corresponding to an exposure point concentration as calculated in the Site 3 RI Human Health Risk Assessment
ICR_{rgo} = Incremental Cancer Risk (unitless) corresponding to the desired remedial goal option
SW_{rgo} = Surface water remedial goal option corresponding a desired ICR (ug/L)

Assumptions for benzo(a)pyrene equivalents:

C_{sw} = 0.896 ug/L
ICR_{exp} = 9.9E-06

Example Carcinogenic Calculation for ICR = 1.0E-06

SW_{rgo} = (0.896 ug/L x 1.0E-06)/9.9E-06= 0.091 ug/L

RISK ASSESSMENT SPREADSHEET - CLEANUP LEVELS

SITE NAME: MARINE CORPS RESERVE DEPOT
LOCATION: PARRIS ISLAND, SOUTH CAROLINA
EXPOSURE SCENARIO: MAINTENANCE WORKERS
MEDIA: ~~SURFACE SOIL~~ Sediment
DATE: APRIL 20, 1999

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURES THROUGH INCIDENTAL INGESTION AND DERMAL CONTACT WITH SOIL ARE CONSIDERED.
ASSUMPTIONS ARE OUTLINED BELOW.

RELEVANT EQUATION:

$$C_s = \frac{TCR \cdot BW \cdot AT}{CF \cdot EF \cdot ED} \cdot \frac{1}{(IR \cdot FI \cdot CSF_{oral} + SA \cdot AF \cdot ABS \cdot CSF_{derm}}$$

$$C_S = \frac{THI \cdot BW \cdot AT}{CF \cdot EF \cdot ED} \cdot \frac{1}{\left(\frac{IR \cdot FI}{RfD_{oral}} + \frac{SA \cdot AF \cdot ABS}{RfD_{derm}}\right)}$$

WHERE:

Cs = :		Concentration in soil (mg/kg)
TCR = :	1.0E-06	Target Cancer Risk
THI = :	1	Target Hazard Index
IR = :	100	Soil Ingestion Rate (mg/day)
CF = :	1.0E-06	Conversion Factor (kg/mg)
FI = :	1	Fraction from contaminated source (unitless)
SA = :	4,100	Skin surface available for contact (cm^2/event)
AF = :	1.0	Soil to skin adherence factor (mg/cm^2)
ABS = :	Chemical Specific	Absorption factor (unitless)
EF = :	25	Exposure Frequency (days/year)
ED = :	25	Exposure Duration (years)
BW = :	70	Body Weight (kg)
ATc = :	25,550	Averaging time for carcinogenic exposures (days)
ATn = :	9,125	Averaging time for noncarcinogenic exposures (days)

Intermediate Values

Carcinogenic = :	2.9E+03	kg-soil/kg-wt/day
Noncarcinogenic = :	1.0E+09	kg-soil/kg-wt/day

CHEMICAL	ABS	Cancer Slope Factor		Reference Dose		Cleanup Level	
		Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Carc. (mg/kg)	Noncarc. (mg/kg)
Benzo(a)pyrene	0.13	7.3	23.55	NA	NA	0.22	NA
Arsenic	0.03	1.5	3.66	0.0003	0.000123	4.77	767

RISK ASSESSMENT SPREADSHEET - CLEANUP LEVELS

SITE NAME: MARINE CORPS RESERVE DEPOT
LOCATION: PARRIS ISLAND, SOUTH CAROLINA
EXPOSURE SCENARIO: CONSTRUCTION WORKERS
MEDIA: SURFACE SOIL
DATE: APRIL 20, 1999

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURES THROUGH INCIDENTAL INGESTION AND DERMAL CONTACT WITH SOIL ARE CONSIDERED.
ASSUMPTIONS ARE OUTLINED BELOW.

RELEVANT EQUATION:

$$C_s = \frac{TCR \cdot BW \cdot AT}{CF \cdot EF \cdot ED} \cdot \frac{1}{(IR \cdot FI \cdot CSF_{oral} + SA \cdot AF \cdot ABS \cdot CSF_{derm}}$$

$$C_S = \frac{THI \cdot BW \cdot AT}{CF \cdot EF \cdot ED} \cdot \frac{1}{\left(\frac{IR \cdot FI}{RfD_{oral}} + \frac{SA \cdot AF \cdot ABS}{RfD_{derm}}\right)}$$

WHERE:

Cs = :		Concentration in soil (mg/kg)
TCR = :	1.0E-06	Target Cancer Risk
THI = :	1	Target Hazard Index
IR = :	480	Soil Ingestion Rate (mg/day)
CF = :	1.0E-06	Conversion Factor (kg/mg)
FI = :	1	Fraction from contaminated source (unitless)
SA = :	4,100	Skin surface available for contact (cm^2/event)
AF = :	1.0	Soil to skin adherence factor (mg/cm^2)
ABS = :	Chemical Specific	Absorption factor (unitless)
EF = :	125	Exposure Frequency (days/year)
ED = :	1	Exposure Duration (years)
BW = :	70	Body Weight (kg)
ATc = :	25,550	Averaging time for carcinogenic exposures (days)
ATn = :	365	Averaging time for noncarcinogenic exposures (days)

Intermediate Values

Carcinogenic = :	1.4E+04	kg-soil/kg-wt/day
Noncarcinogenic = :	2.0E+08	kg-soil/kg-wt/day

CHEMICAL	ABS	Cancer Slope Factor		Reference Dose		Cleanup Level	
		Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Carc. (mg/kg)	Noncarc. (mg/kg)
Benzo(a)pyrene	0.13	7.3	23.55	NA	NA	0.89	NA
Arsenic	0.03	1.5	3.66	0.0003	0.000123	12.23	79

Appendix B-2

Derivation of Ecological RGOs For Soil
Based on Site 3 RI Terrestrial Food Chain Modeling

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to ecological receptors			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 26, 1999

Purpose: To calculate surface soil RGOs based on risks to ecological receptors as determined from the Site 3 RI ecological risk assessment.

Approach:

Surface soil RGOs are calculated:

- For preliminary COCs from the Site 3 RI. Preliminary surface soil COCs are chemicals from the terrestrial chain modeling that exceed a NOAEL HQ of 1.0.
- For the protection of the Short-Tailed Shrew, Deer Mouse, American Robin, and the Red-Tailed Hawk.
- Based on NOAELs and LOAELs and HQs of 1.0 and 0.5

The attached subset of calculations document the derivation of the surface soil RGOs for each receptor. A summary table of the calculated NOAEL and LOAEL values for each receptor is also provided.

NOAEL Summary Table
Soil RGOs

Preliminary COCs	Soil RGOs-Terrestrial Recepters - HQ = 1				Minimum	Receptor
	Shrew	Mouse	Robin	Hawk		
Organics (μg/kg)						
AROCLOR-1254	23.8	1781	93.7	143	23.8	Shrew
AROCLOR-1260	23.8	1781	93.7	143	23.8	Shrew
Inorganics (mg/kg)						
ALUMINUM	24.4	335	1780.3	485916	24.4	Shrew
ARSENIC	0.779	3.92	30.8	2854	0.779	Shrew
IRON	695	180	168.9	1722	169	Robin
LEAD	44.0	240	6.19	3655	6.19	Robin
MERCURY	0.0172	0.275	0.00955	6.11	0.00955	Robin
VANADIUM	2.89	35.9	198.3	38795	2.89	Shrew
ZINC	100	934	10.6	32.4	10.6	Robin

LOAEL Summary Table
Soil RGOs

Preliminary COCs	Soil RGOs-Terrestrial Recepters - HQ = 1				Minimum	Receptor
	Shrew	Mouse	Robin	Hawk		
Organics (µg/kg)						
AROCLOR-1254	238	17814	937	1430	238	Shrew
AROCLOR-1260	238	17814	937	1430	238	Shrew
Inorganics (mg/kg)						
ALUMINUM	244	3347	17803	4859157	244	Shrew
ARSENIC	7.79	39.2	76.9	7129	7.79	Shrew
IRON	6950	1802	1689	17219	1689	Robin
LEAD	440	2397	61.9	36553	61.9	Robin
MERCURY	0.0287	0.459	0.0955	61.1	0.0287	Shrew
VANADIUM	28.9	359	1983	387952	28.9	Shrew
ZINC	200	1867	95.5	293	95.5	Robin

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Short-Tailed Shrew			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modelling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 24, 1999

Purpose: To calculate surface soil RGOs based on risks to the Short-Tailed Shrew as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for preliminary COCs from the Site 3 RI. Preliminary COCs are chemicals from the terrestrial food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. Dose = $(FIR)[(C_{inv})(f_{inv}) + (C_{ss})(f_{ss})]/BW$

2. Dose = (NOAEL)(HQ) or Dose = (LOAEL)(HQ)

3. $C_{inv} = (C_{ss})(BAF_{inv})$

Substituting Eqs. 2 and 3 into 1 and solving for C_{ss},

$C_{ss} = (BW)(NOAEL)(HQ)/[(FIR)\{(BAF_{inv})(f_{inv}) + (f_{ss})\}]$ for RGOs based on NOAELs

$C_{ss} = (BW)(LOAEL)(HQ)/[(FIR)\{(BAF_{inv})(f_{inv}) + (f_{ss})\}]$ for RGOs based on LOAELs

Where:

BW	=	Body weight of receptor
BAF_{inv}	=	Bioaccumulation factor for terrestrial invertebrates
C_{inv}	=	Concentration of chemical in invertebrates
C_{ss}	=	Concentration of chemical in surface soil
f_{inv}	=	Fraction of invertebrates ingested in receptor's daily food intake
f_{ss}	=	Fraction of surface soil ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level

Assumptions for Aroclor 1254:

BW	=	0.0097 kg
BAF_{inv}	=	5.8
C_{inv}	=	0.0448 mg/kg
C_{ss}	=	0.00773 mg/kg
f_{inv}	=	0.9
f_{ss}	=	0.1
FIR	=	0.0052 kg/day
LOAEL	=	0.68 mg/kg/day
NOAEL	=	0.068 mg/kg/day

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Short-Tailed Shrew			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modelling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 24, 1999

Example Calculation for Aroclor 1254 for HQ = 1

Based on NOAELs,

C_{ss} = (0.0097 kg)(0.068 mg/kg/day)/[(0.0052 kg/day){(5.8)(0.9)+ (0.1)}] = 0.0238 mg/kg

Based on LOAELs,

C_{ss} = (0.0097 kg)(0.68 mg/kg/day)/[(0.0052 kg/day){(5.8)(0.9)+ (0.1)}] = 0.238 mg/kg

Surface Soil RGOs Protective of the Short-Tailed Shrew
(Conservative Inputs)

Body Weight	0.0097000 kg		
Food Ingestion Rate	0.0052000 kg/day	% Invert.	0.9
		% Surf. Soil	0.1
Water Ingestion Rate	0.0000000 L/day		

Preliminary COC	Soil Concentration (mg/kg)	Invert. BAFs	Invertebrate Concentration (mg/kg)	Dose (1) (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	RGO (NOAEL) (mg/kg)	RGO (LOAEL) (mg/kg)
PESTICIDES/PCBs										
Aroclor-1254	0.00773	5.8	0.044834	0.022	0.068	0.68	3.24E-01	3.24E-02	0.0238	0.238
Aroclor-1260	0.01361	5.8	0.078938	0.039	0.068	0.68	5.71E-01	5.71E-02	0.0238	0.238
METALS AND INORGANIC										
Aluminum	5745.3125	0.053	304.5015625	454.910	1.93	19.3	2.36E+02	2.36E+01	24.38	243.75
Arsenic	1.665	0.224	0.37296	0.269	0.126	1.26	2.14E+00	2.14E-01	0.78	7.79
Iron	4788.125	0.038	181.94875	344.469	50	500	6.89E+00	6.89E-01	695.00	6950.02
Lead	30.95625	0.266	8.2343625	5.632	8	80	7.04E-01	7.04E-02	43.97	439.69
Mercury	0.057344	1.693	0.097083392	0.050	0.015	0.025	3.33E+00	2.00E+00	0.02	0.03
Vanadium	10.45	0.0393	0.410685	0.758	0.21	2.1	3.61E+00	3.61E-01	2.89	28.94
Zinc	27.29375	3.201	87.36729375	43.616	160	320	2.73E-01	1.36E-01	100.12	200.25

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Deer Mouse			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modelling			
By: J. Brown	**Checked By:** AMB		**Date:** October 19, 1999

Purpose: To calculate surface soil RGOs based on risks to the Deer Mouse as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for preliminary COCs from the Site 3 RI. Preliminary COCs are chemicals from the terrestrial food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. Dose = $(FIR)[(C_{vef})(f_{veg}) + (C_{ss})(f_{ss})]/BW$

2. Dose = (NOAEL)(HQ) or Dose = (LOAEL)(HQ)

3. $C_{veg} = (C_{ss})(BAF_{veg})$

Substituting Eqs. 2 and 3 into 1 and solving for C_{ss},

$C_{ss} = (BW)(NOAEL)(HQ)/[(FIR)\{(BAF_{veg})(f_{veg}) + (f_{ss})\}]$ for RGOs based on NOAELs

$C_{ss} = (BW)(LOAEL)(HQ)/[(FIR)\{(BAF_{veg})(f_{veg}) + (f_{ss})\}]$ for RGOs based on LOAELs

Where:

BW	=	Body weight of receptor
BAF_{veg}	=	Bioaccumulation factor for terrestrial plants (vegetation)
C_{veg}	=	Concentration of chemical in terrestrial plants (vegetation)
C_{ss}	=	Concentration of chemical in surface soil
f_{veg}	=	Fraction of vegetation ingested in receptor's daily food intake
f_{ss}	=	Fraction of surface soil ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level

Assumptions for Aroclor 1254:

BW	=	0.031 kg
BAF_{veg}	=	0.12
C_{veg}	=	0.000928 mg/kg
C_{ss}	=	0.00773 mg/kg
f_{veg}	=	0.98
f_{ss}	=	0.02
FIR	=	0.0086 kg/day
LOAEL	=	0.68 mg/kg/day
NOAEL	=	0.068 mg/kg/day

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Deer Mouse			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modelling			
By: J. Brown	**Checked By:**		**Date:** October 19, 1999

Example Calculation for Aroclor 1254 for HQ = 1

Based on NOAELs,

C_{ss} = (0.031 kg)(0.068 mg/kg/day)(1.0)/[(0.0086 kg/day){(0.12)(0.98)+ (0.02)}] = 1.78 mg/kg

Based on LOAELs,

C_{ss} = (0.031 kg)(0.68 mg/kg/day)(1.0)/[(0.0086 kg/day){(0.12)(0.98)+ (0.02)}] = 17.8 mg/kg

Surface Soil RGOs Protective of the Deer Mouse
(Conservative Inputs)

Body Weight	0.0310000 kg		
Food Ingestion Rate	0.0086000 kg/day	% Veget.	0.98
		% Surface Soil	0.02
Water Ingestion Rate	0.0000000 kg/day		

Preliminary COC	Soil Concentration (mg/kg)	Veg. BAFs	Vegetation Concentration (mg/kg)	Dose (1) (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	RGO (NOAEL) (mg/kg)	RGO (LOAEL) (mg/kg)
PESTICIDES/PCBs										
Aroclor-1254	0.00773	0.12	0.0009276	2.95E-04	0.068	0.68	4.34E-03	4.34E-04	1.78	17.81
Aroclor-1260	0.01361	0.12	0.0016332	5.20E-04	0.068	0.68	7.64E-03	7.64E-04	1.78	17.81
METALS AND INORGANICS										
Aluminum	5745.3125	0.0008	4.59625	3.31E+01	1.93	19.3	1.72E+01	1.72E+00	334.73	3347.28
Arsenic	1.665	0.09791	0.16302015	5.36E-02	0.126	1.26	4.25E-01	4.25E-02	3.92	39.17
Iron	4788.125	1	4788.125	1.33E+03	50	500	2.66E+01	2.66E+00	180.23	1802.33
Lead	30.95625	0.10235	3.168372188	1.03E+00	8	80	1.29E-01	1.29E-02	239.70	2397.05
Mercury	0.057344	0.18	0.01032192	3.12E-03	0.015	0.025	2.08E-01	1.25E-01	0.28	0.46
Vanadium	10.45	0.0011	0.011495	6.11E-02	0.21	2.1	2.91E-01	2.91E-02	35.91	359.13
Zinc	27.29375	0.61	16.6491875	4.68E+00	160	320	2.92E-02	1.46E-02	933.55	1867.09

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the American Robin			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 24, 1999

Purpose: To calculate surface soil RGOs based on risks to the American Robin as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for preliminary COCs from the Site 3 RI. Preliminary COCs are chemicals from the terrestrial food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. Dose = $(FIR)*[(C_{vef})(f_{veg})+(C_{inv})(f_{inv})] + (C_{ss})(f_{ss})] /BW$

2. Dose = (NOAEL)(HQ) or Dose = (LOAEL)(HQ)

3. $C_{veg} = (C_{ss})(BAF_{veg})$

4. $C_{inv} = (C_{ss})(BAF_{inv})$

Substituting Eqs. 2, 3, and 4 into 1 and solving for C_{ss},

For RGOs based on NOAELs,

$$C_{ss} = (BW)(NOAEL)(HQ)/ [(FIR)\{(BAF_{veg})(f_{veg})+ (BAF_{inv})(f_{inv})+ (f_{ss})\}]$$

For RGOs based on LOAELs,

$$C_{ss} = (BW)(LOAEL)(HQ)/ [(FIR)\{(BAF_{veg})(f_{veg})+ (BAF_{inv})(f_{inv})+ (f_{ss})\}]$$

Where:

BW	=	Body weight of receptor
BAF_{veg}	=	Bioaccumulation factor for terrestrial plants (vegetation)
C_{inv}	=	Concentration of chemical in invertebrates
C_{ss}	=	Concentration of chemical in surface soil
C_{veg}	=	Concentration of chemical in terrestrial plants (vegetation)
f_{ss}	=	Fraction of invertebrates ingested in receptor's daily food intake
f_{ss}	=	Fraction of surface soil ingested in receptor's daily food intake
f_{veg}	=	Fraction of vegetation ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level

Assumptions for Aroclor 1254:

BW	=	0.0773 kg
BAF_{inv}	=	5.8
BAF_{veg}	=	0.12
C_{inv}	=	0.0448 mg/kg
C_{veg}	=	0.000928 mg/kg
C_{ss}	=	0.0773 mg/kg

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the American Robin			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** HMB	5-28-99	**Date:** May 24, 1999

F_{inv} = 0.35
f_{veg} = 0.60
f_{ss} = 0.05
FIR = 0.069 kg/day
LOAEL = 1.8 mg/kg/day
NOAEL = 0.18 mg/kg/day

Example Calculation for Aroclor 1254 for HQ = 1

Based on NOAELs,

C_{ss} = (0.0773 kg)(0.18 mg/kg/day)(1)/[(0.069 kg/day){(0.12)(0.60)+ (5.8)(0.35)+ (0.05)}]
= 0.0937 mg/kg

Based on LOAELs,

C_{ss} = (0.0773 kg)(0.18 mg/kg/day)(1)/[(0.069 kg/day){(0.12)(0.60)+ (5.8)(0.35)+ (0.05)}]
= 0.937 mg/kg

Surface Soil RGOs Protective of the American Robin
(Conservative Inputs)

Body Weight	0.0773000	kg		
Food Ingestion Rate	0.0690000	kg/day	% Vegetation	0.6
			% Invertebrates	0.35
			% Surface Soil	0.05
Water Ingestion Rate	0.0000000	L/day		

Preliminary COCs	Soil Concentration (mg/kg)	Vegetation BAFs	Vegetation Concentration (mg/L)	Invertebrate BAFs	Invertebrate Concentration (mg/kg)	Dose (1) (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	RGO (NOAEL) (mg/kg)	RGO (LOAEL) (mg/kg)
PESTICIDES/PCBs												
Aroclor-1254	0.00773	0.12	0.0009276	5.8	0.044834	0.015	0.18	1.8	8.25E-02	8.25E-03	0.0937	0.94
Aroclor-1260	0.01361	0.12	0.0016332	5.8	0.078938	0.026	0.18	1.8	1.45E-01	1.45E-02	0.0937	0.94
METALS AND INORGANIC												
Aluminum	5745.3125	0.0008	4.59625	0.053	304.5015625	354.015	109.7	1097	3.23E+00	3.23E-01	1780.32	17803.24
Arsenic	1.665	0.09791	0.16302015	0.224	0.37296	0.278	5.14	12.84	5.41E-02	2.17E-02	30.77	76.86
Iron	4788.125	1	4788.125	0.038	181.94875	2834.948	100	1000	2.83E+01	2.83E+00	168.90	1688.96
Lead	30.95625	0.10235	3.168372188	0.266	8.2343625	5.651	1.13	11.3	5.00E+00	5.00E-01	6.19	61.90
Mercury	0.057344	0.18	0.01032192	1.693	0.097083392	0.038	0.0064	0.064	6.00E+00	6.00E-01	0.0096	0.0955
Vanadium	10.45	0.0011	0.011495	0.0393	0.410685	0.601	11.4	114	5.27E-02	5.27E-03	198.27	1982.66
Zinc	27.29375	0.61	16.6491875	3.201	87.36729375	37.430	14.5	131	2.58E+00	2.86E-01	10.57	95.52

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Red-Tailed Hawk			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-25-99	**Date:** May 24, 1999

Purpose: To calculate surface soil RGOs based on risks to the Red-Tailed Hawk as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for preliminary COCs from the Site 3 RI. Preliminary COCs are chemicals from the terrestrial food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. Dose = $(FIR)*[(C_{prey})]/BW$

2. Dose = (NOAEL)(HQ) or Dose = (LOAEL)(HQ)

3. $C_{prey} = (C_{shrew} + C_{mouse})/2 = [(C_{ss})(BAF_{veg})(BAF_{mam}) + (C_{ss})(BAF_{inv})(BAF_{mam})]/2$

Substituting Eqs. 2 and 3 into 1 and solving for C_{ss},

For RGOs based on NOAELs,

$C_{ss} = (BW)(NOAEL)(HQ)(2)/ [(FIR)(BAF_{mam})(BAF_{inv} + BAF_{veg})]$

For RGOs based on LOAELs,

$C_{ss} = (BW)(LOAEL)(HQ)(2)/ [(FIR)(BAF_{mam})(BAF_{inv} + BAF_{veg})]$

Where:

BW	=	Body weight of receptor
BAF_{inv}	=	Bioaccumulation factor for invertebrates
BAF_{mam}	=	Bioaccumulation factor for mammals
BAF_{veg}	=	Bioaccumulation factor for terrestrial plants (vegetation)
C_{inv}	=	Concentration of chemical in invertebrates
C_{ss}	=	Concentration of chemical in surface soil
C_{veg}	=	Concentration of chemical in terrestrial plants (vegetation)
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level

Assumptions for Aroclor 1254:

BW	=	1.126 kg
BAF_{inv}	=	5.8
BAF_{mam}	=	3.8
BAF_{veg}	=	0.12
FIR	=	0.126 kg/day
LOAEL	=	1.8 mg/kg/day
NOAEL	=	0.18 mg/kg/day

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface soil RGOs based on risks to the Red-Tailed Hawk			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 24, 1999

Example Calculation for Aroclor 1254 for HQ = 1

Based on NOAELs,

C_{ss} = (1.126 kg)(0.18 mg/kg/day)(1)(2)/[(0.126 kg/day)(3.8)(5.8 + 0.12)] = 0.143 mg/kg

Based on LOAELs,

C_{ss} = (1.126 kg)(1.8 mg/kg/day)(1)(2)/[(0.126 kg/day)(3.8)(5.8 + 0.12)] = 1.43 mg/kg

Surface Soil RGOs Protective of the Red-Tailed Hawk

(Conservative Inputs)

Body Weight	1.1260000 kg		
Food Ingestion Rate	0.1260000 kg/day	% prey	1.00
Water Ingestion Rate	0.0000000 L/day		
Soil Ingestion Rate	0.0000000 kg/day		

Mean Concentrations

Preliminary COC	Soil Concentration (mg/kg)	Vegetation BAFs	Invertebrate BAFs	Mammal BAFs	Prey Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	RGO (NOAEL) (mg/kg)	RGO (LOAEL) (mg/kg)
PESTICIDES/PCBs												
Aroclor-1254	0.00773	0.12	5.8	3.8	0.08694704	9.73E-03	0.18	1.8	5.41E-02	5.41E-03	0.14	1.43
Aroclor-1260	0.01361	0.12	5.8	3.8	0.15308528	1.71E-02	0.18	1.8	9.52E-02	9.52E-03	0.14	1.43
METALS AND INORGA												
Aluminum	5745.3125	0.0008	0.053	0.075	11.59116797	1.30E+00	109.7	1097	1.18E-02	1.18E-03	485915.70	4859156.98
Arsenic	1.665	0.09791	0.224	0.1	0.026799008	3.00E-03	5.14	12.84	5.83E-04	2.34E-04	2853.82	7129.00
Iron	4788.125	1	0.038	1	2485.036875	2.78E+02	100	1000	2.78E+00	2.78E-01	1721.87	17218.71
Lead	30.95625	0.10235	0.266	0.015	0.08552051	9.57E-03	1.13	11.3	8.47E-03	8.47E-04	3655.31	36553.11
Mercury	0.057344	0.18	1.693	0.01	0.000537027	6.01E-05	0.0064	0.064	9.39E-03	9.39E-04	6.11	61.07
Vanadium	10.45	0.0011	0.0393	0.13	0.0274417	3.07E-03	11.4	114	2.69E-04	2.69E-05	38795.20	387951.98
Zinc	27.29375	0.61	3.201	2.1	109.2173053	1.22E+01	14.5	131	8.43E-01	9.33E-02	32.38	292.56

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Appendix B-3

Derivation of Ecological RGOs For Sediment and Surface Water Based on the Site 3 RI Aquatic Food Chain Modeling

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment and surface water RGOs based on risks to ecological receptors			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

Purpose: To calculate sediment and surface water RGOs based on risks to ecological receptors as determined from the Site 3 RI ecological risk assessment.

Approach:

Sediment and surface water RGOs are calculated:

- For preliminary COCs from the Site 3 RI. Preliminary sediment and surface water COCs are chemicals from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.
- For the protection of the Raccoon, Blue Great Heron, Mummichog, Red Drum, and Bald Eagle. For each preliminary COC, the minimum calculated value for each receptor is used as the RGO.
- Based on NOAELs and LOAELs and HQs of 1.0 and 0.5

The attached subset of calculations documenting the derivation of the RGOs for each receptor for each medium. The assumptions made in ecological risk assessment of the Site 3 RI were used. Fish tissue concentrations were calculated by the following equations:

- Sediment-fish pathway

$C_{fish} = BSAF \times f_l \times C_{sed} / f_{oc}$ for organics

$C_{fish} = C_{sed}$ for inorganics

- Surface water-fish pathway:

$C_{fish} = C_{sw} \times BCF_{fish}$ for both organics and inorganics

Where,

BSAF = biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)

BCF_{fish} = Bioconcentration factor for fish

C_{fish} = Concentration of COC in fish

C_{sed} = Concentration of COC in sediment

f_l = Organism lipid content expressed as a decimal fraction

f_{oc} = Total organic carbon (TOC) content of sediment expressed as a decimal fraction

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment and surface water RGOs based on risks to ecological receptors			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

Specific assumptions are as follows:

- BAFs, BCFs, and BSAFs were obtained from Appendix F of the Site 3 RI. Values of 1.0 were assumed where BAFs, BCFs, and BSAFs were not available
- The average total organic carbon content in sediment samples at Site 3 is 1.4 percent.
- Lipid content values were assumed to be 3.5 percent for the mummichog and 1.0 percent for the red drum.
- Surface water RGOs for the protection of the Mummichog and Red Drum were not calculated. Federal criteria (e.g., AWQCs) are assumed to be protective of these species.

A summary table of the calculated NOAEL and LOAEL values for each receptor is also provided.

NOAEL Summary Table
Sediment and Surface Water RGOs

Preliminary COCs	Sediment RGOs -Aquatic Receptors - HQ = 1					Minimum	Receptor
	Raccoon	Heron	Mummichog	Red Drum	Eagle		
Organics (µg/kg)							
4,4'-DDD	5120.81	22.23	NA	NA	116.67	22.2	Heron
4,4'-DDE	212.66	0.809	NA	NA	4.24	0.809	Heron
4,4'-DDT	961.93	3.73	NA	NA	19.56	3.73	Heron
Aroclor-1254	73.98	216.33	NA	NA	1135.14	74	Heron
Inorganics (mg/kg)							
Aluminum	9.00	609.78	NA	NA	914.17	9.0	Raccoon
Arsenic	0.59	28.57	10.17	29.50	42.83	0.59	Raccoon
Barium	23.77	115.62	NA	NA	173.33	23.8	Raccoon
Cobalt	4.66	5.56	NA	NA	8.33	4.66	Raccoon
Iron	233.06	555.86	NA	NA	833.33	233	Raccoon
Lead	37.29	6.28	NA	NA	9.42	6.28	Heron
Mercury	0.070	0.0356	0.138	0.400	0.0533	0.0356	Heron
Selenium	0.93	2.223	NA	NA	3.33	0.93	Raccoon
Thallium	0.0345	2.61	NA	NA	3.92	0.034	Raccoon
Vanadium	0.98	63.37	NA	NA	95.00	0.98	Raccoon
Zinc	745.79	80.60	NA	NA	120.83	80.6	Heron

Preliminary COCs	Surface Water RGOs -Aquatic Receptors - HQ = 1					Minimum	Receptor
	Raccoon	Heron	Mummichog	Red Drum	Eagle		
Organics (ug/L)							
4,4'-DDD	1.21	0.00458	NA	NA	0.00686	0.00458	Heron
4,4'-DDE	1.21	0.00458	NA	NA	0.00686	0.00458	Heron
4,4'-DDT	1.21	0.00458	NA	NA	0.00686	0.00458	Heron
Aroclor-1254	0.0112	0.03207	NA	NA	0.04808	0.0112	Raccoon
Inorganics (ug/L)							
Aluminum	104.3	6405	NA	NA	9623	104	Raccoon
Arsenic	37.6	1661	NA	NA	2520	37.6	Raccoon
Barium	6217.0	27532	NA	NA	43333	6217	Raccoon
Cobalt	17.1	18.52	NA	NA	28	17.1	Raccoon
Iron	95.3	205.9	NA	NA	309	95.3	Raccoon
Lead	9752.1	1496	NA	NA	2354	1496	Heron
Mercury	0.0205	0.00946	NA	NA	0.0142	0.00946	Heron
Selenium	165.4	358.6	NA	NA	556	165	Raccoon
Thallium	0.32	21.92	NA	NA	32.9	0.32	Raccoon
Vanadium	4687.4	302471	NA	NA	9500000	4687	Raccoon
Zinc	17432.5	1708	NA	NA	2571	1708	Heron

LOAEL Summary Table
Sediment and Surface Water RGOs

COCs	Sediment RGOs -Aquatic Receptors - HQ = 1					Minimum	Receptor
	Raccoon	Heron	Mummichog	Red Drum	Eagle		
Organics (µg/kg)							
4,4'-DDD	25604	222	NA	NA	1167	222	Heron
4,4'-DDE	1063	8.09	NA	NA	42.4	8.09	Heron
4,4'-DDT	4810	37.28	NA	NA	196	37.3	Heron
Aroclor-1254	740	2163	NA	NA	11351	740	Raccoon
Inorganics (mg/kg)							
Aluminum	89.96	6097.79	NA	NA	9142	90	Raccoon
Arsenic	5.87	71.37	122.4	355.00	107.00	5.9	Raccoon
Barium	237.72	231.79	NA	NA	347.50	232	Heron
Cobalt	46.61	55.59	NA	NA	83.33	46.6	Raccoon
Iron	2330.61	5558.60	NA	NA	8333	2331	Raccoon
Lead	372.90	62.81	NA	NA	94.17	62.8	Heron
Mercury	0.117	0.356	16.21	47.000	0.533	0.117	Raccoon
Selenium	1.54	4.45	NA	NA	6.67	1.54	Raccoon
Thallium	0.345	26.13	NA	NA	39.17	0.34	Raccoon
Vanadium	9.79	633.68	NA	NA	950	9.8	Raccoon
Zinc	1491.59	728.18	NA	NA	1092	728	Heron

Preliminary COCs	Surface Water (Unfiltered) RGOs -Aquatic Receptors - HQ = 1					Minimum	Receptor
	Raccoon	Heron	Mummichog	Red Drum	Eagle		
Organics (ug/L)							
4,4'-DDD	6.05	0.0458	NA	NA	0.0686	0.0458	Heron
4,4'-DDE	6.05	0.0458	NA	NA	0.0686	0.0458	Heron
4,4'-DDT	6.05	0.0458	NA	NA	0.0686	0.0458	Heron
Aroclor-1254	0.112	0.3207	NA	NA	0.4808	0.112	Raccoon
Inorganics (ug/L)							
Aluminum	1043	64053	NA	NA	96228	1043	Raccoon
Arsenic	376	4150	NA	NA	6294.1	376	Raccoon
Barium	62170	55196	NA	NA	86875.0	55196	Heron
Cobalt	171.4	185	NA	NA	278	171	Raccoon
Iron	953	2059	NA	NA	3086	953	Raccoon
Lead	97521	14957	NA	NA	23542	14957	Heron
Mercury	0.0342	0.0946	NA	NA	0.142	0.0342	Raccoon
Selenium	273	717	NA	NA	1111	273	Raccoon
Thallium	3.2	219	NA	NA	329.1	3.2	Raccoon
Vanadium	46874	3024711	NA	NA	95000000	46874	Raccoon
Zinc	34865	15428	NA	NA	23227	15428	Heron

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Raccoon			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** HMB		**Date:** October 19, 1999

Purpose: To calculate sediment RGOs based on risks to the Raccoon as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for sediment preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

For organics

1. $Dose_{sed} = (FIR)[C_{mum} \times f_{mum} + C_{sed} \times f_{sed}]/BW$

2. $C_{mum} = BSAF \times f_l \times C_{sed} / f_{oc}$

Substituting 2 into 1 and solving for C_{sed},

3. C_{sed} or $RGO_{sed} = (Dose \times BW) / (FIR \times [BSAF \times (f_l \times f_{mum}/f_{oc}) + f_{sed}])$

4. $Dose = (NOAEL \text{ or } LOAEL)(HQ)$

Substituting 4 into 3,

5. C_{sed} or $RGO_{sed} = [(NOAEL \text{ or } LOAEL) \times HQ \times BW] / (FIR \times [BSAF \times (f_l \times f_{mum}/f_{oc}) + f_{sed}])$

Where:

BW = Body weight of receptor
BSAF = biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)
C_{mum} = Concentration of COC in the mummichog
C_{sed} = Concentration of COC in sediment
f_l = Organism lipid content expressed as a decimal fraction
f_{oc} = Total organic carbon (TOC) content of sediment expressed as a decimal fraction
f_{sed} = Fraction of sediment ingested in receptor's daily food intake
f_{mum} = Fraction of the mummichog ingested in receptor's daily food intake
FIR = Food ingestion rate
HQ = Hazard Quotient
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Raccoon			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:**		**Date:** October 19, 1999

For inorganics

6. $Dose_{sed}$ = FIR x C_{sed} /BW , therefore

7. C_{sed} = BW x Dose/FIR

Substituting 4 into 7,

8. C_{sed} or RGO_{sed} = [(NOAEL or LOAEL) x HQ x BW/FIR

Assumptions:

BW	=	3.99 kg
$BSAF_{aroclor\ 1254}$	=	1.85
f_l	=	0.035
f_{oc}	=	0.014
f_{sed}	=	0.094
f_{mum}	=	0.906
FIR	=	0.856 kg/day
$NOAEL_{aroclor\ 1254}$	=	0.068 mg/kg/day
$NOAEL_{arsenic}$	=	0.126 mg/kg/day

Example Calculation for Aroclor 1254, based on a NOAEL HQ = 1

RGO_{sed} = [(0.068 mg/kg/day) x 1.0 x 3.99 kg]/(0.856 kg/day x [1.85 x (0.035 x 0.906/0.014) + 0.094])
= 0.074 mg/kg

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sed} = 0.126 mg/kg/day x 1.0 x 3.99 kg /0.856 kg/day = 0.587 mg/kg

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks to the Raccoon			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:**		**Date:** October 19, 1999

Purpose: To calculate surface water RGOs based on risks to the Raccoon as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for surface water preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. $Dose_{sw} = [(FIR)(C_{fish} \times f_{fish}) + (WIR \times C_{sw})]/BW$

2. $C_{fish} = C_{sw} \times BCF_{fish}$

Substituting 2 into 1 and solving for C_{sed},

3. C_{sw} or $RGO_{sw} = (Dose \times BW) / [(FIR \times BCF_{fish} \times f_{fish}) + WIR]$

4. Dose = (NOAEL or LOAEL)(HQ)

Substituting 4 into 3,

5. C_{sed} or $RGO_{sed} = [(NOAEL \text{ or } LOAEL) \times HQ \times BW] / [(FIR \times BCF_{fish} \times f_{fish}) + WIR]$

Where:

BW	=	Body weight of receptor
BCF_{fish}	=	Bioconcentration factor for fish
C_{fish}	=	Concentration of COC in fish
C_{sw}	=	Concentration of COC in surface water
f_{fish}	=	Fraction of fish ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level
WIR	=	Water ingestion rate

Assumptions for Arsenic:

BW	=	3.99 kg
BCF_{fish}	=	17 L/kg
f_{fish}	=	0.906
FIR	=	0.856 kg/day
LOAEL	=	1.26 mg/kg/day
NOAEL	=	0.126 mg/kg/day
WIR	=	0.171 L/day

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sw} = [0.126 mg/kg/day x 1.0 x 3.99 kg] / [(0.856 kg/day x 17 L/kg x 0.906) + 0.171 L/day]
= 0.038 mg/L

Sediment and Surface Water RGOs Protective of the Raccoon

(Conservative Inputs)

Body Weight	3.9900000 kg		
Food Ingestion Rate	0.8560000 kg/day	% prey	0.906
		% sed	0.094
Water Ingestion Rate	0.1710000 L/day		

f_{loc} = 0.014

f_l = 0.035

Preliminary COC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	BSAF	BCF (fish)	Mummichog Concentration (mg/kg)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	Sed. RGO NOAEL (mg/kg) HQ = 1	Sed. RGO LOAEL (mg/kg) HQ = 1	SW RGO NOAEL (mg/L) HQ = 1	SW RGO LOAEL (mg/L) HQ = 1
PESTICIDES/PCBs															
4,4'-DDD	0.04135	0	0.28	3400	0.028945	#N/A	0.006	0.8	4	8.07E-03	1.61E-03	5.12	25.60	0.0012105	0.0060523
4,4'-DDE	0.02919	0	7.7	3400	0.5619075	#N/A	0.110	0.8	4	1.37E-01	2.75E-02	0.21	1.06	0.0012105	0.0060523
4,4'-DDT	0.02909	0	1.67	3400	0.12145075	#N/A	0.024	0.8	4	3.02E-02	6.05E-03	0.96	4.81	0.0012105	0.0060523
Aroclor-1254	0.02844	0	1.85	31200	0.131535	#N/A	0.026	0.068	0.68	3.84E-01	3.84E-02	0.074	0.74	0.0000112	0.0001121
INORGANICS															
Aluminum	13060.47619	5.3596325	1	95	13060.47619	509.1650875	2802.176	1.93	19.3	1.45E+03	1.45E+02	8.996	89.96	0.1043	1.0428
Arsenic	6.436667	0.0057625	1	17	6.436667	0.0979625	1.381	0.126	1.26	1.10E+01	1.10E+00	0.587	5.87	0.0376	0.3764
Barium	17.238095	0.029125	1	4	17.238095	0.1165	3.699	5.1	51	7.25E-01	7.25E-02	23.772	237.72	6.2170	62.1696
Cobalt	2.030952	0.00134	1	300	2.030952	0.402	0.436	1	10	4.36E-01	4.36E-02	4.661	46.61	0.0171	0.1714
Iron	12744.76191	6.1071575	1	2700	12744.76191	16489.32525	2734.476	50	500	5.47E+01	5.47E+00	233.061	2330.61	0.0953	0.9527
Lead	29.914286	0.0090625	1	4	29.914286	0.03625	6.418	8	80	8.02E-01	8.02E-02	37.290	372.90	9.7521	97.5209
Mercury	0.055952	0.000055	1	3760	0.055952	0.2068	0.012	0.015	0.025	8.00E-01	4.80E-01	0.070	0.12	0.0000205	0.0000342
Selenium	0.340833	0	1	6	0.340833	#N/A	0.073	0.2	0.33	3.66E-01	2.22E-01	0.932	1.54	0.1654	0.2729
Thallium	0.214405	0	1	119	0.214405	#N/A	0.046	0.0074	0.074	6.22E+00	6.22E-01	0.034	0.34	0.00032	0.0032
Vanadium	29.078571	0.014536	1	0.01	29.078571	0.00014536	6.239	0.21	2.1	2.97E+01	2.97E+00	0.979	9.79	4.6874	46.8741
Zinc	43.311905	0.02168	1	47	43.311905	1.01896	9.293	160	320	5.81E-02	2.90E-02	745.794	1491.59	17.4325	34.8651

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Great Blue Heron			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

Purpose: To calculate sediment RGOs based on risks to the Great Blue Heron as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for sediment preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

For organics

1. $Dose_{sed} = FIR \times C_{mum} / BW$

2. $C_{mum} = BSAF \times f_l \times C_{sed} / f_{oc}$

Substituting 2 into 1 and solving for C_{sed},

3. C_{sed} or $RGO_{sed} = (Dose \times BW \times f_{oc})/(FIR \times BSAF \times f_l)$

4. Dose = (NOAEL or LOAEL)(HQ)

Substituting 4 into 3,

5. C_{sed} or $RGO_{sed} = [(NOAEL \text{ or } LOAEL) \times HQ \times BW \times f_{oc}]/(FIR \times BSAF \times f_l)$

Where:

BW = Body weight of receptor
BSAF = biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)
C_{mum} = Concentration of COC in the mummichog
C_{sed} = Concentration of COC in sediment
f_l = Organism lipid content expressed as a decimal fraction
f_{oc} = Total organic carbon (TOC) content of sediment expressed as a decimal fraction
FIR = Food ingestion rate
HQ = Hazard Quotient
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Great Blue Heron			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

For inorganics

6. $Dose_{sed}$ = FIR x C_{sed} /BW, therefore

7. C_{sed} = BW x Dose/FIR

Substituting 4 into 7,

8. C_{sed} or RGO_{sed} = [(NOAEL or LOAEL) x HQ x BW/FIR

Assumptions:

BW	=	2.229 kg
$BSAF_{aroclor\ 1254}$	=	1.85
f_l	=	0.035
f_{oc}	=	0.014
FIR	=	0.401 kg/day
WIR	=	0.08 L/day
LOAEL	=	1.8 mg/kg/day
NOAEL	=	0.18 mg/kg/day
$NOAEL_{aroclor\ 1254}$	=	0.068 mg/kg/day
$NOAEL_{arsenic}$	=	5.14 mg/kg/day

Example Calculation for Aroclor 1254, based on a NOAEL HQ = 1

RGO_{sed} = [0.18 mg/kg/day x 1.0 x 2.229 kg x 0.014]/(0.401 kg/day x 1.85 x 0.035) = 0.216 mg/kg

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sed} = 5.14 mg/kg/day x 1.0 x 2.229 kg/0.401 kg/day = 28.6 mg/kg

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks to the Great Blue Heron			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 26, 1999

Purpose: To calculate surface water RGOs based on risks to the Great Blue Heron as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for surface water preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. $Dose_{sw} = [(FIR)(C_{fish}) + (WIR \times C_{sw})]/BW$

2. $C_{fish} = C_{sw} \times BCF_{fish}$

Substituting 2 into 1 and solving for C_{sw},

3. C_{sw} or $RGO_{sw} = (Dose \times BW) / [(FIR \times BCF_{fish}) + WIR]$

4. Dose = (NOAEL or LOAEL)(HQ)

Substituting 4 into 3,

5. C_{sw} or $RGO_{sw} = [(NOAEL \text{ or } LOAEL) \times HQ \times BW] / [(FIR \times BCF_{fish}) + WIR]$

Where:

BW	=	Body weight of receptor
BCF_{fish}	=	Bioconcentration factor for fish
C_{fish}	=	Concentration of COC in fish
C_{sw}	=	Concentration of COC in surface water
f_{fish}	=	Fraction of fish ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level
WIR	=	Water ingestion rate

Assumptions for Arsenic:

BW	=	2.229 kg
BCF_{fish}	=	17 L/kg
FIR	=	0.401 kg/day
LOAEL	=	12.84 mg/kg/day
NOAEL	=	5.14 mg/kg/day
WIR	=	0.08 L/day

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sw} = [5.14 mg/kg/day x 1.0 x 2.229 kg] / [(0.401 kg/day x 17 L/kg) + 0.08 L/day]
= 1.66 mg/L

Sediment and Surface Water RGOs Protective of the Great Blue Heron

(Conservative Inputs)

Body Weight	2.2290000 kg		
Food Ingestion Rate	0.4010000 kg/day	% fish	1
Water Ingestion Rate	0.0800000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		

f_{toc} = 0.014

f_l = 0.035

Preliminary COC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	BSAF	BCF (Fish)	Mummichog Concentration (mg/kg)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	Sed. RGO NOAEL (mg/kg) HQ = 1	Sed. RGO LOAEL (mg/kg) HQ = 1	SW RGO NOAEL (mg/L) HQ = 1	SW RGO LOAEL (mg/L) HQ = 1
PESTICIDES/PCBs															
4,4'-DDD	0.04135	0	0.28	3400	0.028945	#N/A	0.012	0.0028	0.028	4.15E+00	4.15E-01	0.02223	0.22234	0.00000458	0.00004577
4,4'-DDE	0.02919	0	7.7	3400	0.5619075	#N/A	0.225	0.0028	0.028	8.05E+01	8.05E+00	0.00081	0.00809	0.00000458	0.00004577
4,4'-DDT	0.02909	0	1.67	3400	0.12145075	#N/A	0.049	0.0028	0.028	1.74E+01	1.74E+00	0.00373	0.03728	0.00000458	0.00004577
Aroclor-1254	0.02844	0	1.85	31200	0.131535	#N/A	0.053	0.18	1.8	2.93E-01	2.93E-02	0.21633	2.16335	0.00003207	0.00032069
INORGANICS															
Aluminum	13060.47619	5.3596325	1	95	13060.47619	509.1650875	5237.443	109.7	1097	4.77E+01	4.77E+00	609.77880	6097.78803	6.405	64.053
Arsenic	6.436667	0.0057625	1	17	6.436667	0.0979625	2.581	5.14	12.84	5.02E-01	2.01E-01	28.57122	71.37247	1.661	4.150
Barium	17.238095	0.029125	1	4	17.238095	0.1165	6.914	20.8	41.7	3.32E-01	1.66E-01	115.61895	231.79377	27.532	55.196
Cobalt	2.030952	0.00134	1	300	2.030952	0.402	0.814	1	10	8.14E-01	8.14E-02	5.55860	55.58603	0.019	0.185
Iron	12744.76191	6.1071575	1	2700	12744.76191	16489.32525	5110.869	100	1000	5.11E+01	5.11E+00	555.86035	5558.60349	0.206	2.059
Lead	29.914286	0.0090625	1	4	29.914286	0.03625	11.996	1.13	11.3	1.06E+01	1.06E+00	6.28122	62.81222	1.496	14.957
Mercury	0.055952	0.000055	1	3760	0.055952	0.2068	0.022	0.0064	0.064	3.51E+00	3.51E-01	0.03558	0.35575	0.00000946	0.000
Selenium	0.340833	0	1	6	0.340833	#N/A	0.137	0.4	0.8	3.42E-01	1.71E-01	2.22344	4.44688	0.359	0.717
Thallium	0.214405	0	1	119	0.214405	#N/A	0.086	0.47	4.7	1.83E-01	1.83E-02	2.61254	26.12544	0.022	0.219
Vanadium	29.078571	0.014536	1	0.01	29.078571	0.00014536	11.661	11.4	114	1.02E+00	1.02E-01	63.36808	633.68080	302.471	3024.711
Zinc	43.311905	0.02168	1	47	43.311905	1.01896	17.369	14.5	131	1.20E+00	1.33E-01	80.59975	728.17706	1.708	15.428

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Mummichog			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

Purpose: To calculate sediment RGOs based on risks to the Mummichog as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for sediment preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. $Dose_{sed} = FIR \times C_{sed} / BW$

2. Dose = (NOAEL or LOAEL)(HQ)

Substituting 2 into 1,

3. C_{sed} or RGO_{sed} = [(NOAEL or LOAEL) x HQ x BW]/FIR

Where:

BW = Body weight of receptor
C_{sed} = Concentration of COC in sediment
FIR = Food ingestion rate
HQ = Hazard Quotient
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level

Assumptions for Arsenic:

BW = 0.003 kg
FIR = 0.000174 kg/day
LOAEL = 7.1 mg/kg/day
NOAEL = 0.59 mg/kg/day

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sed} = 0.59 mg/kg/day x 1.0 x 0.003 kg / 0.000174 kg/day = 10.2 mg/kg

Sediment and Surface Water RGOs Protective of the Mummichog
(Conservative Inputs)

Body Weight	0.0030000 kg
Food Ingestion Rate	0.0001740 L/day or kg/day
Water Ingestion Rate	0.0000000 L/day (No Data)
Sediment Ingestion Rate	0.0000000 kg/day (No Data)

Preliminary COC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	TBP Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	Sed. RGO NOAEL HQ = 1	Sed. RGO LOAEL HQ = 1	SW RGO NOAEL (mg/L) HQ = 1	SW RGO LOAEL (mg/L) HQ = 1
PESTICIDES/PCBs												
4,4'-DDD	0.04135	0	0.028945	0.0023983	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
4,4'-DDE	0.02919	0	0.5619075	0.00169302	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
4,4'-DDT	0.02909	0	0.12145075	0.00168722	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Aroclor-1254	0.02844	0	0.131535	0.00164952	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
INORGANICS												
Aluminum	13060.47619	5.3596325	13060.47619	757.507619	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Arsenic	6.436667	0.0057625	6.436667	0.37332669	0.59	7.1	6.33E-01	5.26E-02	10.17	122.41	NA	NA
Barium	17.238095	0.029125	17.238095	0.99980951	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Cobalt	2.030952	0.00134	2.030952	0.11779522	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Iron	12744.76191	6.1071575	12744.76191	739.19619	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Lead	29.914286	0.0090625	29.914286	1.73502859	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Mercury	0.055952	0.000055	0.055952	0.00324522	0.008	0.94	4.06E-01	3.45E-03	0.138	16.21	NA	NA
Selenium	0.340833	0	0.340833	0.01976831	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Thallium	0.214405	0	0.214405	0.01243549	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Vanadium	29.078571	0.014536	29.078571	1.68655712	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Zinc	43.311905	0.02168	43.311905	2.51209049	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Red Drum			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB		**Date:** October 19, 1999

Purpose: To calculate sediment RGOs based on risks to the Red Drum as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for sediment preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

For organics

NOAELs and LOAELs for organic COCs do not exist for the Red Drum. Therefore, RGOs for organic COCs will not be calculated.

For inorganics

1. $Dose_{sed}$ = FIR x C_{sed} /BW , therefore

2. C_{sed} = BW x Dose/FIR

Substituting 3 into 2,

3. C_{sed} or RGO_{sed} = [(NOAEL or LOAEL) x HQ x BW/FIR

Where:

BW = Body weight of receptor
C_{sed} = Concentration of COC in sediment
FIR = Food ingestion rate
HQ = Hazard Quotient
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level

Assumptions:

BW = 1.4 kg
FIR = 0.028 kg/day
$NOAEL_{arsenic}$ = 0.59 mg/kg/day

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sed} = 0.59 mg/kg/day x 1.0 x 1.4 kg/0.028 kg/day = 29.5 mg/kg

Sediment and Surface Water RGOs Protective of the Red Drum
(Conservative Inputs)

Body Weight	1.4000000 kg			
Food Ingestion Rate	0.0280000 kg/day or L/day	%fish	0.85	
		% sed	0.15	
Water Ingestion Rate	0.0000000 L/day			
Sediment Ingestion Rate	0.0280000 kg/day			

f_{toc} = 0.014
f_l = 0.035

Preliminary COC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	BSAF	Mummichog TBP Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	Sed. RGO NOAEL (mg/kg) HQ = 1	Sed. RGO LOAEL (mg/kg) HQ = 1	SW RGO NOAEL (mg/L) HQ = 1	SW RGO LOAEL (mg/L) HQ = 1
PESTICIDES/PCBs													
4,4'-DDD	0.04135	0	0.28	0.028945	0.00061612	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
4,4'-DDE	0.02919	0	7.7	0.5619075	0.00964	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
4,4'-DDT	0.02909	0	1.67	0.12145075	0.00215193	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Aroclor-1254	0.02844	0	1.85	0.131535	0.00232142	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
INORGANICS													
Aluminum	13060.47619	5.3596325	1	13060.47619	261.209524	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Arsenic	6.436667	0.0057625	1	6.436667	0.12873334	0.59	7.1	2.18E-01	1.81E-02	29.50	355.00	NA	NA
Barium	17.238095	0.029125	1	17.238095	0.3447619	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Cobalt	2.030952	0.00134	1	2.030952	0.04061904	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Iron	12744.76191	6.1071575	1	12744.76191	254.895238	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Lead	29.914286	0.0090625	1	29.914286	0.59828572	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Mercury	0.055952	0.000055	1	0.055952	0.00111904	0.008	0.94	1.40E-01	1.19E-03	0.40	47.00	NA	NA
Selenium	0.340833	0	1	0.340833	0.00681666	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Thallium	0.214405	0	1	0.214405	0.0042881	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Vanadium	29.078571	0.014536	1	29.078571	0.58157142	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA
Zinc	43.311905	0.02168	1	43.311905	0.8662381	0	0	#DIV/0!	#DIV/0!	NA	NA	NA	NA

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Bald Eagle			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

Purpose: To calculate sediment RGOs based on risks to the Bald Eagle as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for sediment preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

For organics

1. $Dose_{sed} = FIR \times C_{rd} / BW$

2. $C_{rd} = BSAF \times f_l \times C_{sed} / f_{oc}$

Substituting 2 into 1 and solving for C_{sed},

3. C_{sed} or $RGO_{sed} = (Dose \times BW \times f_{oc}) / (FIR \times BSAF \times f_l)$

4. Dose = (NOAEL or LOAEL)(HQ)

Substituting 4 into 3,

5. C_{sed} or $RGO_{sed} = [(NOAEL \text{ or } LOAEL) \times HQ \times BW \times f_{oc}] / (FIR \times BSAF \times f_l)$

Where:

BW = Body weight of receptor
BSAF = biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalized to lipid, to the concentration of the chemical in surface sediment, normalized to organic carbon)
C_{rd} = Concentration of COC in the red drum
C_{sed} = Concentration of COC in sediment
f_l = Organism lipid content expressed as a decimal fraction
f_{oc} = Total organic carbon (TOC) content of sediment expressed as a decimal fraction
FIR = Food ingestion rate
HQ = Hazard Quotient
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of sediment RGOs based on risks to the Bald Eagle			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 28, 1999

For inorganics

6. $Dose_{sed}$ = FIR x C_{sed} /BW, therefore

7. C_{sed} = BW x Dose/FIR

Substituting 4 into 7,

8. C_{sed} or RGO_{sed} = [(NOAEL or LOAEL) x HQ x BW/FIR

Assumptions:

BW	=	3.75 kg
$BSAF_{aroclor\ 1254}$	=	1.85
f_{oc}	=	0.014
f_l	=	0.01
FIR	=	0.45 kg/day
$NOAEL_{aroclor\ 1254}$	=	0.18 mg/kg/day
$NOAEL_{arsenic}$	=	5.14 mg/kg/day

Example Calculation for Aroclor 1254, based on a NOAEL HQ = 1

RGO_{sed} = [0.18 mg/kg/day x 1.0 x 3.75 kg x 0.014] / (0.45 kg/day x 1.85 x 0.01) = 1.14 mg/kg

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sed} = 5.14 mg/kg/day x 1.0 x 3.75 kg /0.45 kg/day = 42.8 mg/kg

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of surface water RGOs based on risks to the Bald Eagle			
Based On: MCRD Parris Island Site 3 RI Ecological Risk Assessment Food Chain Modeling			
By: J. Brown	**Checked By:** AMB	5-28-99	**Date:** May 26, 1999

Purpose: To calculate surface water RGOs based on risks to the Bald Eagle as determined from the Site 3 RI ecological risk assessment. RGOs are calculated for surface water preliminary COCs from the aquatic food chain modeling that exceed a NOAEL HQ of 1.0.

Equations:

1. $Dose_{sw} = FIR \times C_{fish} / BW$

2. $C_{fish} = C_{sw} \times BCF_{fish}$

Substituting 2 into 1 and solving for C_{sw},

3. C_{sw} or $RGO_{sw} = (Dose \times BW) / (FIR \times BCF_{fish})$

4. Dose = (NOAEL or LOAEL)(HQ)

Substituting 4 into 3,

5. C_{sw} or RGO_{sw} = [(NOAEL or LOAEL) x HQ x BW] / ($FIR \times BCF_{fish}$)

Where:

BW	=	Body weight of receptor
BCF_{fish}	=	Bioconcentration factor for fish
C_{fish}	=	Concentration of COC in fish
C_{sw}	=	Concentration of COC in surface water
f_{fish}	=	Fraction of fish ingested in receptor's daily food intake
FIR	=	Food ingestion rate
HQ	=	Hazard Quotient
LOAEL	=	Lowest observed adverse effects level
NOAEL	=	No observed adverse effects level

Assumptions for Arsenic:

BW	=	3.75 kg
BCF_{fish}	=	17 L/kg
FIR	=	0.45 kg/day
LOAEL	=	12.84 mg/kg/day
NOAEL	=	5.14 mg/kg/day

Example Calculation for Arsenic, based on a NOAEL HQ = 1

RGO_{sw} = [5.14 mg/kg/day x 1.0 x 3.75 kg] / (0.45 kg/day x 17 L/kg)
= 2.52 mg/L

Sediment and Surface Water RGOs Protective of the Bald Eagle
(Conservative Inputs)

Body Weight	3.7500000 kg		
Food Ingestion Rate	0.4500000 kg/day	% fish	1
Water Ingestion Rate	0.0000000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		

f_{foc} = 0.014
f_l = 0.01

Preliminary COC	Sediment Concentration (mg/kg)	BSAF	BCF (fish)	Red Drum Concentration (mg/kg)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l	Sed. RGO NOAEL (mg/kg) HQ = 1	Sed. RGO LOAEL (mg/kg) HQ = 1	SW RGO NOAEL (mg/L) HQ = 1	SW RGO LOAEL (mg/L) HQ = 1
PESTICIDES/PCBs														
4,4'-DDD	0.04135	0.28	3400	0.00827	#N/A	0.001	0.0028	0.028	3.54E-01	3.54E-02	0.1166667	1.167	0.0000069	0.0000686
4,4'-DDE	0.02919	7.7	3400	0.160545	#N/A	0.019	0.0028	0.028	6.88E+00	6.88E-01	0.0042424	0.042	0.0000069	0.0000686
4,4'-DDT	0.02909	1.67	3400	0.034700214	#N/A	0.004	0.0028	0.028	1.49E+00	1.49E-01	0.0195609	0.196	0.0000069	0.0000686
Aroclor-1254	0.02844	1.85	31200	0.037581429	#N/A	0.005	0.18	1.8	2.51E-02	2.51E-03	1.1351351	11.351	0.0000481	0.0004808
INORGANICS														
Aluminum	13060.47619	1	95	13060.47619	509.1650875	1567.257	109.7	1097	1.43E+01	1.43E+00	914.167	9141.667	9.62	96.23
Arsenic	6.436667	1	17	6.436667	0.0979625	0.772	5.14	12.84	1.50E-01	6.02E-02	42.833	107.000	2.52	6.29
Barium	17.238095	1	4	17.238095	0.1165	2.069	20.8	41.7	9.95E-02	4.96E-02	173.333	347.500	43.33	86.88
Cobalt	2.030952	1	300	2.030952	0.402	0.244	1	10	2.44E-01	2.44E-02	8.333	83.333	0.03	0.28
Iron	12744.76191	1	2700	12744.76191	16489.32525	1529.371	100	1000	1.53E+01	1.53E+00	833.333	8333.333	0.31	3.09
Lead	29.914286	1	4	29.914286	0.03625	3.590	1.13	11.3	3.18E+00	3.18E-01	9.417	94.167	2.35	23.54
Mercury	0.055952	1	3760	0.055952	0.2068	0.007	0.0064	0.064	1.05E+00	1.05E-01	0.053	0.533	0.0000142	0.0001418
Selenium	0.340833	1	6	0.340833	#N/A	0.041	0.4	0.8	1.02E-01	5.11E-02	3.333	6.667	0.56	1.11
Thallium	0.214405	1	119	0.214405	#N/A	0.026	0.47	4.7	5.47E-02	5.47E-03	3.917	39.167	0.03	0.33
Vanadium	29.078571	1	0.01	29.078571	0.00014536	3.489	11.4	114	3.06E-01	3.06E-02	95.000	950.000	9500.00	95000.00
Zinc	43.311905	1	47	43.311905	1.01896	5.197	14.5	131	3.58E-01	3.97E-02	120.833	1091.667	2.57	23.23

1 - Dose and HQs calculated from the Site 3 ERA food chain modeling.

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Appendix C

Impacted Soil and Sediment
Area and Volume Calculations

Client: MCRD Parris Island South Carolina		**Job Number** 7394	
Subject: Calculation of Area and Volume of Impacted Surface Soil, Sediment, and Waste at Site 3			
Based On: Surface Soil and Sediment Analytical Results, RGOs, and Aerial Photographs			
By: J. Brown	**Checked By:**		**Date:** May 22, 2000

Purpose: To estimate the area of impacted soil and area and volume of impacted sediment at Site 3.

Approach: The following approach is taken:

1. Surface soil and sediment results from the Site 3 RI/RFI are compared against the RGOs summarized in Tables 3-7 and 3-8 of the FS/CMS report. Sampling locations that exceed RGOs for the protection of human health and ecological receptors are identified as impacted.
2. At each surface soil sampling location during the RI/RFI, field personnel advanced soil borings until the top of waste was encountered. Locations where less than two feet of soil cover was observed are identified as impacted.
3. To set a boundary between an impacted sampling location and a clean location (non-detect or less than RGOs), the concentration of the COC is assumed to logarithmically decay from the impacted location to the clean location.
4. For sediment, an extent of contamination using 1999 delineation samples as clean boundary points is also provided for comparative purposes. In instances where a delineation sample contains a COC that exceeds an RGO, the boundary is estimated as described in Step 3.
5. Based on the established boundaries, the area of impacted soil and the area and volume of impacted sediment is calculated.

Equations: To estimate the distance of a RGO compliance point (excavation boundary) from an impacted sampling location:

$$D_{imp\text{-}RGO} = \frac{[\log(C_{imp}) - \log(C_{RGO})]}{[\log(C_{imp}) - \log(C_{cl})]} \times D_{imp\text{-}cl}$$

Where,

C_{imp} = concentration of a COC at an impacted location (ug/kg or mg/kg)
C_{cl} = concentration of a COC at a clean location (ug/kg or mg/kg) – the detected value or ½ the detection limit for non-detected values
C_{RGO} = RGO concentration (ug/kg or mg/kg)
$D_{imp\text{-}RGO}$ = distance between an impacted sampling location and the estimated RGO compliance point (ft)
$D_{imp\text{-}cl}$ = distance between an impacted sampling location and the closest clean sample (ft)

Assumption:

- Based on the geometry of the causeway and the maximum water level elevation of the pond (4 feet), the depth of impacted sediment is assumed to be 2 feet.

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Calculations:

Determination of impacted sampling locations

- Surface soil and sediment RGOs for the protection of human health and ecological receptors are presented in Tables 3-7 and 3-8 (a copy of these tables are provided in this Appendix).
- Soil sampling locations that exceed soil RGOs for the protection of human health and ecological receptors are presented in Tables C-1 and C-2, respectively.
- Sediment sampling locations that exceed sediment RGOs for the protection of human health and ecological receptors are presented in Tables C-3 and C-4, respectively.
- Table C-5 illustrates soil boring logs from surface soil sample locations. Sampling locations where less than two feet of soil cover exists are bolded and are classified as impacted.

Boundary Determinations

- Concerning the soil cover, the general trend of the hand auger boring logs indicate that the lower half of the causeway has less than two feet of soil cover (from PAI-03-SS-07 to the southeast end of the causeway). This area is identified as impacted regardless of the RGO set used.

- When 1998 RI surface soil results were compared against RGOs that represent an ILCR of 1.0E-06 to human receptors and low risk to ecological receptors, 15 out of 16 locations exceed RGOs for the protection of ecological receptors. Only one location exceed RGOs for the protection of human health. Under this scenario, the entire causeway is identified as impacted (see Figure C-1).

- When 1998 RI surface soil results were compared against RGOs that represent an ILCR of 1.0E-05 to human receptors and moderate risk to ecological receptors, 4 locations exceed RGOs for the protection of ecological receptors and no locations exceed RGOs for the protection of human health. Two of the impacted ecological locations correspond to the areas where less than two feet of soil cover is observed. To estimate the ecologically impacted soil outside of the area where less than two feet of soil cover is observed, the boundaries were defined assuming logarithmic decay from the impacted soil location to the closest clean sample. Attachment 1 presents this boundary determination. Figure C-2 illustrates the boundary of impacted soil.

- When 1998 RI surface soil results were compared against RGOs that represent an ILCR of 1.0E-04 to human receptors and high risk to ecological receptors, one location exceeds RGOs for the protection of ecological receptors and no locations exceed RGOs for the protection of human health. The boundaries of ecologically impacted soil were defined assuming logarithmic decay from the impacted soil location to the closest clean sample. Attachment 1 presents this boundary determination. Figure C-3 illustrates the boundary of impacted soil.

- When 1998 RI sediment results were compared against RGOs that represent an ILCR of 1.0E-06 to human receptors and low risk to ecological receptors, 16 out of 20 locations exceed RGOs for the protection of ecological receptors. Eleven out of 20 locations exceed RGOs for the protection of human health. A boundary could not be defined to reflect the extent of impacted sediment under this scenario.

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- When sediment concentrations were compared against RGOs that represent an ILCR of 1.0E-05 to human receptors and moderate risk to ecological receptors, four "hot spots" were identified.

  - PAHs are the COCs that comprise Hot Spot 1. Two volume estimates are provided for this hot spot (using approach steps 3 and 4, noted previously). Figure C-4 illustrates the boundaries of impacted sediment for this hot spot.
  - One COC (Aroclor-1254) comprises Hot Spot 2. Two volume estimates are also provided for this hot spot (using approach steps 3 and 4). Because PAI-03-SD-34-01 contains a detection of Aroclor-1254 that exceeds the RGO, PAI-03-SD-19 was used to estimate the hot spot boundary. PAI-03-SD-19 is located approximately 350 feet southeast of PAI-03-SD-34. Figure C-5 illustrates the boundaries of impacted sediment for this hot spot.
  - Pesticides are the COCs that comprise Hot Spot 3. Because location PAI-03-SD-36 contains 4,4'-DDE and 4,4'-DDD detections above their respective RGOs, only an estimated extent of contamination (using approach step 3) is provided. Figure C-6 illustrates the boundaries of impacted sediment for this hot spot.
  - Pesticides are also the COCs that comprise Hot Spot 4. One volume estimate is provided for this hot spot (using approach step 3). Because location PAI-03-SD-38 contains detections of 4,4'-DDE and 4,4'-DDD above their respective RGOs, PAI-03-SD-37 was used to estimate the hot spot boundary. PAI-03-SD-37 is located approximately 700 feet northwest of PAI-03-SD-38. Figure C-7 illustrates the boundaries of impacted sediment for this hot spot.

- When sediment concentrations were compared against RGOs that represent an ILCR of 1.0E-04 to human receptors and high risk to ecological receptors, no sediment locations exceed RGOs.

Area and Volume Calculations:

Based on the delineated areas of impact defined on Figures C-1 through C-7, areas of impacted soil and areas and volumes of impacted sediment were determined. Backup calculations are provided in Attachment 2.

RGO Set Used	Figure	Area of Impacted Surface Soil (ft^2)	Area of Impacted Surface Soil (acres)
ILCR = 1.0E-06, low risk to eco.	C-1	677,500	15.6
ILCR = 1.0E-05, moderate risk to eco.	C-2	427,500	9.6
ILCR = 1.0E-04, high risk to eco.	C-3	385,000	8.8

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RGO Set Used	Figure	Maximum Extent		Estimated Extent	
		Area of Impacted Sediment (ft^2)	Volume of Impacted Sediment (yd^3)	Area of Impacted Sediment (ft^2)	Volume of Impacted Sediment (yd^3)
ILCR = 1.0E-06, low risk to eco.	-	NA	NA	NA	NA
ILCR = 1.0E-05, moderate risk to eco.					
Hot Spot 1	C-4	37,800	2,800	5,400	400
Hot Spot 2	C-5	13,600	1,000	4,300	320
Hot Spot 3	C-6	9,300	690	9,300	690
Hot Spot 4	C-7	35,300	2,620	35,300	2,620
Totals		96,000	7,110	54,300	4,030
ILCR = 1.0E-04, high risk to eco.	-	0	0	0	0

TABLE 3-7

SURFACE SOIL RGOS SUMMARY TABLE
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

COC	Human Health ILCR = 1.0E-06	Ref.	Low Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-05	Ref.	Moderate Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-04	Ref.	High Risk to Ecological Receptors*	Ref.
SVOCs (µg/kg)												
ACENAPHTHYLENE	-	-	100	h	-	-	5,000	i	-	-	50,000	g
ANTHRACENE	-	-	100	h, j	-	-	10,000	i	-	-	100,000	g
BENZO(A)ANTHRACENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(A)PYRENE	890	b	100	h, j	8,900	c	1,000	i	89,000	d	10,000	g
BENZO(B)FLUORANTHENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(G,H,I)PERYLENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
BENZO(K)FLUORANTHENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
CHRYSENE	-	-	100	h	-	-	1,000	i	-	-	10,000	g
FLUORANTHENE	-	-	100	h	-	-	10,000	i	-	-	100,000	g
INDENO(1,2,3-CD)PYRENE	-	-	100	h, j	-	-	1,000	i	-	-	10,000	g
PHENANTHRENE	-	-	100	h, j	-	-	5,000	i	-	-	50,000	g
PYRENE	-	-	100	h, j	-	-	10,000	i	-	-	100,000	g
PCBs (µg/kg)												
AROCLOR-1254	-	-	20.0	j	-	-	238	f	-	-	2,380	g
AROCLOR-1260	-	-	20.0	j	-	-	238	f	-	-	2,380	g
Inorganics (mg/kg)												
ARSENIC	-	-	1.4	a	-	-	7.79	f	-	-	78.0	k
LEAD	-	-	12.5	a	-	-	61.9	f	-	-	619	k
MERCURY	-	-	0.11	a	-	-	0.11	a	-	-	0.29	k
VANADIUM	-	-	9.5	a	-	-	28.9	f	-	-	289	k
ZINC	-	-	10.6	e	-	-	95.5	f	-	-	955	k

References:
a. Inorganic background
b. Site-Specific Human Health RGOs - ILCR = 1.E-06
c. Site-Specific Human Health RGOs - ILCR = 1.E-05
d. Site-Specific Human Health RGOs - ILCR = 1.E-04
e. NOAEL, HQ = 1
f. LOAEL, HQ = 1
g. The moderate risk ecological RGO multiplied by 10
"-" = Not Applicable
* Values may be revised upward based on site-specific ecological studes.
h. Dutch Soil Clean-up Act "a" Values
i. Dutch Soil Clean-up Act "b" Values
j. U.S. EPA Region IV Ecological Screening Values for Soils
k. LOAEL, HQ = 10

TABLE 3-8

SEDIMENT RGOS SUMMARY TABLE
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

COC	Human Health ILCR = 1.0E-06	Ref.	Low Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-05	Ref.	Moderate Risk to Ecological Receptors*	Ref.	Human Health ILCR = 1.0E-04	Ref.	High Risk to Ecological Receptors*	Ref.
PAHs (µg/kg)												
ANTHRACENE	-	-	46.9	k,l	-	-	245	n	-	-	2,450	p
BENZO(A)PYRENE	2.09	c	88.8	k,l	303	f	763	n	3,030	g	7,630	p
BENZO(A)ANTHRACENE	20.9	c	74.8	k,l	3,030	f	693	n	30,300	g	6,930	p
BENZO(B)FLUORANTHENE	20.9	c	655	l	3,030	f	6,550	o	30,300	g	65,500	p
CARBAZOLE	219	c	-	-	31,700	f	-	-	317,000	g	-	p
CHRYSENE	-	-	108	k,l	-	-	846	n	-	-	8,460	p
FLUORANTHENE	-	-	113	k,l	-	-	1,494	n	-	-	14,900	
INDENO(1,2,3-CD)PYRENE	20.9	c	655	l	3,030	f	6,550	o	30,300	g	65,500	p
PHENANTHRENE	-	-	86.7	k,l	-	-	544	n	-	-	5,440	p
PYRENE	-	-	153	k,l	-	-	1,398	n	-	-	14,000	p
PCBs (µg/kg)												
AROCLOR-1254	1.19	c	21.6	k,l	178	f	180	m	1,780	g	1,800	p
AROCLOR-1260	1.19	c	21.6	k,l	175	f	180	m	1,750	g	1,800	p
Pesticides (µg/kg)												
ALPHA-CHLORDANE	13.9	b	13.9	b	382	f	13.9	b	3,820	g	139	p
4,4'-DDD	65.9	c	33.6	b	9,670	f	33.6	b	96,700	g	336	p
4,4'-DDE	31.6	b	31.6	b	251	f	31.6	b	2,510	g	316	p
GAMMA-CHLORDANE	13.2	b	13.2	b	824	f	13.2	b	8,240	g	132	p
Inorganics (mg/kg)												
ARSENIC	16.8	d	12.0	a	59.7	e	12.0	a	489	h	59	q
COBALT	-	-	4.66	i	-	-	46.6	j	-	-	466	q
COPPER	-	-	18.7	l	-	-	108	m	-		1,080	q
LEAD	-	-	21.0	a	-	-	62.8	j	-	-	628	q
MERCURY	-	-	0.09	a	-	-	0.117	j	-	-	1.17	q
SELENIUM	-	-	0.93	i	-	-	1.54	j	-	-	15.4	q
THALLIUM	-	-	0.41	a	-	-	0.41	a	-	-	3.4	q
VANADIUM	-	-	50.0	a	-	-	50.0	a	-	-	98	q
ZINC	-	-	80.6	i	-	-	271	m	-	-	2,710	q

References:
a. Inorganic background
b. Typical Facility Pesticide Concentrations
c. Human health RGOs based on ingestion of fish (conservative inputs) - ILCR = 1.0E-06
d. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-06
e. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-05
f. Human health RGOs based on ingestion of fish (site-specific inputs) - ILCR = 1.0E-05
g. Human health RGOs based on ingestion of fish (site-specific inputs) - ILCR = 1.0E-04
h. Site-specific human health RGOs based on dermal contact - ILCR = 1.E-04
i. NOAEL, HQ = 1
j. LOAEL, HQ = 1
k. ER-L
l. U.S. EPA Region IV Effects Value
m. ER-M
n. PEL
o. 10 times the ecological low risk RGO.
p. 10 times the ecological moderate risk RGO.
q. LOAEL, HQ = 10
"-" = Not Applicable
* Values may be revised upward based on site-specific ecological studes.

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TABLE C-1

SURFACE SOIL COMPARED TO BACKGROUND AND HUMAN HEALTH RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUAL	UNITS
Detected organic COCs and inorganic COCs that exceed background						
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)PYRENE	OS	4000.000000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	BENZO(A)PYRENE	OS	13.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(A)PYRENE	OS	170.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	BENZO(A)PYRENE	OS	24.000000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	BENZO(A)PYRENE	OS	4.100000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(A)PYRENE	OS	9.800000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(A)PYRENE	OS	39.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	BENZO(A)PYRENE	OS	13.000000	J	UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(A)PYRENE	OS	150.000000	J	UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BENZO(A)PYRENE	OS	25.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(A)PYRENE	OS	18.000000		UG/KG
COCs that exceed RGOs that represent an ILCR of 1.0E-06						
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)PYRENE	OS	4000.000000		UG/KG
COCs that exceed RGOs that represent an ILCR of 1.0E-05						
No exceedances						
COCs that exceed RGOs that represent an ILCR of 1.0E-04						
No exceedances						

TABLE C-2

SURFACE SOIL COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUAL	UNITS
Detected organic COCs and inorganic COCs that exceed background						
PAI-03-SS-15	PAI-03-SS-15-01	ARSENIC	M	1.600000		MG/KG
PAI-03-SS-02	PAI-03-SS-02-01	ARSENIC	M	2.500000		MG/KG
PAI-03-SS-03	PAI-03-SS-03-01	ARSENIC	M	11.800000		MG/KG
PAI-03-SS-13	PAI-03-SS-13-01	LEAD	M	13.900000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	LEAD	M	14.600000		MG/KG
PAI-03-SS-09	PAI-03-SS-09-01	LEAD	M	23.200000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	LEAD	M	35.300000		MG/KG
PAI-03-SS-12	PAI-03-SS-12-01	LEAD	M	53.600000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	LEAD	M	264.000000		MG/KG
PAI-03-SS-10	PAI-03-SS-10-01	MERCURY	M	0.180000		MG/KG
PAI-03-SS-09	PAI-03-SS-09-01	MERCURY	M	0.430000		MG/KG
PAI-03-SS-08	PAI-03-SS-08-01	VANADIUM	M	9.600000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	VANADIUM	M	11.100000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	VANADIUM	M	11.900000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	VANADIUM	M	12.200000		MG/KG
PAI-03-SS-02	PAI-03-SS-02-01	VANADIUM	M	13.400000		MG/KG
PAI-03-SS-10	PAI-03-SS-10-01	VANADIUM	M	16.400000		MG/KG
PAI-03-SS-05	PAI-03-SS-05-01	VANADIUM	M	17.300000		MG/KG
PAI-03-SS-04	PAI-03-SS-04-01	VANADIUM	M	21.400000		MG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	ZINC	M	10.500000		MG/KG
PAI-03-SS-16	PAI-03-SS-16-01	ZINC	M	11.000000		MG/KG
PAI-03-SS-14	PAI-03-SS-14-01	ZINC	M	12.500000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	ZINC	M	14.800000		MG/KG
PAI-03-SS-13	PAI-03-SS-13-01	ZINC	M	16.000000		MG/KG
PAI-03-SS-05	PAI-03-SS-05-01	ZINC	M	17.500000		MG/KG
PAI-03-SS-03	PAI-03-SS-03-01	ZINC	M	19.700000		MG/KG
PAI-03-SS-12	PAI-03-SS-12-01	ZINC	M	20.700000		MG/KG
PAI-03-SS-04	PAI-03-SS-04-01	ZINC	M	22.800000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	ZINC	M	55.700000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ZINC	M	205.000000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ACENAPHTHYLENE	OS	1800.000000	J	UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	ANTHRACENE	OS	1.700000	J	UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	ANTHRACENE	OS	2.200000	J	UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	ANTHRACENE	OS	4.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	ANTHRACENE	OS	9.900000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	ANTHRACENE	OS	41.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ANTHRACENE	OS	340.000000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	BENZO(A)ANTHRACENE	OS	3.000000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(A)ANTHRACENE	OS	7.000000	J	UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	BENZO(A)ANTHRACENE	OS	10.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(A)ANTHRACENE	OS	12.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BENZO(A)ANTHRACENE	OS	14.000000	J	UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	BENZO(A)ANTHRACENE	OS	17.000000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(A)ANTHRACENE	OS	32.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(A)ANTHRACENE	OS	140.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(A)ANTHRACENE	OS	180.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)ANTHRACENE	OS	3000.000000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	BENZO(A)PYRENE	OS	4.100000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(A)PYRENE	OS	9.800000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	BENZO(A)PYRENE	OS	13.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	BENZO(A)PYRENE	OS	13.000000	J	UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(A)PYRENE	OS	18.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	BENZO(A)PYRENE	OS	24.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BENZO(A)PYRENE	OS	25.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(A)PYRENE	OS	39.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(A)PYRENE	OS	150.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(A)PYRENE	OS	170.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)PYRENE	OS	4000.000000		UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	BENZO(B)FLUORANTHENE	OS	2.200000	J	UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	BENZO(B)FLUORANTHENE	OS	2.800000		UG/KG
PAI-03-SS-04	PAI-03-SS-04-01	BENZO(B)FLUORANTHENE	OS	3.100000	J	UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	BENZO(B)FLUORANTHENE	OS	7.200000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	BENZO(B)FLUORANTHENE	OS	8.700000		UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(B)FLUORANTHENE	OS	10.000000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	BENZO(B)FLUORANTHENE	OS	12.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BENZO(B)FLUORANTHENE	OS	18.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	BENZO(B)FLUORANTHENE	OS	24.000000		UG/KG

TABLE C-2

SURFACE SOIL COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUAL	UNITS
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(B)FLUORANTHENE	OS	30.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(B)FLUORANTHENE	OS	32.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	BENZO(B)FLUORANTHENE	OS	73.000000	J	UG/KG
PAI-03-SS-07	PAI-03-SS-07-01	BENZO(B)FLUORANTHENE	OS	76.000000	J	UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(B)FLUORANTHENE	OS	150.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(B)FLUORANTHENE	OS	180.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(B)FLUORANTHENE	OS	3400.000000		UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(G,H,I)PERYLENE	OS	9.300000	J	UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(G,H,I)PERYLENE	OS	13.000000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(G,H,I)PERYLENE	OS	20.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(G,H,I)PERYLENE	OS	92.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(G,H,I)PERYLENE	OS	2500.000000		UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	BENZO(K)FLUORANTHENE	OS	1.700000	J	UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	BENZO(K)FLUORANTHENE	OS	2.000000		UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	BENZO(K)FLUORANTHENE	OS	3.600000		UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	BENZO(K)FLUORANTHENE	OS	4.300000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	BENZO(K)FLUORANTHENE	OS	7.200000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BENZO(K)FLUORANTHENE	OS	8.600000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	BENZO(K)FLUORANTHENE	OS	10.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	BENZO(K)FLUORANTHENE	OS	12.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	BENZO(K)FLUORANTHENE	OS	14.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(K)FLUORANTHENE	OS	64.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(K)FLUORANTHENE	OS	1300.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	BIS(2-ETHYLHEXYL)PHTHALA	OS	2300.000000		UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	CHRYSENE	OS	3.600000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	CHRYSENE	OS	4.100000	J	UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	CHRYSENE	OS	5.300000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	CHRYSENE	OS	9.600000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	CHRYSENE	OS	15.000000	J	UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	CHRYSENE	OS	20.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	CHRYSENE	OS	22.000000	J	UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	CHRYSENE	OS	25.000000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	CHRYSENE	OS	34.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	CHRYSENE	OS	49.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	CHRYSENE	OS	180.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	CHRYSENE	OS	200.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	CHRYSENE	OS	210.000000	J	UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	CHRYSENE	OS	2900.000000		UG/KG
PAI-03-SS-05	PAI-03-SS-05-01	FLUORANTHENE	OS	6.400000	J	UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	FLUORANTHENE	OS	6.400000		UG/KG
PAI-03-SS-04	PAI-03-SS-04-01	FLUORANTHENE	OS	7.100000	J	UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	FLUORANTHENE	OS	16.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	FLUORANTHENE	OS	26.000000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	FLUORANTHENE	OS	27.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	FLUORANTHENE	OS	34.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	FLUORANTHENE	OS	43.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	FLUORANTHENE	OS	63.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	FLUORANTHENE	OS	110.000000		UG/KG
PAI-03-SS-07	PAI-03-SS-07-01	FLUORANTHENE	OS	170.000000	J	UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	FLUORANTHENE	OS	300.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	FLUORANTHENE	OS	420.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	FLUORANTHENE	OS	500.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	FLUORANTHENE	OS	5100.000000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	INDENO(1,2,3-CD)PYRENE	OS	2.600000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	INDENO(1,2,3-CD)PYRENE	OS	6.900000	J	UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	INDENO(1,2,3-CD)PYRENE	OS	9.400000		UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	INDENO(1,2,3-CD)PYRENE	OS	13.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	INDENO(1,2,3-CD)PYRENE	OS	13.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	INDENO(1,2,3-CD)PYRENE	OS	14.000000	J	UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	INDENO(1,2,3-CD)PYRENE	OS	17.000000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	INDENO(1,2,3-CD)PYRENE	OS	17.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	INDENO(1,2,3-CD)PYRENE	OS	97.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	INDENO(1,2,3-CD)PYRENE	OS	2600.000000		UG/KG
PAI-03-SS-10	PAI-03-SS-10-01	PHENANTHRENE	OS	2.200000	J	UG/KG
PAI-03-SS-05	PAI-03-SS-05-01	PHENANTHRENE	OS	4.900000	J	UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	PHENANTHRENE	OS	6.000000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	PHENANTHRENE	OS	10.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	PHENANTHRENE	OS	10.000000	J	UG/KG

TABLE C-2

SURFACE SOIL COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUAL	UNITS
PAI-03-SS-09	PAI-03-SS-09-01	PHENANTHRENE	OS	11.000000	J	UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	PHENANTHRENE	OS	12.000000		UG/KG
PAI-03-SS-11	PAI-03-SS-11-01	PHENANTHRENE	OS	14.000000		UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	PHENANTHRENE	OS	15.000000	J	UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	PHENANTHRENE	OS	22.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	PHENANTHRENE	OS	44.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	PHENANTHRENE	OS	160.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	PHENANTHRENE	OS	180.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	PHENANTHRENE	OS	210.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	PHENANTHRENE	OS	1200.000000		UG/KG
PAI-03-SS-03	PAI-03-SS-03-01	PYRENE	OS	13.000000	J	UG/KG
PAI-03-SS-12	PAI-03-SS-12-01	PYRENE	OS	18.000000		UG/KG
PAI-03-SS-02	PAI-03-SS-02-01	PYRENE	OS	20.000000	J	UG/KG
PAI-03-SS-15	PAI-03-SS-15-01	PYRENE	OS	29.000000	J	UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	PYRENE	OS	40.000000	J	UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	PYRENE	OS	52.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	PYRENE	OS	75.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	PYRENE	OS	330.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	PYRENE	OS	360.000000	J	UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	PYRENE	OS	4500.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	AROCLOR-1254	PEST/PCB	56.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	AROCLOR-1260	PEST/PCB	11.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	AROCLOR-1260	PEST/PCB	20.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01-D	AROCLOR-1260	PEST/PCB	23.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	AROCLOR-1260	PEST/PCB	31.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	AROCLOR-1260	PEST/PCB	100.000000		UG/KG
COCs that exceed RGOs that represent low risk to ecological receptors						
PAI-03-SS-15	PAI-03-SS-15-01	ARSENIC	M	1.600000		MG/KG
PAI-03-SS-02	PAI-03-SS-02-01	ARSENIC	M	2.500000		MG/KG
PAI-03-SS-03	PAI-03-SS-03-01	ARSENIC	M	11.800000		MG/KG
PAI-03-SS-13	PAI-03-SS-13-01	LEAD	M	13.900000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	LEAD	M	14.600000		MG/KG
PAI-03-SS-09	PAI-03-SS-09-01	LEAD	M	23.200000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	LEAD	M	35.300000		MG/KG
PAI-03-SS-12	PAI-03-SS-12-01	LEAD	M	53.600000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	LEAD	M	264.000000		MG/KG
PAI-03-SS-10	PAI-03-SS-10-01	MERCURY	M	0.180000		MG/KG
PAI-03-SS-09	PAI-03-SS-09-01	MERCURY	M	0.430000		MG/KG
PAI-03-SS-08	PAI-03-SS-08-01	VANADIUM	M	9.600000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	VANADIUM	M	11.100000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	VANADIUM	M	11.900000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	VANADIUM	M	12.200000		MG/KG
PAI-03-SS-02	PAI-03-SS-02-01	VANADIUM	M	13.400000		MG/KG
PAI-03-SS-10	PAI-03-SS-10-01	VANADIUM	M	16.400000		MG/KG
PAI-03-SS-05	PAI-03-SS-05-01	VANADIUM	M	17.300000		MG/KG
PAI-03-SS-04	PAI-03-SS-04-01	VANADIUM	M	21.400000		MG/KG
PAI-03-SS-16	PAI-03-SS-16-01	ZINC	M	11.000000		MG/KG
PAI-03-SS-14	PAI-03-SS-14-01	ZINC	M	12.500000		MG/KG
PAI-03-SS-07	PAI-03-SS-07-01	ZINC	M	14.800000		MG/KG
PAI-03-SS-13	PAI-03-SS-13-01	ZINC	M	16.000000		MG/KG
PAI-03-SS-05	PAI-03-SS-05-01	ZINC	M	17.500000		MG/KG
PAI-03-SS-03	PAI-03-SS-03-01	ZINC	M	19.700000		MG/KG
PAI-03-SS-12	PAI-03-SS-12-01	ZINC	M	20.700000		MG/KG
PAI-03-SS-04	PAI-03-SS-04-01	ZINC	M	22.800000		MG/KG
PAI-03-SS-15	PAI-03-SS-15-01	ZINC	M	55.700000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ZINC	M	205.000000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ACENAPHTHYLENE	OS	1800.000000	J	UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ANTHRACENE	OS	340.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(A)ANTHRACENE	OS	140.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(A)ANTHRACENE	OS	180.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)ANTHRACENE	OS	3000.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(A)PYRENE	OS	150.000000	J	UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(A)PYRENE	OS	170.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)PYRENE	OS	4000.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	BENZO(B)FLUORANTHENE	OS	150.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	BENZO(B)FLUORANTHENE	OS	180.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(B)FLUORANTHENE	OS	3400.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(G,H,I)PERYLENE	OS	2500.000000		UG/KG

TABLE C-2

SURFACE SOIL COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUAL	UNITS
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(K)FLUORANTHENE	OS	1300.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	CHRYSENE	OS	180.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	CHRYSENE	OS	200.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	CHRYSENE	OS	210.000000	J	UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	CHRYSENE	OS	2900.000000		UG/KG
PAI-03-SS-16	PAI-03-SS-16-01	FLUORANTHENE	OS	110.000000		UG/KG
PAI-03-SS-07	PAI-03-SS-07-01	FLUORANTHENE	OS	170.000000	J	UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	FLUORANTHENE	OS	300.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	FLUORANTHENE	OS	420.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	FLUORANTHENE	OS	500.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	FLUORANTHENE	OS	5100.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	INDENO(1,2,3-CD)PYRENE	OS	2600.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	PHENANTHRENE	OS	160.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	PHENANTHRENE	OS	180.000000		UG/KG
PAI-03-SS-06	PAI-03-SS-06-01	PHENANTHRENE	OS	210.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	PHENANTHRENE	OS	1200.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	PYRENE	OS	330.000000		UG/KG
PAI-03-SS-14	PAI-03-SS-14-01	PYRENE	OS	360.000000	J	UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	PYRENE	OS	4500.000000		UG/KG
PAI-03-SS-09	PAI-03-SS-09-01	AROCLOR-1254	PEST/PCB	56.000000		UG/KG
PAI-03-SS-08	PAI-03-SS-08-01	AROCLOR-1260	PEST/PCB	31.000000		UG/KG
PAI-03-SS-13	PAI-03-SS-13-01	AROCLOR-1260	PEST/PCB	100.000000		UG/KG
COCs that exceed RGOs that represent moderate risk to ecological receptors						
PAI-03-SS-03	PAI-03-SS-03-01	ARSENIC	M	11.800000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	LEAD	M	264.000000		MG/KG
PAI-03-SS-10	PAI-03-SS-10-01	MERCURY	M	0.180000		MG/KG
PAI-03-SS-09	PAI-03-SS-09-01	MERCURY	M	0.430000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	ZINC	M	205.000000		MG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)ANTHRACENE	OS	3000.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(A)PYRENE	OS	4000.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(B)FLUORANTHENE	OS	3400.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(G,H,I)PERYLENE	OS	2500.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	BENZO(K)FLUORANTHENE	OS	1300.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	CHRYSENE	OS	2900.000000		UG/KG
PAI-03-SS-01	PAI-03-SS-01-01	INDENO(1,2,3-CD)PYRENE	OS	2600.000000		UG/KG
COCs that exceed RGOs that represent high risk to ecological receptors						
PAI-03-SS-09	PAI-03-SS-09-01	MERCURY	M	0.430000		MG/KG

TABLE C-3

SEDIMENT COMPARED TO BACKGROUND AND HUMAN HEALTH RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
Detected organic COCs and inorganic COCs that exceed background						
PAI-03-SD-26	PAI-03-SD-26-01	ARSENIC	M	16.1		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	ARSENIC	M	19.8		MG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(A)ANTHRACENE	OS	5.1	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(A)ANTHRACENE	OS	8.9	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(A)ANTHRACENE	OS	12		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(A)ANTHRACENE	OS	14	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(A)ANTHRACENE	OS	16		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(A)ANTHRACENE	OS	20	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)ANTHRACENE	OS	25	J	UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)ANTHRACENE	OS	74	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)ANTHRACENE	OS	1200		UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(A)PYRENE	OS	8.1		UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(A)PYRENE	OS	8.2	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(A)PYRENE	OS	16		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(A)PYRENE	OS	16	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(A)PYRENE	OS	18		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)PYRENE	OS	28	J	UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)PYRENE	OS	92		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG
PAI-03-SD-16	PAI-03-SD-16-01	BENZO(B)FLUORANTHENE	OS	1.8	J	UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	BENZO(B)FLUORANTHENE	OS	4.5		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	BENZO(B)FLUORANTHENE	OS	6		UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(B)FLUORANTHENE	OS	7.6		UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(B)FLUORANTHENE	OS	7.8	J	UG/KG
PAI-03-SD-24	PAI-03-SD-24-01	BENZO(B)FLUORANTHENE	OS	8.3	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(B)FLUORANTHENE	OS	15		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(B)FLUORANTHENE	OS	16		UG/KG
PAI-03-SD-09	PAI-03-SD-09-01	BENZO(B)FLUORANTHENE	OS	16	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(B)FLUORANTHENE	OS	19	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	BENZO(B)FLUORANTHENE	OS	19	J	UG/KG
PAI-03-SD-21	PAI-03-SD-21-01	BENZO(B)FLUORANTHENE	OS	24	J	UG/KG
PAI-03-SD-12	PAI-03-SD-12-01	BENZO(B)FLUORANTHENE	OS	26	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(B)FLUORANTHENE	OS	90		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(B)FLUORANTHENE	OS	990		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	CARBAZOLE	OS	570		UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	INDENO(1,2,3-CD)PYRENE	OS	9.9	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	INDENO(1,2,3-CD)PYRENE	OS	14	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	INDENO(1,2,3-CD)PYRENE	OS	660		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	4,4'-DDD	PEST/PCB	40	J	UG/KG
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDD	PEST/PCB	62	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDD	PEST/PCB	70	J	UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDD	PEST/PCB	290		UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDE	PEST/PCB	45	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDE	PEST/PCB	60	J	UG/KG
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDE	PEST/PCB	75	J	UG/KG
PAI-03-SD-14-01	PAI-03-SD-14-01	4,4'-DDT	PEST/PCB	34	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	ALPHA-CHLORDANE	PEST/PCB	28	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	AROCLOR-1254	PEST/PCB	65		UG/KG
PAI-03-SD-32-01	PAI-03-SD-32-01	AROCLOR-1254	PEST/PCB	76		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1254	PEST/PCB	97		UG/KG
PAI-03-SD-34-01	PAI-03-SD-34-01-AVG	AROCLOR-1254	PEST/PCB	250	J	UG/KG
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1260	PEST/PCB	45		UG/KG

TABLE C-3

SEDIMENT COMPARED TO BACKGROUND AND HUMAN HEALTH RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
PAI-03-SD-15	PAI-03-SD-15-01	AROCLOR-1260	PEST/PCB	70		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	GAMMA-CHLORDANE	PEST/PCB	28	J	UG/KG
COCs that exceed RGOs that represent an ILCR of 1.0E-06						
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)ANTHRACENE	OS	74	J	UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)PYRENE	OS	92		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(B)FLUORANTHENE	OS	90		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1254	PEST/PCB	97		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1260	PEST/PCB	45		UG/KG
PAI-03-SD-12	PAI-03-SD-12-01	BENZO(B)FLUORANTHENE	OS	26	J	UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDD	PEST/PCB	290		UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDE	PEST/PCB	45	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)ANTHRACENE	OS	25	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)PYRENE	OS	28	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	AROCLOR-1260	PEST/PCB	70		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(A)PYRENE	OS	16		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	AROCLOR-1254	PEST/PCB	65		UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(A)PYRENE	OS	8.1		UG/KG
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG
PAI-03-SD-21	PAI-03-SD-21-01	BENZO(B)FLUORANTHENE	OS	24	J	UG/KG
PAI-03-SD-21	PAI-03-SD-21-01	4,4'-DDT	PEST/PCB	34	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)ANTHRACENE	OS	1200		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(B)FLUORANTHENE	OS	990		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	CARBAZOLE	OS	570		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	INDENO(1,2,3-CD)PYRENE	OS	660		UG/KG
PAI-03-SD-24	PAI-03-SD-24-01	ARSENIC	M	19.8		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(A)PYRENE	OS	16	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	ALPHA-CHLORDANE	PEST/PCB	28	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	GAMMA-CHLORDANE	PEST/PCB	28	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(A)PYRENE	OS	18		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(A)PYRENE	OS	8.2	J	UG/KG
PAI-03-SD-32-01	PAI-03-SD-32-01	AROCLOR-1254	PEST/PCB	76		UG/KG
PAI-03-SD-34-01	PAI-03-SD-34-01-AVG	AROCLOR-1254	PEST/PCB	250	J	UG/KG
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDE	PEST/PCB	75	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDD	PEST/PCB	70	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDE	PEST/PCB	60	J	UG/KG
COCs that exceed RGOs that represent an ILCR of 1.0E-05						
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG
PAI-03-SD-34-01	PAI-03-SD-34-01-AVG	AROCLOR-1254	PEST/PCB	250	J	UG/KG
COCs that exceed RGOs that represent an ILCR of 1.0E-04						
No exceedances						

TABLE C-4

SEDIMENT COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
Detected organic COCs and inorganic COCs that exceed background						
PAI-03-SD-24	PAI-03-SD-24-01	ARSENIC	M	19.8		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	ARSENIC	M	16.1		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	COBALT	M	5.6		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	COBALT	M	4.8		MG/KG
PAI-03-SD-25	PAI-03-SD-25-01	COBALT	M	4.4		MG/KG
PAI-03-SD-12	PAI-03-SD-12-02	COBALT	M	4		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	COBALT	M	3.8		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	COBALT	M	3.4		MG/KG
PAI-03-SD-13	PAI-03-SD-13-01	COBALT	M	2.9		MG/KG
PAI-03-SD-13	PAI-03-SD-13-01-D	COBALT	M	2.9		MG/KG
PAI-03-SD-23	PAI-03-SD-23-01	COBALT	M	2.7		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	COPPER	M	46.9		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	COPPER	M	31.7		MG/KG
PAI-03-SD-25	PAI-03-SD-25-01	COPPER	M	25.7		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	COPPER	M	25.2		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	COPPER	M	21.9		MG/KG
PAI-03-SD-12	PAI-03-SD-12-02	COPPER	M	20.7		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	COPPER	M	20.5		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	COPPER	M	18.1		MG/KG
PAI-03-SD-23	PAI-03-SD-23-01	COPPER	M	17.3		MG/KG
PAI-03-SD-13	PAI-03-SD-13-01-D	COPPER	M	16.8		MG/KG
PAI-03-SD-13	PAI-03-SD-13-01	COPPER	M	16.4		MG/KG
PAI-03-SD-27	PAI-03-SD-27-01	COPPER	M	14.4		MG/KG
PAI-03-SD-10	PAI-03-SD-10-01	COPPER	M	13.1		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	COPPER	M	10.9		MG/KG
PAI-03-SD-18	PAI-03-SD-18-01	COPPER	M	10.7		MG/KG
PAI-03-SD-17	PAI-03-SD-17-01	LEAD	M	105		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	LEAD	M	52.9		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	LEAD	M	49.2		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	LEAD	M	44		MG/KG
PAI-03-SD-18	PAI-03-SD-18-01	LEAD	M	41.8		MG/KG
PAI-03-SD-10	PAI-03-SD-10-01	LEAD	M	39		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	LEAD	M	38.2		MG/KG
PAI-03-SD-22	PAI-03-SD-22-01	LEAD	M	37.5		MG/KG
PAI-03-SD-23	PAI-03-SD-23-01	LEAD	M	25.9		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	LEAD	M	24.1		MG/KG
PAI-03-SD-12	PAI-03-SD-12-02	LEAD	M	23		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	LEAD	M	22.1		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	MERCURY	M	0.35		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	MERCURY	M	0.14		MG/KG
PAI-03-SD-15	PAI-03-SD-15-01	MERCURY	M	0.14		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	SELENIUM	M	1.1		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	SELENIUM	M	0.74		MG/KG
PAI-03-SD-23	PAI-03-SD-23-01	SELENIUM	M	0.72		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	SELENIUM	M	0.58		MG/KG
PAI-03-SD-25	PAI-03-SD-25-01	SELENIUM	M	0.46		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	SELENIUM	M	0.41		MG/KG
PAI-03-SD-09	PAI-03-SD-09-01	SELENIUM	M	0.32		MG/KG
PAI-03-SD-27	PAI-03-SD-27-01	THALLIUM	M	0.62		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	VANADIUM	M	63.7		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	VANADIUM	M	62.4		MG/KG
PAI-03-SD-23	PAI-03-SD-23-01	VANADIUM	M	56.6		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	ZINC	M	159		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	ZINC	M	80.3		MG/KG
PAI-03-SD-28	PAI-03-SD-28-01	ZINC	M	55.8		MG/KG
PAI-03-SD-26	PAI-03-SD-26-01	ZINC	M	55.6		MG/KG
PAI-03-SD-10	PAI-03-SD-10-01	ZINC	M	54.3		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	ZINC	M	54.1		MG/KG
PAI-03-SD-12	PAI-03-SD-12-02	ZINC	M	50.1		MG/KG
PAI-03-SD-24	PAI-03-SD-24-01	ZINC	M	47.6		MG/KG
PAI-03-SD-22	PAI-03-SD-22-01	ANTHRACENE	OS	770		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	ANTHRACENE	OS	9.1	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	ANTHRACENE	OS	6.1	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	ANTHRACENE	OS	3.8		UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	ANTHRACENE	OS	3.7		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)ANTHRACENE	OS	1200		UG/KG

TABLE C-4

SEDIMENT COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)ANTHRACENE	OS	74	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)ANTHRACENE	OS	25	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(A)ANTHRACENE	OS	20	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(A)ANTHRACENE	OS	16		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(A)ANTHRACENE	OS	14	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(A)ANTHRACENE	OS	12		UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(A)ANTHRACENE	OS	8.9	J	UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(A)ANTHRACENE	OS	5.1	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)PYRENE	OS	92		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(A)PYRENE	OS	28	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	BENZO(A)PYRENE	OS	22	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(A)PYRENE	OS	18		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(A)PYRENE	OS	16		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(A)PYRENE	OS	16	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(A)PYRENE	OS	8.2	J	UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(A)PYRENE	OS	8.1		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(B)FLUORANTHENE	OS	990		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(B)FLUORANTHENE	OS	90		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	BENZO(B)FLUORANTHENE	OS	28		UG/KG
PAI-03-SD-12	PAI-03-SD-12-01	BENZO(B)FLUORANTHENE	OS	26	J	UG/KG
PAI-03-SD-21	PAI-03-SD-21-01	BENZO(B)FLUORANTHENE	OS	24	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	BENZO(B)FLUORANTHENE	OS	19	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	BENZO(B)FLUORANTHENE	OS	19	J	UG/KG
PAI-03-SD-09	PAI-03-SD-09-01	BENZO(B)FLUORANTHENE	OS	16	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	BENZO(B)FLUORANTHENE	OS	16		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	BENZO(B)FLUORANTHENE	OS	15		UG/KG
PAI-03-SD-24	PAI-03-SD-24-01	BENZO(B)FLUORANTHENE	OS	8.3	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	BENZO(B)FLUORANTHENE	OS	7.8	J	UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	BENZO(B)FLUORANTHENE	OS	7.6		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	BENZO(B)FLUORANTHENE	OS	6		UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	BENZO(B)FLUORANTHENE	OS	4.5		UG/KG
PAI-03-SD-16	PAI-03-SD-16-01	BENZO(B)FLUORANTHENE	OS	1.8	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	CHRYSENE	OS	1900		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	CHRYSENE	OS	180		UG/KG
PAI-03-SD-12	PAI-03-SD-12-01	CHRYSENE	OS	66	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	CHRYSENE	OS	51		UG/KG
PAI-03-SD-26	PAI-03-SD-26-01	CHRYSENE	OS	36	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	CHRYSENE	OS	30	J	UG/KG
PAI-03-SD-13	PAI-03-SD-13-01	CHRYSENE	OS	29	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	CHRYSENE	OS	22		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	CHRYSENE	OS	21		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	CHRYSENE	OS	20	J	UG/KG
PAI-03-SD-24	PAI-03-SD-24-01	CHRYSENE	OS	17	J	UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	CHRYSENE	OS	12		UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	CHRYSENE	OS	10		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	CHRYSENE	OS	6.5	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	CHRYSENE	OS	6.1	J	UG/KG
PAI-03-SD-16	PAI-03-SD-16-01	CHRYSENE	OS	3.2	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	FLUORANTHENE	OS	3500		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	FLUORANTHENE	OS	150		UG/KG
PAI-03-SD-12	PAI-03-SD-12-01	FLUORANTHENE	OS	80	J	UG/KG
PAI-03-SD-21	PAI-03-SD-21-01	FLUORANTHENE	OS	67	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	FLUORANTHENE	OS	60		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	FLUORANTHENE	OS	47	J	UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	FLUORANTHENE	OS	33		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	FLUORANTHENE	OS	31		UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	FLUORANTHENE	OS	21	J	UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	FLUORANTHENE	OS	16		UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	FLUORANTHENE	OS	15		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	FLUORANTHENE	OS	15		UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	FLUORANTHENE	OS	13	J	UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	INDENO(1,2,3-CD)PYRENE	OS	660		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	INDENO(1,2,3-CD)PYRENE	OS	14	J	UG/KG
PAI-03-SD-30-01	PAI-03-SD-30-01	INDENO(1,2,3-CD)PYRENE	OS	9.9	J	UG/KG

TABLE C-4

SEDIMENT COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
PAI-03-SD-22	PAI-03-SD-22-01	PHENANTHRENE	OS	2400		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	PHENANTHRENE	OS	37		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	PHENANTHRENE	OS	29	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	PHENANTHRENE	OS	25		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	PHENANTHRENE	OS	12		UG/KG
PAI-03-SD-24	PAI-03-SD-24-01	PHENANTHRENE	OS	12	J	UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	PHENANTHRENE	OS	8.5		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	PHENANTHRENE	OS	6	J	UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	PHENANTHRENE	OS	5.8		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	PYRENE	OS	2700		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	PYRENE	OS	140	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	PYRENE	OS	44		UG/KG
PAI-03-SD-29-01	PAI-03-SD-29DU-01	PYRENE	OS	43	J	UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	PYRENE	OS	42	J	UG/KG
PAI-03-SD-29-01	PAI-03-SD-29-01	PYRENE	OS	28		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	PYRENE	OS	24		UG/KG
PAI-03-SD-25	PAI-03-SD-25-01	PYRENE	OS	19	J	UG/KG
PAI-03-SD-27	PAI-03-SD-27-01	PYRENE	OS	16	J	UG/KG
PAI-03-SD-31-01	PAI-03-SD-31-01	PYRENE	OS	13	J	UG/KG
PAI-03-SD-19	PAI-03-SD-19-01	PYRENE	OS	11	J	UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDD	PEST/PCB	290		UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDD	PEST/PCB	70	J	UG/KG
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDD	PEST/PCB	62	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	4,4'-DDD	PEST/PCB	40	J	UG/KG
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDE	PEST/PCB	75	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDE	PEST/PCB	60	J	UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDE	PEST/PCB	45	J	UG/KG
PAI-03-SD-14-01	PAI-03-SD-14-01	4,4'-DDT	PEST/PCB	34	J	UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	ALPHA-CHLORDANE	PEST/PCB	28	J	UG/KG
PAI-03-SD-34-01	PAI-03-SD-34-01	AROCLOR-1254	PEST/PCB	370	J	UG/KG
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG
PAI-03-SD-34-01	PAI-03-SD-34DU-01	AROCLOR-1254	PEST/PCB	130	J	UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1254	PEST/PCB	97		UG/KG
PAI-03-SD-32-01	PAI-03-SD-32-01	AROCLOR-1254	PEST/PCB	76		UG/KG
PAI-03-SD-18	PAI-03-SD-18-01	AROCLOR-1254	PEST/PCB	65		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	AROCLOR-1260	PEST/PCB	70		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1260	PEST/PCB	45		UG/KG
PAI-03-SD-28	PAI-03-SD-28-01	GAMMA-CHLORDANE	PEST/PCB	28	J	UG/KG
COCs that exceed RGOs that represent low risk to ecological receptors						
PAI-03-SD-09	PAI-03-SD-09-01	SELENIUM	M	0.32		MG/KG
PAI-03-SD-10	PAI-03-SD-10-01	LEAD	M	39		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	SELENIUM	M	0.41		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	LEAD	M	44		MG/KG
PAI-03-SD-11	PAI-03-SD-11-01	FLUORANTHENE	OS	150		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	CHRYSENE	OS	180		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	BENZO(A)PYRENE	OS	92		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1260	PEST/PCB	45		UG/KG
PAI-03-SD-11	PAI-03-SD-11-01	AROCLOR-1254	PEST/PCB	97		UG/KG
PAI-03-SD-12	PAI-03-SD-12-02	LEAD	M	23		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	LEAD	M	24.1		MG/KG
PAI-03-SD-12	PAI-03-SD-12-01	COPPER	M	20.5		MG/KG
PAI-03-SD-12	PAI-03-SD-12-02	COPPER	M	20.7		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	MERCURY	M	0.14		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	LEAD	M	38.2		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	COPPER	M	21.9		MG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDE	PEST/PCB	45	J	UG/KG
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDD	PEST/PCB	290		UG/KG
PAI-03-SD-15	PAI-03-SD-15-01	MERCURY	M	0.14		MG/KG
PAI-03-SD-15	PAI-03-SD-15-01	AROCLOR-1260	PEST/PCB	70		UG/KG
PAI-03-SD-17	PAI-03-SD-17-01	LEAD	M	105		MG/KG
PAI-03-SD-18	PAI-03-SD-18-01	LEAD	M	41.8		MG/KG
PAI-03-SD-18	PAI-03-SD-18-01	AROCLOR-1254	PEST/PCB	65		UG/KG
PAI-03-SD-20	PAI-03-SD-20-01	ZINC	M	159		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	LEAD	M	52.9		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	COPPER	M	46.9		MG/KG
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG
PAI-03-SD-22	PAI-03-SD-22-01	LEAD	M	37.5		MG/KG

TABLE C-4

SEDIMENT COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS	
PAI-03-SD-22	PAI-03-SD-22-01	PYRENE	OS	2700		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	PHENANTHRENE	OS	2400		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	INDENO(1,2,3-CD)PYRENE	OS	660		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	FLUORANTHENE	OS	3500		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	CHRYSENE	OS	1900		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(B)FLUORANTHENE	OS	990		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)ANTHRACENE	OS	1200		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	ANTHRACENE	OS	770		UG/KG	
PAI-03-SD-23	PAI-03-SD-23-01	VANADIUM	M	56.6		MG/KG	
PAI-03-SD-23	PAI-03-SD-23-01	SELENIUM	M	0.72		MG/KG	
PAI-03-SD-23	PAI-03-SD-23-01	LEAD	M	25.9		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	VANADIUM	M	62.4		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	SELENIUM	M	0.74		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	LEAD	M	22.1		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	COPPER	M	25.2		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	COBALT	M	4.8		MG/KG	
PAI-03-SD-24	PAI-03-SD-24-01	ARSENIC	M	19.8		MG/KG	
PAI-03-SD-25	PAI-03-SD-25-01	SELENIUM	M	0.46		MG/KG	
PAI-03-SD-25	PAI-03-SD-25-01	COPPER	M	25.7		MG/KG	
PAI-03-SD-26	PAI-03-SD-26-01	VANADIUM	M	63.7		MG/KG	
PAI-03-SD-26	PAI-03-SD-26-01	SELENIUM	M	0.58		MG/KG	
PAI-03-SD-26	PAI-03-SD-26-01	COPPER	M	31.7		MG/KG	
PAI-03-SD-26	PAI-03-SD-26-01	COBALT	M	5.6		MG/KG	
PAI-03-SD-26	PAI-03-SD-26-01	ARSENIC	M	16.1		MG/KG	
PAI-03-SD-27	PAI-03-SD-27-01	THALLIUM	M	0.62		MG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	SELENIUM	M	1.1		MG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	MERCURY	M	0.35		MG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	LEAD	M	49.2		MG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	GAMMA-CHLORDANE	PEST/PCB	28	J	UG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	ALPHA-CHLORDANE	PEST/PCB	28	J	UG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	4,4'-DDD	PEST/PCB	40	J	UG/KG	
PAI-03-SD-32-01	PAI-03-SD-32-01	AROCLOR-1254	PEST/PCB	76		UG/KG	
PAI-03-SD-34-01	PAI-03-SD-34-01	AROCLOR-1254	PEST/PCB	370	J	UG/KG	
PAI-03-SD-34-01	PAI-03-SD-34DU-01	AROCLOR-1254	PEST/PCB	130	J	UG/KG	
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDE	PEST/PCB	75	J	UG/KG	
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDD	PEST/PCB	62	J	UG/KG	
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDE	PEST/PCB	60	J	UG/KG	
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDD	PEST/PCB	70	J	UG/KG	
COCs that exceed RGOs that represent moderate risk to ecological receptors							
PAI-03-SD-14	PAI-03-SD-14-01	MERCURY	M	0.14		MG/KG	(3)
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDE	PEST/PCB	45	J	UG/KG	
PAI-03-SD-14	PAI-03-SD-14-01	4,4'-DDD	PEST/PCB	290		UG/KG	
PAI-03-SD-15	PAI-03-SD-15-01	MERCURY	M	0.14		MG/KG	(3)
PAI-03-SD-17	PAI-03-SD-17-01	LEAD	M	105		MG/KG	(3)
PAI-03-SD-20	PAI-03-SD-20-01	AROCLOR-1254	PEST/PCB	250		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	PYRENE	OS	2700		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	PHENANTHRENE	OS	2400		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	FLUORANTHENE	OS	3500		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	CHRYSENE	OS	1900		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)PYRENE	OS	1200		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	BENZO(A)ANTHRACENE	OS	1200		UG/KG	
PAI-03-SD-22	PAI-03-SD-22-01	ANTHRACENE	OS	770		UG/KG	
PAI-03-SD-23	PAI-03-SD-23-01	VANADIUM	M	56.6		MG/KG	(1)
PAI-03-SD-24	PAI-03-SD-24-01	VANADIUM	M	62.4		MG/KG	(1)
PAI-03-SD-24	PAI-03-SD-24-01	ARSENIC	M	19.8		MG/KG	(1)
PAI-03-SD-26	PAI-03-SD-26-01	VANADIUM	M	63.7		MG/KG	(1)
PAI-03-SD-26	PAI-03-SD-26-01	ARSENIC	M	16.1		MG/KG	(1)
PAI-03-SD-27	PAI-03-SD-27-01	THALLIUM	M	0.62		MG/KG	(2)
PAI-03-SD-28	PAI-03-SD-28-01	MERCURY	M	0.35		MG/KG	(3)
PAI-03-SD-28	PAI-03-SD-28-01	GAMMA-CHLORDANE	PEST/PCB	28	J	UG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	ALPHA-CHLORDANE	PEST/PCB	28	J	UG/KG	
PAI-03-SD-28	PAI-03-SD-28-01	4,4'-DDD	PEST/PCB	40	J	UG/KG	
PAI-03-SD-34-01	PAI-03-SD-34-01	AROCLOR-1254	PEST/PCB	370	J	UG/KG	
PAI-03-SD-34-01	PAI-03-SD-34DU-01	AROCLOR-1254	PEST/PCB	130	J	UG/KG	
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDE	PEST/PCB	75	J	UG/KG	
PAI-03-SD-36-01	PAI-03-SD-36-01	4,4'-DDD	PEST/PCB	62	J	UG/KG	

TABLE C-4

SEDIMENT COMPARED TO BACKGROUND AND ECOLOGICAL RGOS
SITE 3 - CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

LOCATION	SAMPLE	PARAMETER	FRACTION	NUMERIC_RE	QUALIFIER	UNITS
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDE	PEST/PCB	60	J	UG/KG
PAI-03-SD-38-01	PAI-03-SD-38-01	4,4'-DDD	PEST/PCB	70	J	UG/KG
COCs that exceed RGOs that represent high risk to ecological receptors						
No exceedances						

Notes

(1) Sediment locations PAI-03-SD-23, PAI-03-SD-24, and PAI-03-SD-25 will not be retained as impacted sediment areas. Concentrations of vanadium at these locations were detected from 56.6 to 63.7 mg/kg, only 13 to 27 percent above background (50 mg/kg). Additionally, the one detection of arsenic was observed at a concentration of 19.8 mg/kg that is within a factor of two of the its background concentration (12 mg/kg). For the raccoon, LOAEL HQs calculated based on exposure to site average arsenic and vanadium concentrations (HQs of 1.1 and 2.97, respectively) only slightly exceeded a HQ of 1. Because published biota sediment accumulation factors (BSAFs) are not available for inorganics, HQs for arsenic and vanadium were calculated assuming a BSAF of 1. This is a conservative assumption since transfer through the food chain does not occur for most metals.

(2) Thallium is close to its background concentration of 0.41 mg/kg. This area will not be retained as an impacted sediment area.

(3) The RI for Site 3 concluded that mercury and lead at these concentrations do not significantly impact food-chain receptors. Several conservative assumptions used in the food chain modeling for lead result in considerable overestimates of risk. First, most toxicity studies of dietary exposure use a highly bioavailable form of lead. The mammal and avian NOAELs and LOAELs that are used as TRVs for Site 3 were based on laboratory studies in which lead acetate was administered in the diet (Sample et al, 1996). Lead acetate is considered to be 100 percent bioavailable (Wixon and Davies, 1993). The bioavailability (i.e., the portion that is absorbed) of environmental lead after ingestion depends upon a variety of factors, including the chemical form of lead, the species of organism, as well as the age, sex, and nutritional status of the individual (Eisler, 1988). The absorption of oral lead in newborn rats can be up to 90 percent, but decreases to 15 percent within 20 to 30 days of age (Ma, 1996). In general, absorption rates of environmental forms of lead in mammals varies from 2 to 20 percent (Ma, 1996). Absorption rates for environmental lead in birds were not available, but are probably less than 100 percent. Thus, the TRVs used in the food chain model overestimate the potential risks of lead ingestion under field conditions. The extent of any overestimation, however, is uncertain.

A second factor that contributes to the overestimation of risk via the food chain is the assumption that concentrations of lead in prey items are equal to sediment concentrations. This assumption was used since BSAFs do not exist for inorganic compounds. Although the ratio of lead concentrations in aquatic prey items to concentrations in sediment is variable, available data indicate that such ratios (i.e., BSAFs) are usually much less than 1.0 (Eisler, 1988).

Furthermore, upper level receptors (mammals, birds) will be exposed to lead concentrations throughout the site, not just at the location of the maximum concentration and the mean concentration probably better represents the actual exposure term better than the maximum concentration. Therefore, with the above considerations in mind, the HQs in Table 7-12 of the RI (NOAEL HQs of 4.76 for lead and 1.57 for mercury) are not significantly elevated.

Lastly, the referenced locations and constituents do not exceed effects range - median values. Consequently, these sample locations will not be retained as impacted sediment areas.

References

Eisler, R., 1988, Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, U.S. Fish and Wildlife Service Biological Report 85 (1.14).

Ma, W., 1996. "Lead in Mammals" in Beyer, W. N., G. H. Heinz, and A. W. Redmond-Norwood, 1996. Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations, CRC Press, Boca Raton, Florida, 494 pp.

Wixson, B. G. and B. E. Davies. 1993. Bioavailability of Lead for Animals, Lead in Soil Task Force Recommended Guidelines, Society for Environmental Geochemistry and Health. Science Reviews, 132 pp.

Table C-5

Soil Boring Descriptions From Surface Soil Locations
Site 3 – Causeway Landfill
MCRD Parris Island, South Carolina

Boring[1]	Top of Waste (feet below ground surface)	Description	Comments
PAI-03-SS-12	3.6	light brown fine – medium - grained sand-dry/some gravel	
PAI-03-SS-11	2.2	(0'-0.5') light brown fine – medium - grained –sand-dry/some gravel	
		(0.5'-1.0') light yellow fine – medium – grained sand-dry/some gravel	
		(1.0'-2.2') white fine – medium sand-dry/some gravel	gas smell
PAI-03-SS-16	2.6	brown fine – medium – grained sand (0'-0.5')	
		light brown fine - medium - grained sand (0.5'-2.6')	gas smell
PAI-03-SS-10	2.7	light brown fine- medium – grained sand (0'-2.7')	gas smell
PAI-03-SS-15	3.2	light brown fine- medium – grained sand (0'-2.0')	
		gray fine- medium - grained sand (2.0'-3.2')	
PAI-03-SS-09	2.6	light brown fine – medium -grained sand (0'-1.0'	
		light brown- orange fine – medium - grained sand (1.0'-2.6')	
PAI-03-SS-08	2.6	light brown fine - medium – grained sand (0.0'-2.6')	
PAI-03-SS-07	**1.6**	light brown fine - medium – grained sand (0.0'-0.5')	
		tan fine- medium sand (0.5'-1.6')	
PAI-03-SS-06	3.5	light brown fine- medium – grained sand (0.0'-1.5') grayish-brown fine- medium – grained sand (1.5'-3.5')	
PAI-03-SS-14	2.4	light brown-brown fine- medium – grained sand (0.0'-1.0') encountered	
		light gray – fine – medium – grained sand (1.0'-2.4')	(Refusal). Some waste debris observed in last few inches of boring
PAI-03-SS-13	**1.9**	light brown-tan fine- medium - grained sand (0.0'-0.5')	
		light brown fine - medium - grained sand (0.5'-1.9')	
PAI-03-SS-05	**1.9**	light brown fine - medium - grained sand (0.0'-1.9')	
PAI-03-SS-04	**1.7**	light brown fine- medium - grained sand (0.0'-1.7')	
PAI-03-SS-03	2.5	light brown fine- medium - grained sand (0.0'-2.0')	
		grayish fine – medium - grained sand (2.0'-2.5')	
PAI-03-SS-02	**1.1**	brown fine- medium - grained sand (0.0'-1.1')	
PAI-03-SS-01	**0-0.5**	brown fine- medium - grained sand (0.0'-0.5')	

[1]Borings hand augured to top of waste in May 1998.
Locations where less than two feet of soil cover was observed are bolded.

Attachment 1

Clean Boundary Determinations

Determine Clean Boundaries
Surface Soil Compared to RGOs (Low and Moderate Risk Anticipated)
Site 3 - Causeway Landfill
MCRD Parris Island

Surface Soil (Compared to RGOs - ILCR = 1.0E-05, Moderate Risk to Ecological Receptors)
Refer to Figure C-2

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-09	Mercury	Eco	0.43	0.11	mg/kg	425	294
C_{cl}	SS-15			0.06		mg/kg		

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-09	Mercury	Eco	0.43	0.11	mg/kg	500	181
C_{cl}	SS-08*			0.01		mg/kg		

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-10	Mercury	Eco	0.18	0.11	mg/kg	250	112
C_{cl}	SS-15			0.06		mg/kg		

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-10	Mercury	Eco	0.18	0.11	mg/kg	250	43
C_{cl}	SS-16*			0.01		mg/kg		

Surface Soil (Compared to RGOs - ILCR = 1.0E-04, High Risk to Ecological Receptors)
Refer to Figure C-3

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-09	Mercury	Eco	0.43	0.29	mg/kg	425	85
C_{cl}	SS-15			0.06		mg/kg		

Location		COC	Eco or HH COC?	Conc.	C_{RGO}	Units	D_{imp-cl} (ft)	$D_{imp-RGO}$ (ft)
C_{imp}	SS-09	Mercury	Eco	0.43	0.29	mg/kg	500	52
C_{cl}	SS-08*			0.01		mg/kg		

Sediment Analytical Data Used For Hot Spot Boundary Determinations

Hot Spot 1 - PAHs	SD-22	SD-29[1]	SD-30	SD-31	RGO	Basis
Anthracene	770	4	*3.3*	*1.2*	245	Florida PEL
Benzo(a)anthracene	1200	18	*8*	8.9	693	Florida PEL
Benzo(a)pyrene	1200	20	22	8.2	303/763	ILCR = 1.0E-05 Fish Ingestion/PEL
Chrysene	1900	13.25	*8*	6.1	846	Florida PEL
Fluoranthene	3500	39	21	13	1,494	Florida PEL
Phenanthrene	2400	*16.3*	*17*	*4.8*	544	Florida PEL
Pyrene	2700	35.5	*16.5*	13	1,398	Florida PEL

Hot Spot 2 - PCBs	SD-20	SD-32	SD-33	SD-34[1]	SD-19	RGO	Basis
Aroclor-1254	250	76	*9*	250	*6*	178/180	ILCR = 1.0E-05 Fish Ingestion/PEL

Hot Spot 3 - Pesticides	SD-14	SD-35	SD-36	SD-37	RGO	Basis
4,4'-DDE	45	*13.5*	75	*12.5*	33.6	Typical Facility Pest. Conc.
4,4'-DDD	290	*13.5*	62	*12.5*	31.6	Typical Facility Pest. Conc.

Hot Spot 4 - Pesticides	SD-28	SD-38	SD-39	SD-40[1]	RGO	Basis
alpha-Chlordane	28	*13*	*7*	*6*	13.9	Typical Facility Pest. Conc.
gamma-Chlordane	28	*13*	*7*	*6*	13.2	Typical Facility Pest. Conc.
4,4'-DDE	*29.5*	60	*14*	*12*	31.6	Typical Facility Pest. Conc.
4,4'-DDD	40	70	*14*	*12*	33.6	Typical Facility Pest. Conc.

sediment results in ug/kg
One-half the non-detected values were used. These values are italicized.
[1]Average of sample and duplicate.

C-31

Determine Clean Boundaries - Sediment Compared To RGOs (ILCR = 1.0E-05, Moderate Risk to Eco.)
Site 3 - Causeway Landfill - MCRD Parris Island

Notes

PAHS

SD-22 to SD-29 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-22	Anthracene	Eco	770	ug/kg	100	245	22
C_{cl}	SD-29			4.00	ug/kg			
C_{imp}	SD-22	Benzo(a)anthracene	Eco	1200	ug/kg	100	693	13
C_{cl}	SD-29			18.00	ug/kg			
C_{imp}	SD-22	Benzo(a)pyrene	HH/Eco	1200	ug/kg	100	303	34
C_{cl}	SD-29			20.00	ug/kg			
C_{imp}	SD-22	Chrysene	Eco	1900	ug/kg	100	846	16
C_{cl}	SD-29			13.25	ug/kg			
C_{imp}	SD-22	Fluoranthene	Eco	3500	ug/kg	100	1494	19
C_{cl}	SD-29			39.00	ug/kg			
C_{imp}	SD-22	Phenanthrene	Eco	2400	ug/kg	100	544	30
C_{cl}	SD-29			16.30	ug/kg			
C_{imp}	SD-22	Pyrene	Eco	2700	ug/kg	100	1398	15
C_{cl}	SD-29			35.50	ug/kg			
						Max Distance		34

SD-22 to SD-30 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-22	Anthracene	Eco	770	ug/kg	180	245	38
C_{cl}	SD-30			3.30	ug/kg			
C_{imp}	SD-22	Benzo(a)anthracene	Eco	1200	ug/kg	180	693	20
C_{cl}	SD-30			8.00	ug/kg			
C_{imp}	SD-22	Benzo(a)pyrene	HH/Eco	1200	ug/kg	180	303	62
C_{cl}	SD-30			22.00	ug/kg			
C_{imp}	SD-22	Chrysene	Eco	1900	ug/kg	180	846	27
C_{cl}	SD-30			8.00	ug/kg			
C_{imp}	SD-22	Fluoranthene	Eco	3500	ug/kg	180	1494	30
C_{cl}	SD-30			21.00	ug/kg			
C_{imp}	SD-22	Phenanthrene	Eco	2400	ug/kg	180	544	54
C_{cl}	SD-30			17.00	ug/kg			
C_{imp}	SD-22	Pyrene	Eco	2700	ug/kg	180	1398	23
C_{cl}	SD-30			16.50	ug/kg			
						Max Distance		62

SD-22 to SD-31 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-22	Anthracene	Eco	770	ug/kg	300	245	53
C_{cl}	SD-31			1.20	ug/kg			
C_{imp}	SD-22	Benzo(a)anthracene	Eco	1200	ug/kg	300	693	34
C_{cl}	SD-31			8.90	ug/kg			
C_{imp}	SD-22	Benzo(a)pyrene	HH/Eco	1200	ug/kg	300	303	83
C_{cl}	SD-31			8.20	ug/kg			
C_{imp}	SD-22	Chrysene	Eco	1900	ug/kg	300	846	42
C_{cl}	SD-31			6.10	ug/kg			
C_{imp}	SD-22	Fluoranthene	Eco	3500	ug/kg	300	1494	46
C_{cl}	SD-31			13.00	ug/kg			
C_{imp}	SD-22	Phenanthrene	Eco	2400	ug/kg	300	544	72
C_{cl}	SD-31			4.80	ug/kg			
C_{imp}	SD-22	Pyrene	Eco	2700	ug/kg	300	1398	37
C_{cl}	SD-31			13.00	ug/kg			
						Max Distance		83

Determine Clean Boundaries - Sediment Compared To RGOs (ILCR = 1.0E-05, Moderate Risk to Eco.)
Site 3 - Causeway Landfill - MCRD Parris Island

Notes

PCBs

SD-20 to SD-32 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-20	Aroclor-1254	HH/Eco	250	ug/kg	77.6	178	22
C_{cl}	SD-32			76.00	ug/kg			

SD-20 to SD-33 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-20	Aroclor-1254	HH/Eco	250	ug/kg	75	178	8
C_{cl}	SD-33			9.00	ug/kg			

SD-20 to SD-34 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-20	Aroclor-1254	HH/Eco	250	ug/kg	77.6	178	NA
C_{cl}	SD-34			250.00	ug/kg			

Not bounded. Use SD-19 and SD-34 to determine boundary.

SD-34 to SD-19 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-34	Aroclor-1254	HH/Eco	370	ug/kg	370	178	110
C_{cl}	SD-19			9.84	ug/kg			

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SD-14 to SD-35 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-14	4,4'-DDE	Eco	45 J	ug/kg	77.6	31.6	23
C_{cl}	SD-35			13.50	ug/kg			
C_{imp}	SD-14	4,4'-DDD	Eco	290	ug/kg	77.6	33.6	55
C_{cl}	SD-35			13.50	ug/kg			
						Max Distance		55

SD-14 to SD-36 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-14	4,4'-DDE	Eco	45 J	ug/kg	75	31.6	NA
C_{cl}	SD-36			75.00	ug/kg			
C_{imp}	SD-14	4,4'-DDD	Eco	290	ug/kg	75	33.6	140
C_{cl}	SD-36			62.00	ug/kg			
						Max Distance		140

Not bounded. Use 140 ft for cost estimation purposes.

SD-14 to SD-37 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)
C_{imp}	SD-14	4,4'-DDE	Eco	45 J	ug/kg	77.6	31.6	21
C_{cl}	SD-37			12.50	ug/kg			
C_{imp}	SD-14	4,4'-DDD	Eco	290	ug/kg	77.6	33.6	53
C_{cl}	SD-37			12.50	ug/kg			
						Max Distance		53

Determine Clean Boundaries - Sediment Compared To RGOs (ILCR = 1.0E-05, Moderate Risk to Eco.)
Site 3 - Causeway Landfill - MCRD Parris Island

Notes

SD-28 to SD-38 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)	Notes
C_{imp}	SD-28	alpha-chlordane	Eco	28	ug/kg	75	13.9	68	
C_{cl}	SD-38			13.00	ug/kg				
C_{imp}	SD-28	gamma-chlordane	Eco	28	ug/kg	75	13.2	74	
C_{cl}	SD-38			13.00	ug/kg				
C_{imp}	SD-28	4,4'-DDE	Eco	29.5	ug/kg	75	31.6	7	
C_{cl}	SD-38			60.00	ug/kg				
C_{imp}	SD-28	4,4'-DDD	Eco	40	ug/kg	75	33.6	NA	Not bounded. Use SD-38 and SD-37 to determine boundary.
C_{cl}	SD-38			70.00	ug/kg				
						Max Distance		74	

SD-38 to SD-37 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)	Notes
C_{imp}	SD-38	alpha-chlordane	Eco	13.00	ug/kg	700	13.9	NA	Both concentrations are below RGO
C_{cl}	SD-37			6.50	ug/kg				
C_{imp}	SD-38	gamma-chlordane	Eco	13.00	ug/kg	700	13.2	NA	Both concentrations are below RGO
C_{cl}	SD-37			6.50	ug/kg				
C_{imp}	SD-38	4,4'-DDE	Eco	60.00	ug/kg	700	31.6	286	
C_{cl}	SD-37			12.50	ug/kg				
C_{imp}	SD-38	4,4'-DDD	Eco	70.00	ug/kg	700	33.6	298	
C_{cl}	SD-37			12.50	ug/kg				
						Max Distance		298	

SD-28 to SD-39 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)	Notes
C_{imp}	SD-28	alpha-chlordane	Eco	28	ug/kg	75	13.9	38	
C_{cl}	SD-39			7.00	ug/kg				
C_{imp}	SD-28	gamma-chlordane	Eco	28	ug/kg	75	13.2	41	
C_{cl}	SD-39			7.00	ug/kg				
C_{imp}	SD-28	4,4'-DDE	Eco	29.5	ug/kg	75	31.6	NA	Both concentrations are below RGO
C_{cl}	SD-39			14.00	ug/kg				
C_{imp}	SD-28	4,4'-DDD	Eco	40	ug/kg	75	33.6	12	
C_{cl}	SD-39			14.00	ug/kg				
						Max Distance		41	

SD-28 to SD-40 Boundary

Location		COC	Eco or HH COC?	Conc.	Units	D_{imp-cl} (ft)	C_{RGO}	$D_{imp-RGO}$ (ft)	Notes
C_{imp}	SD-28	alpha-chlordane	Eco	28	ug/kg	75	13.9	34	
C_{cl}	SD-40			6.00	ug/kg				
C_{imp}	SD-28	gamma-chlordane	Eco	28	ug/kg	75	13.2	37	
C_{cl}	SD-40			6.00	ug/kg				
C_{imp}	SD-28	4,4'-DDE	Eco	29.5	ug/kg	75	31.6	NA	Both concentrations are below RGO
C_{cl}	SD-40			12.00	ug/kg				
C_{imp}	SD-28	4,4'-DDD	Eco	40	ug/kg	75	33.6	11	
C_{cl}	SD-40			12.00	ug/kg				
						Max Distance		37	

PRELIMINARY

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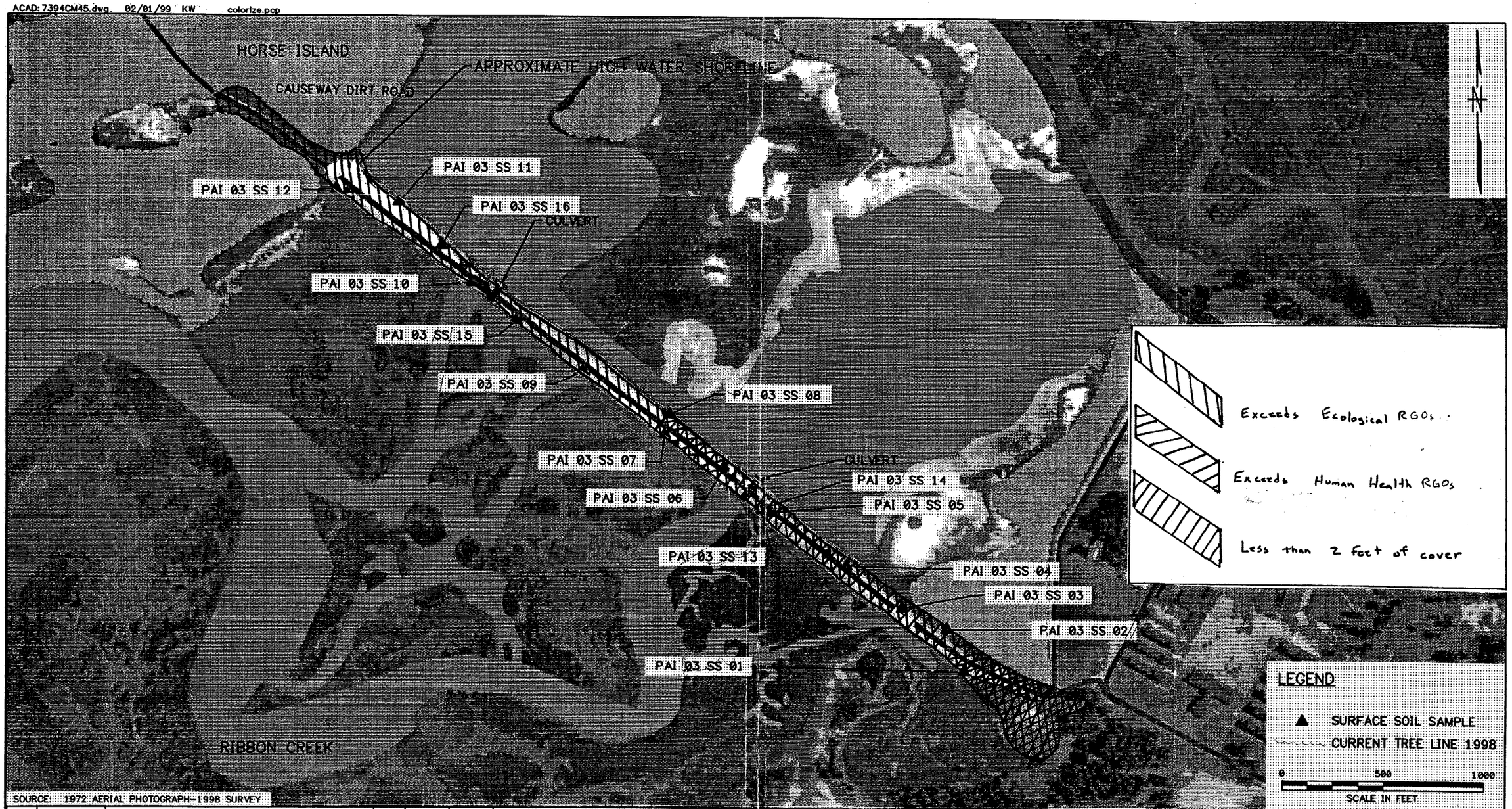

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NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Areal Extent of Contamination
SURFACE SOIL
~~SAMPLE LOCATION MAP~~
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
COC Exceedances Against RGOs: ILCR=1.0E-06 and Low Risk to Ecological Receptors

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE C-1
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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C-25 171 A 0112 CTO 0020

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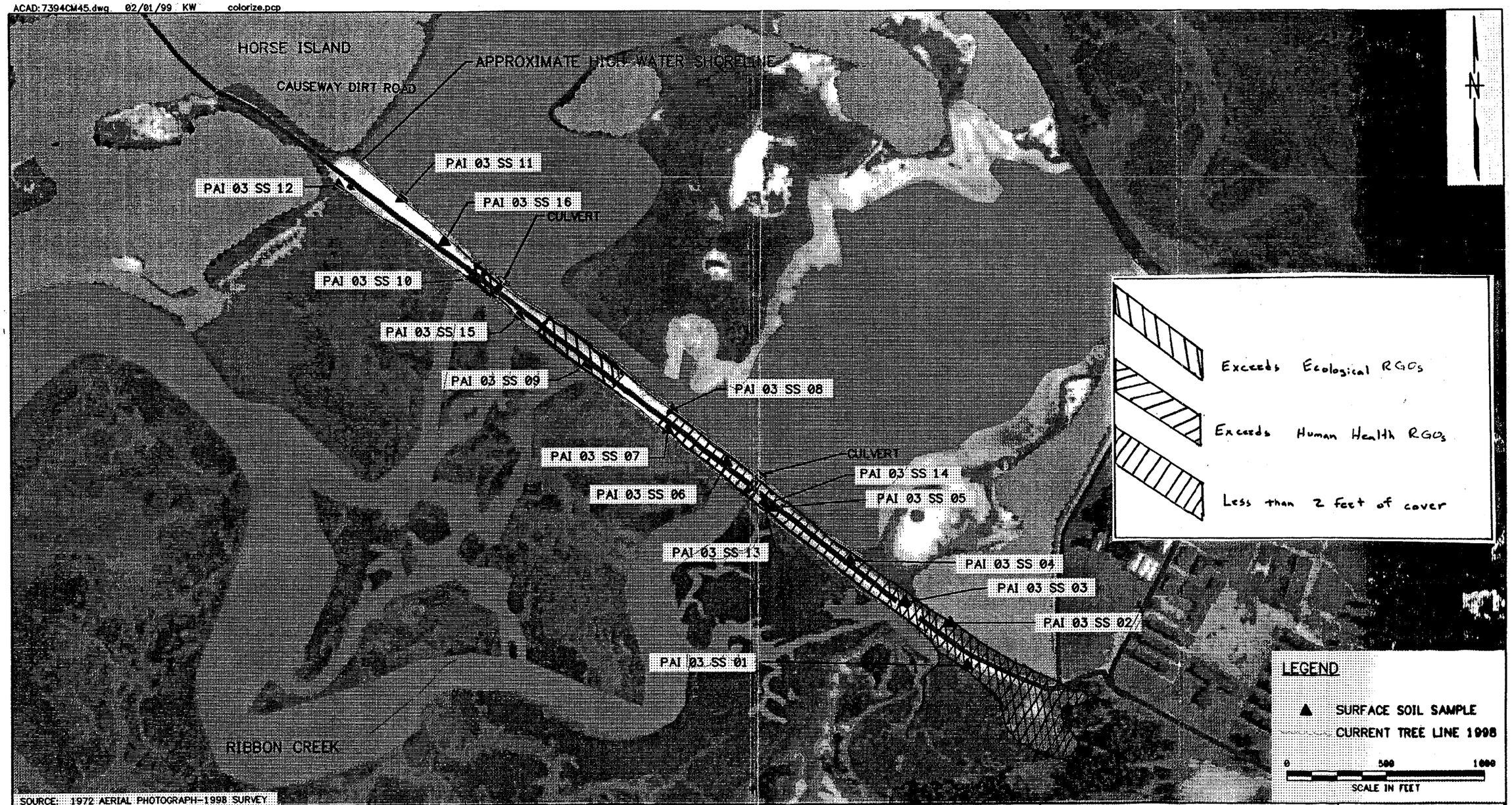

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NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Areal Extent of Contamination
SURFACE SOIL
SAMPLE LOCATION MAP
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
COC Exceedances Against RGOs: ILCR = 1.0E-05 and Moderate Risk to Ecological Receptors

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE C-2
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

029905/P

CTO 0020

PRELIMINARY

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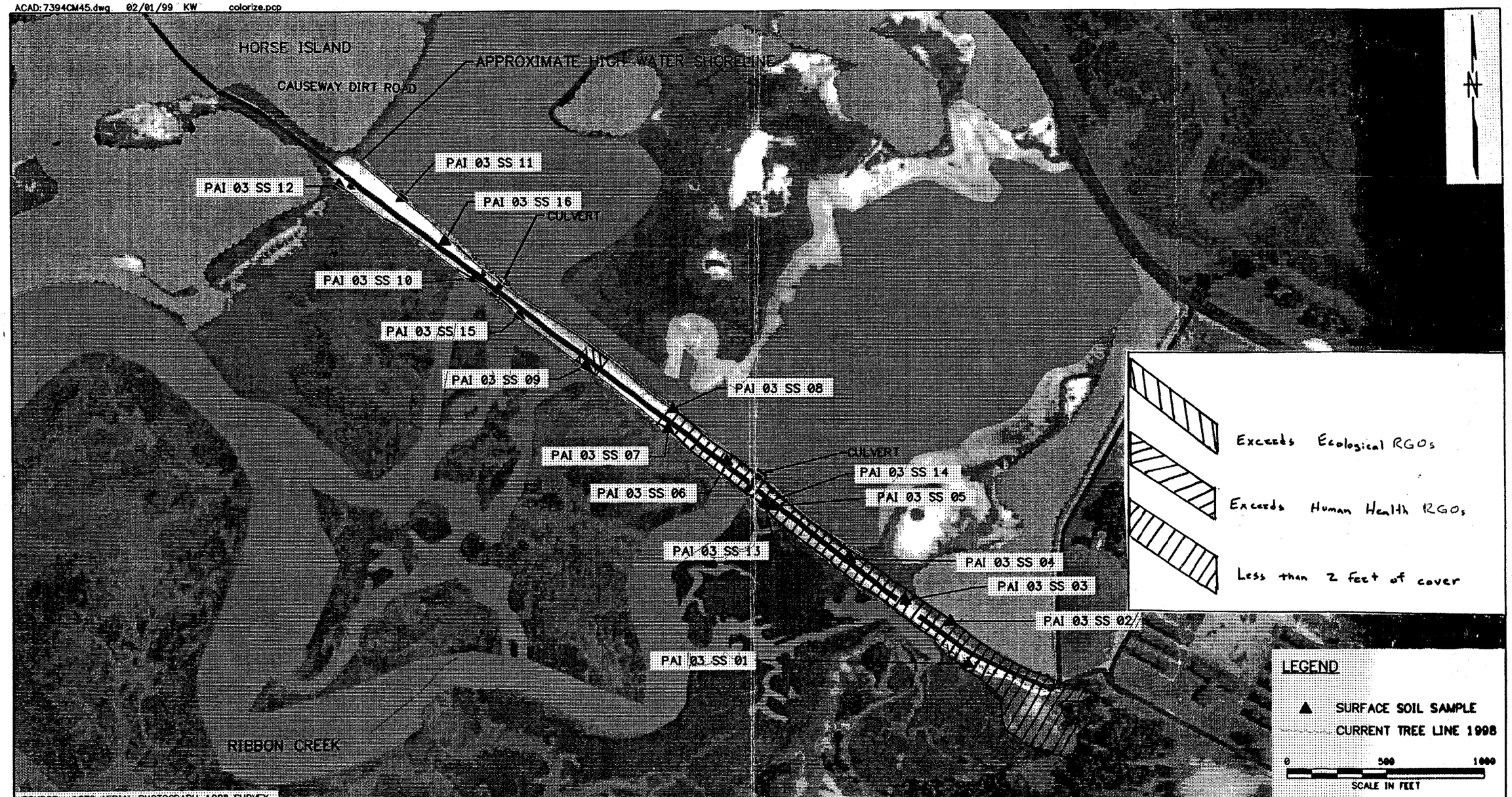

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NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY · SOUTHERN DIV FACILITIES ENGINEERING COMD

Aerial Extent of Contamination
SURFACE SOIL
~~SAMPLE LOCATION MAP~~
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA
COC Exceedances Against RGOs: ILCR = 1.0 E-04 & High Risk to Ecological Receptors

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE C-3 REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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C-29

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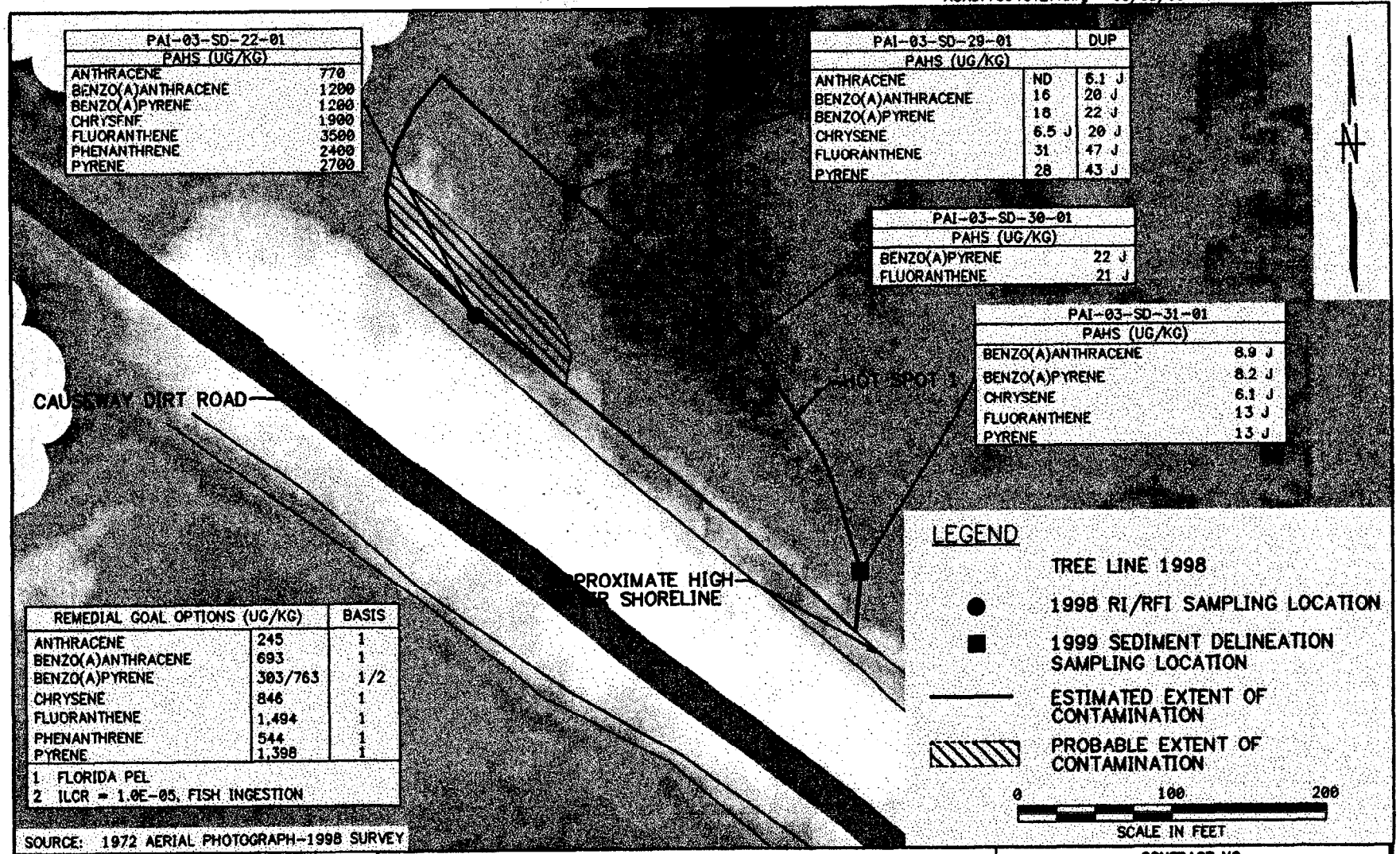

PAI-03-SD-22-01	
PAHS (UG/KG)	
ANTHRACENE	770
BENZO(A)ANTHRACENE	1200
BENZO(A)PYRENE	1200
CHRYSENE	1900
FLUORANTHENE	3500
PHENANTHRENE	2400
PYRENE	2700

PAI-03-SD-29-01		DUP
PAHS (UG/KG)		
ANTHRACENE	ND	6.1 J
BENZO(A)ANTHRACENE	16	20 J
BENZO(A)PYRENE	18	22 J
CHRYSENE	6.5 J	20 J
FLUORANTHENE	31	47 J
PYRENE	28	43 J

PAI-03-SD-30-01	
PAHS (UG/KG)	
BENZO(A)PYRENE	22 J
FLUORANTHENE	21 J

PAI-03-SD-31-01	
PAHS (UG/KG)	
BENZO(A)ANTHRACENE	8.9 J
BENZO(A)PYRENE	8.2 J
CHRYSENE	6.1 J
FLUORANTHENE	13 J
PYRENE	13 J

REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
ANTHRACENE	245	1
BENZO(A)ANTHRACENE	693	1
BENZO(A)PYRENE	303/763	1/2
CHRYSENE	846	1
FLUORANTHENE	1,494	1
PHENANTHRENE	544	1
PYRENE	1,398	1

1 FLORIDA PEL
2 ILCR = 1.0E-05, FISH INGESTION

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY	DATE
HJP	5/25/00
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE	AS NOTED

SEDIMENT HOT SPOT 1 – PAHs
EXTENT OF CONTAMINATION
ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3 – CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE C-4	REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

C-31

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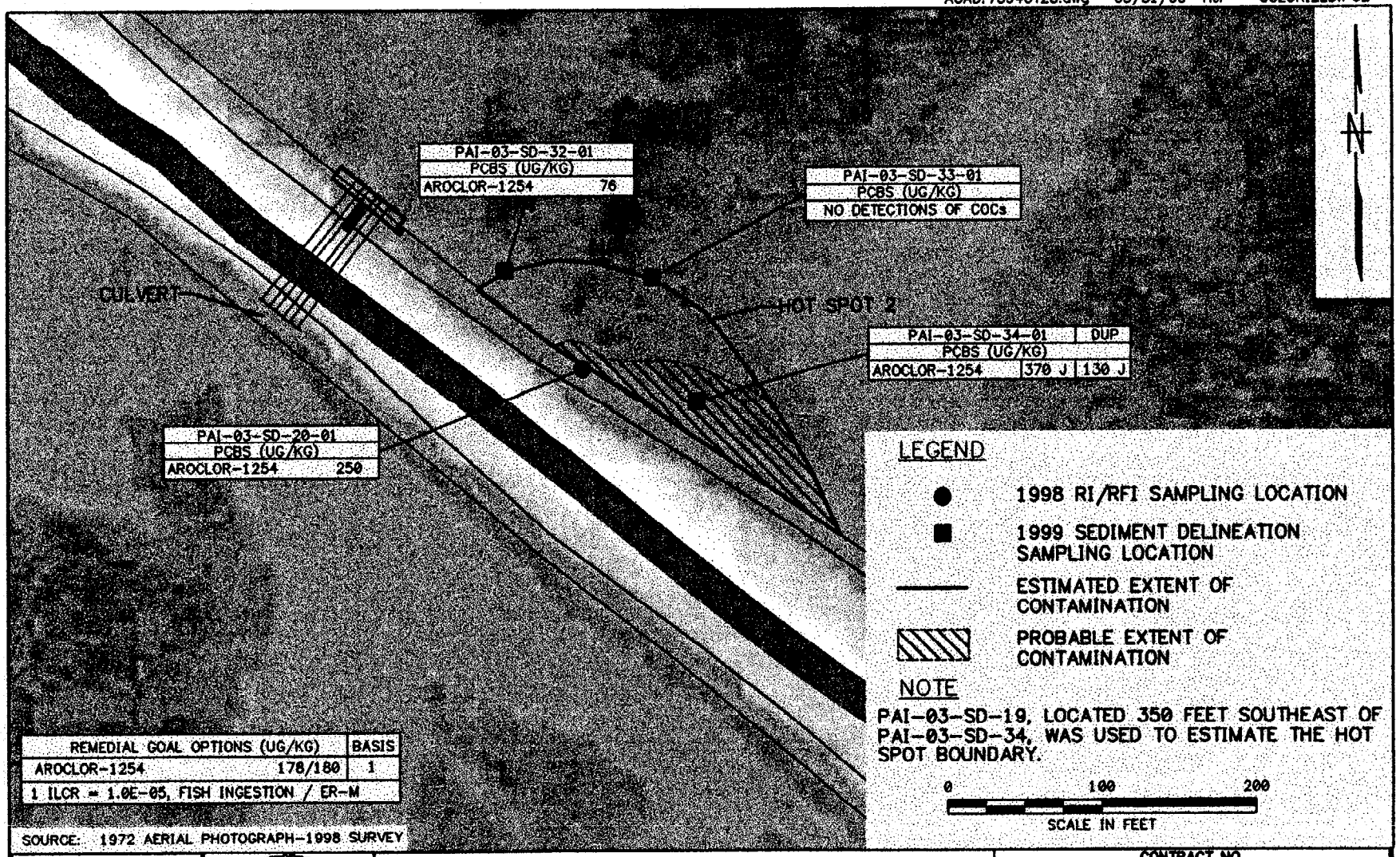


REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
AROCLOR-1254	178/180	1
1 ILCR = 1.0E-05, FISH INGESTION / ER-M		

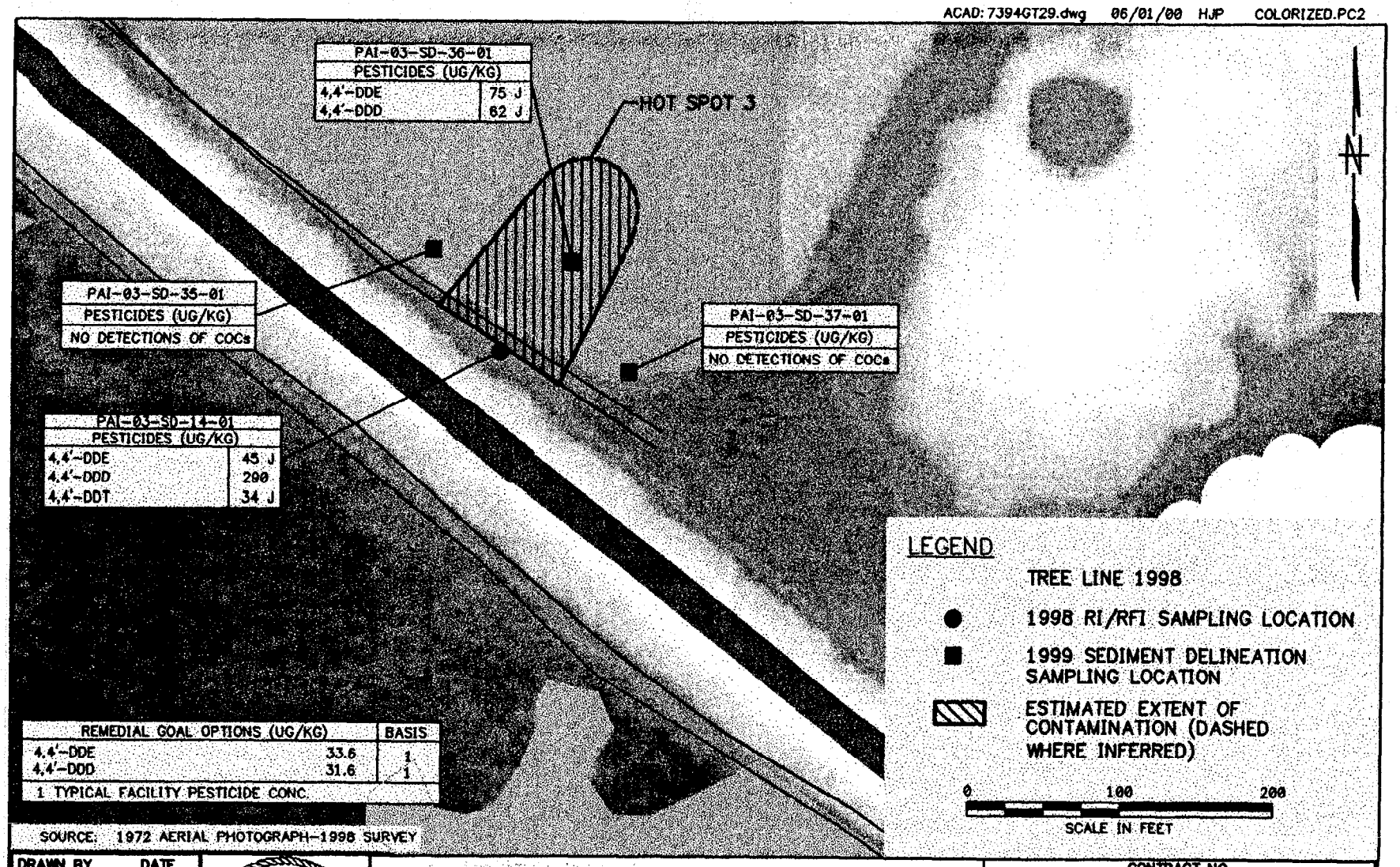
SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY HJP	DATE 5/25/00	SEDIMENT HOT SPOT 2 - PCBs EXTENT OF CONTAMINATION ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS SITE 3 - CAUSEWAY LANDFILL MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7394
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE C-5 / REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

C-32

ACAD: 7394GT29.dwg 06/01/00 HJP COLORIZED.PC2



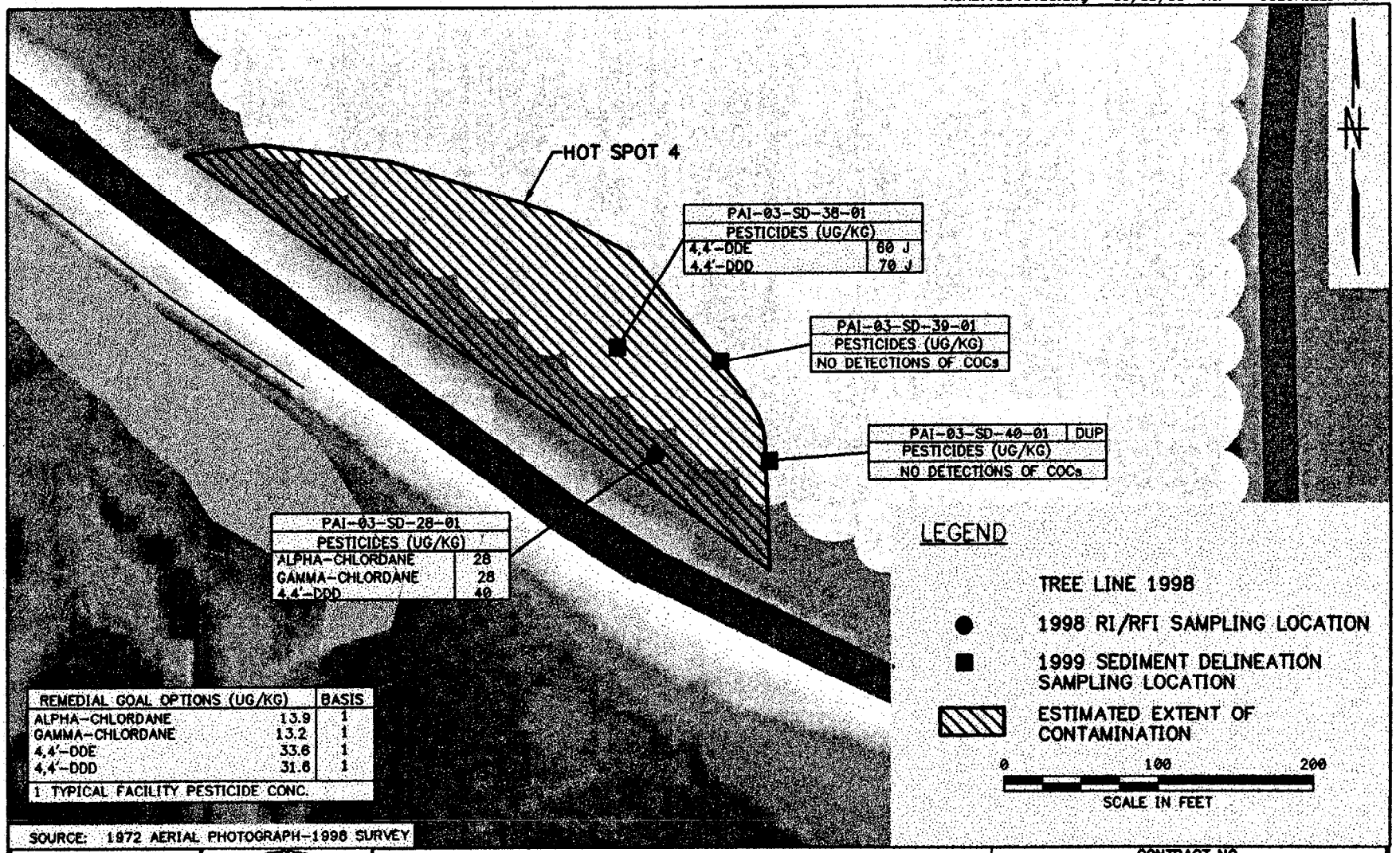
REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
4,4'-DDE	33.6	1
4,4'-DDD	31.6	1
1 TYPICAL FACILITY PESTICIDE CONC.		

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY HJP DATE 5/25/00	SEDIMENT HOT SPOT 3 - PESTICIDES EXTENT OF CONTAMINATION ILCR = 1.0E-05 AND MODERATE RISK OF ECOLOGICAL RECEPTORS SITE 3 - CAUSEWAY LANDFILL MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7394	
CHECKED BY DATE		APPROVED BY DATE	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE AS NOTED		DRAWING NO. FIGURE C-6	REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

ACAD: 7394GT30.dwg 06/01/00 HJP COLORIZED.PC2



REMEDIAL GOAL OPTIONS (UG/KG)		BASIS
ALPHA-CHLORDANE	13.9	1
GAMMA-CHLORDANE	13.2	1
4,4'-DDE	33.6	1
4,4'-DDD	31.6	1

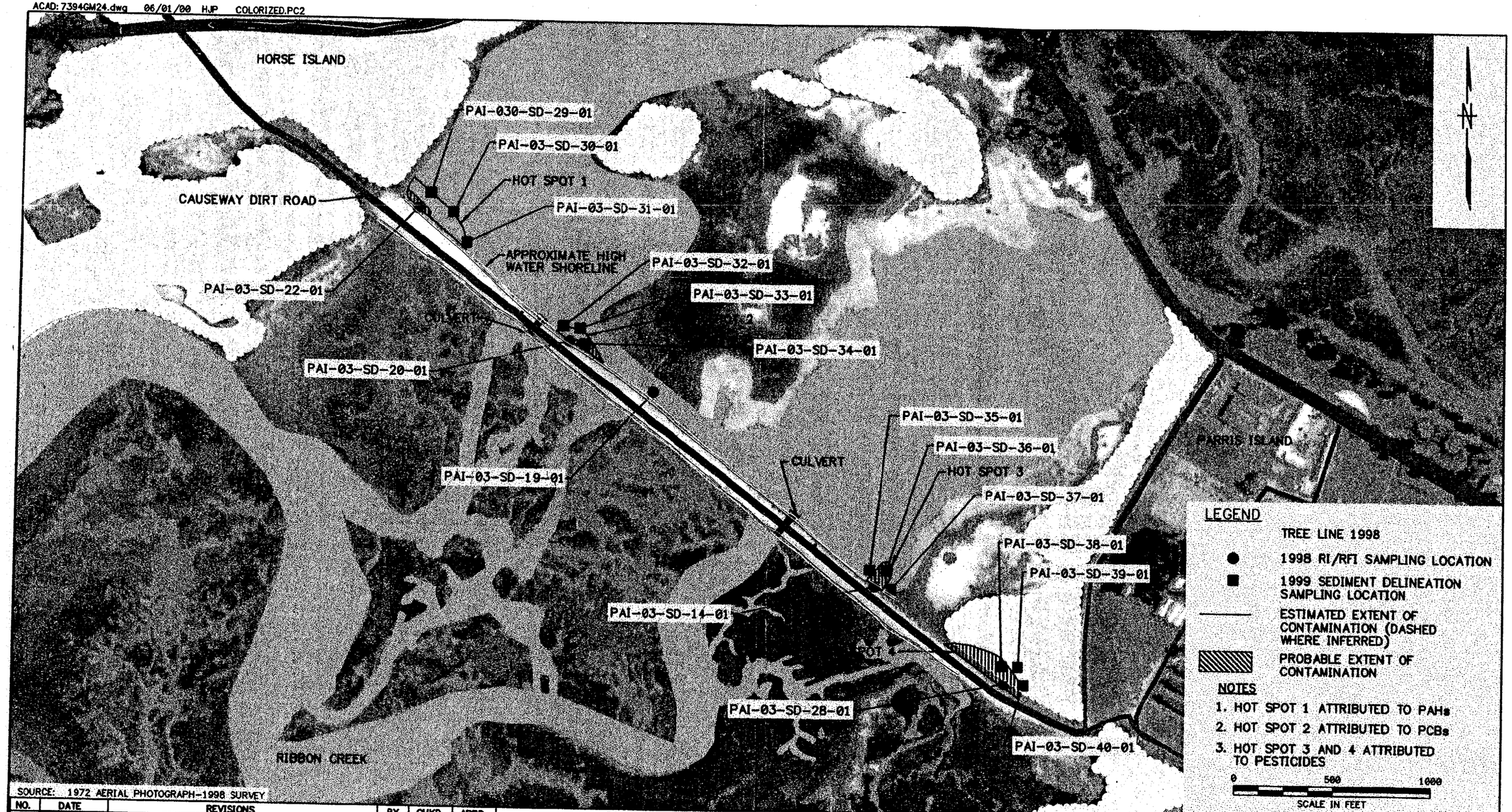
1 TYPICAL FACILITY PESTICIDE CONC.

SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

DRAWN BY HJP DATE 5/25/00	SEDIMENT HOT SPOT 4 – PESTICIDES EXTENT OF CONTAMINATION ILCR = 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS SITE 3 – CAUSEWAY LANDFILL MCRD PARRIS ISLAND, SOUTH CAROLINA	CONTRACT NO. 7394
CHECKED BY DATE		APPROVED BY DATE
COST/SCHED-AREA		APPROVED BY DATE
SCALE AS NOTED		DRAWING NO. FIGURE C-7 REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

ACAD: 7394GM24.dwg 06/01/00 HJP COLORIZED.PC2



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 10/13/99
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

EXTENT OF IMPACTED SEDIMENT BASED ON RGOs REPRESENTING A HUMAN HEALTH ILCR EQUAL TO 1.0E-05 AND MODERATE RISK TO ECOLOGICAL RECEPTORS
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE C-8
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

C-35 171A122

Attachment 2

Volume and Area Calculations

CLIENT		JOB NUMBER	
MCRD Parris Island			
SUBJECT	Site 3 Area & Volume Calcs		
BASED ON		DRAWING NUMBER	
BY JJB 5/22/00	CHECKED BY JJB	APPROVED BY	DATE

Volume Calculations

Soil - ILCR = 1.0E-06 & low risk to ecological receptors (Refer to Figure C-1)

Planimeter reading = 2.71 in^2

Area = $(2.71\ in^2)\left(\frac{500\ ft}{1\ in}\right)^2 = 677,500\ ft^2 = 15.6$ acres

- Assume 15' of fill material ⇒ ≈ 375,000 yd^3 of waste

Soil - ILCR = 1.0E-05 & moderate risk to eco (Refer to Figure C-2)

Area = $(1.67\ in^2)\left(\frac{500\ ft}{1\ in}\right)^2 = 418,300\ ft^2 = 9.6$ acres

Soil - ILCR = 1.0E-04 & high risk to eco (Refer to Figure C-3)

Area = $(1.53\ in^2)\left(\frac{500\ ft}{1\ in}\right)^2 = 382,500\ ft^2 = 8.8$ acres

Sediment - ILCR = 1.0E-05 & moderate risk to eco

Hot Spot 1 - PAHs (Figure C-4)

- Maximum Extent (using delineation sampling points as boundaries)
  Area = $(3.78\ in^2)\left(\frac{100\ ft}{1\ in}\right)^2 = 37,800\ ft^2$
  Volume = $(37,800\ ft^2)(2\ ft)/27 = 2,800\ yd^3$

- Estimated Extent (using log. decay)
  Area = $(0.543\ in^2)(100^2) = 5,430\ ft^2$
  Vol = $(5,430\ ft^2)(2)/27) = 402\ yd^3$

CLIENT	MCRD Parris Island	JOB NUMBER	
SUBJECT	Site 3 Area + Vol. Calcs		
BASED ON		DRAWING NUMBER	
BY JJB 5/22/00	CHECKED BY	APPROVED BY	DATE

Sediment (continued)

Hot Spot 2 - PCBs

- Est Extent: Area = $(1.36\ in^2)(100)^2 = 13,600\ ft^2$
  Vol. = $(13,600)(2)/27 = 1,007\ yd^3$

Prob. Extent: Area = $(0.73\ in^2)(100)^2 = 7,300\ ft^2$
Vol = $(7,300)(2)/27 = 541\ yd^3$

Hot Spot 3 - Pesticides

- Max/Est Ext.: Area = $(0.93\ in^2)(100)^2 = 9,300\ ft^2$
  Vol = $(9,300)(2)/27 = 689\ yd^3$

Hot Spot 4 - Pesticides

- Max. Extent: Area = $(3.53\ in^2)(100) = 35,300\ ft^2$
  Vol = $(35,300)(2)/27 = 2,615\ yd^3$

Appendix D

Cost Estimate

Appendix D-1

FS Cost Estimate Spreadsheets

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 16 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	0	event	$50,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$5,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill)
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	2,093	lcy		$10.00	$0.31	$0.84	$0	$20,930	$649	$1,758	$23,337		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	698	lcy		$14.63	$0.56	$1.52	$0	$10,212	$391	$1,061	$11,664	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	22,264	lcy		$10.00	$0.31	$0.84	$0	$222,640	$6,902	$18,702	$248,244		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	7,421	lcy		$14.63	$0.56	$1.52	$0	$108,569	$4,156	$11,280	$124,005		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	4,061	lcy		$8.00	$0.31	$0.84	$0	$32,488	$1,259	$3,411	$37,158		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,529,430	$319,174	$236,802	$2,085,406		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,560,019	$256,935	$202,466	$2,019,420		
Overhead on Labor Cost @ 0.3									$77,081		$77,081		
G & A on Labor Cost @ 0.1									$25,694		$25,694		
G & A on Material Cost @ 0.1								$156,002			$156,002		
Total Direct Cost								$1,716,021	$359,709	$202,466	$2,278,196		
Indirects on Total Direct Labor Cost @ 0.75									$269,782		$269,782		
Profit on Total Direct Cost @ 0.1											$227,820		
Subtotal											$2,775,797		

D-1

Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Health & Safety Monitoring @ 0.005											$13,879		
Total Field Cost											**$2,789,676**		
Subtotal Subcontractor Cost							$501,015				$501,015		
G & A on Subcontract Cost @ 0.1							$50,102				$50,102		
Profit on Subcontractor Cost @ 0.05											$25,051		
Subcontractor Cost											**$576,167**		
Subtotal											**$3,365,843**		
Contingency on Total Field and Subcontractor Costs @ 0.15											$504,876		
Engineering on Total Field Cost @ 0.08											$223,174		
TOTAL COST											**$4,093,894**		

D-2

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$3,150.00		(2) 4 GW and 3 sediment samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$4,550.00		(2) 7 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$58,700.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year two
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,093,894		$4,093,893.78	1.000	$4,093,894
1		$68,700.00	$68,700.00	0.935	$64,235
2		$65,700.00	$65,700.00	0.873	$57,356
3		$62,700.00	$62,700.00	0.816	$51,163
4		$58,700.00	$58,700.00	0.763	$44,788
5		$74,700.00	$74,700.00	0.713	$53,261
6		$58,700.00	$58,700.00	0.666	$39,094
7		$58,700.00	$58,700.00	0.623	$36,570
8		$58,700.00	$58,700.00	0.582	$34,163
9		$58,700.00	$58,700.00	0.544	$31,933
10		$74,700.00	$74,700.00	0.508	$37,948
11		$58,700.00	$58,700.00	0.475	$27,883
12		$58,700.00	$58,700.00	0.444	$26,063
13		$58,700.00	$58,700.00	0.415	$24,361
14		$58,700.00	$58,700.00	0.388	$22,776
15		$74,700.00	$74,700.00	0.362	$27,041
16		$58,700.00	$58,700.00	0.339	$19,899
17		$58,700.00	$58,700.00	0.317	$18,608
18		$58,700.00	$58,700.00	0.296	$17,375
19		$58,700.00	$58,700.00	0.277	$16,260
20		$74,700.00	$74,700.00	0.258	$19,273
21		$58,700.00	$58,700.00	0.242	$14,205
22		$58,700.00	$58,700.00	0.226	$13,266
23		$58,700.00	$58,700.00	0.211	$12,386
24		$58,700.00	$58,700.00	0.197	$11,564
25		$74,700.00	$74,700.00	0.184	$13,745
26		$58,700.00	$58,700.00	0.172	$10,096
27		$58,700.00	$58,700.00	0.161	$9,451
28		$58,700.00	$58,700.00	0.150	$8,805
29		$58,700.00	$58,700.00	0.141	$8,277
30		$74,700.00	$74,700.00	0.131	$9,786
				TOTAL PRESENT WORTH	**$4,875,523**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatio	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 16 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	0	event	$50,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$5,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including haulin	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	4,585	lcy		$10.00	$0.31	$0.84	$0	$45,850	$1,421	$3,851	$51,123		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	1,529	lcy		$14.63	$0.56	$1.52	$0	$22,369	$856	$2,324	$25,550	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	mef	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	35,545	lcy		$10.00	$0.31	$0.84	$0	$355,450	$11,019	$29,858	$396,327		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	11,848	lcy		$14.63	$0.56	$1.52	$0	$173,336	$6,635	$18,009	$197,980		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	mef	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	6,200	lcy		$8.00	$0.31	$0.84	$0	$49,600	$1,922	$5,208	$56,730		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,781,197	$327,671	$259,841	$2,368,708		
Local Area Adjustments	8							102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,816,821	$263,775	$222,164	$2,302,760		
Overhead on Labor Cost @ 0.3									$79,133		$79,133		
G & A on Labor Cost @ 0.1									$26,378		$26,378		
G & A on Material Cost @ 0.1								$181,682			$181,682		
Total Direct Cost								$1,998,503	$369,285	$222,164	$2,589,952		
Indirects on Total Direct Labor Cost @ 0.75									$276,964		$276,964		
Profit on Total Direct Cost @ 0.1											$258,995		
Subtotal											$3,125,911		

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Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Health & Safety Monitoring @ 0.005											$15,630		
Total Field Cost											**$3,141,541**		
Subtotal Subcontractor Cost							$501,015				$501,015		
G & A on Subcontract Cost @ 0.1							$50,102				$50,102		
Profit on Subcontractor Cost @ 0.05											$25,051		
Subcontractor Cost											**$576,167**		
Subtotal											**$3,717,708**		
Contingency on Total Field and Subcontractor Costs @ 0.15											$557,656		
Engineering on Total Field Cost @ 0.08											$251,323		
TOTAL COST											**$4,526,687**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$3,150.00		(2) 4 GW and 3 sediment samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$4,550.00		(2) 7 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$58,700.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,526,687		$4,526,687.16	1.000	$4,526,687
1		$68,700.00	$68,700.00	0.935	$64,235
2		$65,700.00	$65,700.00	0.873	$57,356
3		$62,700.00	$62,700.00	0.816	$51,163
4		$58,700.00	$58,700.00	0.763	$44,788
5		$74,700.00	$74,700.00	0.713	$53,261
6		$58,700.00	$58,700.00	0.666	$39,094
7		$58,700.00	$58,700.00	0.623	$36,570
8		$58,700.00	$58,700.00	0.582	$34,163
9		$58,700.00	$58,700.00	0.544	$31,933
10		$74,700.00	$74,700.00	0.508	$37,948
11		$58,700.00	$58,700.00	0.475	$27,883
12		$58,700.00	$58,700.00	0.444	$26,063
13		$58,700.00	$58,700.00	0.415	$24,361
14		$58,700.00	$58,700.00	0.388	$22,776
15		$74,700.00	$74,700.00	0.362	$27,041
16		$58,700.00	$58,700.00	0.339	$19,899
17		$58,700.00	$58,700.00	0.317	$18,608
18		$58,700.00	$58,700.00	0.296	$17,375
19		$58,700.00	$58,700.00	0.277	$16,260
20		$74,700.00	$74,700.00	0.258	$19,273
21		$58,700.00	$58,700.00	0.242	$14,205
22		$58,700.00	$58,700.00	0.226	$13,266
23		$58,700.00	$58,700.00	0.211	$12,386
24		$58,700.00	$58,700.00	0.197	$11,564
25		$74,700.00	$74,700.00	0.184	$13,745
26		$58,700.00	$58,700.00	0.172	$10,096
27		$58,700.00	$58,700.00	0.161	$9,451
28		$58,700.00	$58,700.00	0.150	$8,805
29		$58,700.00	$58,700.00	0.141	$8,277
30		$74,700.00	$74,700.00	0.131	$9,786
				TOTAL PRESENT WORTH	**$5,308,316**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation

Item	Quantity	Unit	Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	18	mo	$500.00	$0.00	$0.00	$0.00	$9,000	$0	$0	$0	$9,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	18	mo	$85.00	$0.00	$0.00	$0.00	$1,530	$0	$0	$0	$1,530		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr. quant. thicknesses	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilization	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	18	mo	$1,000.00	$0.00	$0.00	$0.00	$18,000	$0	$0	$0	$18,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	30,000	gal		$0.25	$0.00	$0.00	$0	$7,500	$0	$0	$7,500		
2.3 Decon Water Storage Tank (6,000 gallon)	18	mo	$577.50	$0.00	$0.00	$0.00	$10,395	$0	$0	$0	$10,395		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	18	mo	$472.50	$0.00	$0.00	$0.00	$8,505	$0	$0	$0	$8,505		e99-1903-0403
2.5 PPE (1p * 5 days * 24 weeks)	120	day		$30.00	$0.00	$0.00	$0	$3,600	$0	$0	$3,600		
3 SEDIMENT REMOVAL / COVER													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	1	event	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$1,500.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0.0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0.0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
3.11 Cover Soil (off-site borrow source, 18")	3,017	cy		$10.00	$0.31	$0.84	$0	$30,170	$935	$2,534	$33,640		m99-022-262-0010
3.12 Mob / Demob of clamshell crane	1	ea	$6,000.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000	includes full set up	estimate based on m-99 mob/demob figures
3.13 150' boom crane (place soil cover in standing water)	30	day	$2,366.00	$0.00	$0.00	$0.00	$70,980	$0	$0	$0	$70,980	rental per day including equip and crew	m99-016-460-1400
3.14 Geotextile (450 sy plus 15% for joints and waste)	12,067	sy		$1.30	$2.24	$0.50	$0	$15,687	$27,030	$6,034	$48,751	labor 8x for working in stading water	m99-022-412-1550 mat 2x - heavier geotextile
3.15 Rip Rap	1,676	cy		$20.20	$27.60	$8.40	$0	$33,855	$46,258	$14,078	$94,191	labor 4X for working in stading water	m99-022-712-0100
3.16 Super Silt Fence	500	lf		$1.40	$1.44	$0.00	$0	$700	$720	$0	$1,420	4x for super silt	m99-022-704-1100
3.17 Hay Bales (install, remove, and mat)	500	lf		$6.00	$0.29	$0.10	$0	$3,000	$145	$50	$3,195		m99-022-704-1250
3.18 Turbidity Curtain	500	lf		$7.60	$0.94	$0.00	$0	$3,800	$470	$0	$4,270		past experience, similar site
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	2,093	lcy		$10.00	$0.31	$0.84	$0	$20,930	$649	$1,758	$23,337		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	698	lcy		$14.63	$0.56	$1.52	$0	$10,212	$391	$1,061	$11,664	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	22,264	lcy		$10.00	$0.31	$0.84	$0	$222,640	$6,902	$18,702	$248,244		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	7,421	lcy		$14.63	$0.56	$1.52	$0	$108,569	$4,156	$11,280	$124,005		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	4,061	lcy		$8.00	$0.31	$0.84	$0	$32,488	$1,259	$3,411	$37,158		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94	$0.00	$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1560	hours		$0.00	$25.00	$0.00	$0	$0	$39,000	$0	$39,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	780	hours		$0.00	$30.00	$0.00	$0	$0	$23,400	$0	$23,400		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,620,342	$415,532	$259,499	$2,295,373		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,652,749	$334,503	$221,871	$2,209,124		
Overhead on Labor Cost @ 0.3									$100,351		$100,351		
G & A on Labor Cost @ 0.1									$33,450		$33,450		
G & A on Material Cost @ 0.1								$165,275			$165,275		

Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Total Direct Cost								$1,818,024	$468,304	$221,871	$2,508,200		
Indirects on Total Direct Labor Cost @	0.75								$351,228		$351,228		
Profit on Total Direct Cost @	0.1										$250,820		
Subtotal											$3,110,248		
Health & Safety Monitoring @	0.005										$15,551		
Total Field Cost											**$3,125,799**		
Subtotal Subcontractor Cost							$643,805				$643,805		
G & A on Subcontract Cost @	0.1						$64,381				$64,381		
Profit on Subcontractor Cost @	0.05										$32,190		
Subcontractor Cost											**$740,376**		
Subtotal											**$3,866,175**		
Contingency on Total Field and Subcontractor Costs @	0.15										$579,926		
Engineering on Total Field Cost @	0.08										$250,064		
TOTAL COST											**$4,696,165**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$3,150.00		(2) 4 GW and 3 sediment samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$4,550.00		(2) 7 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$58,700.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,696,165		$4,696,165.44	1.000	$4,696,165
1		$68,700.00	$68,700.00	0.935	$64,235
2		$65,700.00	$65,700.00	0.873	$57,356
3		$62,700.00	$62,700.00	0.816	$51,163
4		$58,700.00	$58,700.00	0.763	$44,788
5		$74,700.00	$74,700.00	0.713	$53,261
6		$58,700.00	$58,700.00	0.666	$39,094
7		$58,700.00	$58,700.00	0.623	$36,570
8		$58,700.00	$58,700.00	0.582	$34,163
9		$58,700.00	$58,700.00	0.544	$31,933
10		$74,700.00	$74,700.00	0.508	$37,948
11		$58,700.00	$58,700.00	0.475	$27,883
12		$58,700.00	$58,700.00	0.444	$26,063
13		$58,700.00	$58,700.00	0.415	$24,361
14		$58,700.00	$58,700.00	0.388	$22,776
15		$74,700.00	$74,700.00	0.362	$27,041
16		$58,700.00	$58,700.00	0.339	$19,899
17		$58,700.00	$58,700.00	0.317	$18,608
18		$58,700.00	$58,700.00	0.296	$17,375
19		$58,700.00	$58,700.00	0.277	$16,260
20		$74,700.00	$74,700.00	0.258	$19,273
21		$58,700.00	$58,700.00	0.242	$14,205
22		$58,700.00	$58,700.00	0.226	$13,266
23		$58,700.00	$58,700.00	0.211	$12,386
24		$58,700.00	$58,700.00	0.197	$11,564
25		$74,700.00	$74,700.00	0.184	$13,745
26		$58,700.00	$58,700.00	0.172	$10,096
27		$58,700.00	$58,700.00	0.161	$9,451
28		$58,700.00	$58,700.00	0.150	$8,805
29		$58,700.00	$58,700.00	0.141	$8,277
30		$74,700.00	$74,700.00	0.131	$9,786
				TOTAL PRESENT WORTH	**$5,477,795**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	18	mo	$500.00	$0.00	$0.00	$0.00	$9,000	$0	$0	$0	$9,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	18	mo	$85.00	$0.00	$0.00	$0.00	$1,530	$0	$0	$0	$1,530		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	18	mo	$1,000.00	$0.00	$0.00	$0.00	$18,000	$0	$0	$0	$18,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	30,000	gal		$0.25	$0.00	$0.00	$0	$7,500	$0	$0	$7,500		
2.3 Decon Water Storage Tank (6,000 gallon)	18	mo	$577.50	$0.00	$0.00	$0.00	$10,395	$0	$0	$0	$10,395		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	18	mo	$472.50	$0.00	$0.00	$0.00	$8,505	$0	$0	$0	$8,505		e99-1903-0403
2.5 PPE (1p * 5 days * 24 weeks)	120	day		$30.00	$0.00	$0.00	$0	$3,600	$0	$0	$3,600		
3 SEDIMENT REMOVAL / COVER													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	1	event	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$1,500.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
3.11 Cover Soil (off-site borrow source, 18")	3,017	cy		$10.00	$0.31	$0.84	$0	$30,170	$935	$2,534	$33,640		m99-022-262-0010
3.12 Mob / Demob of clamshell crane	1	ea	$6,000.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000	includes full set up	estimate based on m-99 mob/demob figures
3.13 150' boom crane (place soil cover in standing water)	30	day	$2,366.00	$0.00	$0.00	$0.00	$70,980	$0	$0	$0	$70,980	rental per day including equip and crew	m99-016-460-1400
3.14 Geotextile (450 sy plus 15% for joints and waste)	12,067	sy		$1.30	$2.24	$0.50	$0	$15,687	$27,030	$6,034	$48,751	labor 8x for working in stading water	m99-022-412-1550 mat 2x - heavier geotextile
3.15 Rip Rap	1,676	cy		$20.20	$27.60	$8.40	$0	$33,855	$46,258	$14,078	$94,191	labor 4X for working in stading water	m99-022-712-0100
3.16 Super Silt Fence	500	lf		$1.40	$1.44	$0.00	$0	$700	$720	$0	$1,420	4x for super silt	m99-022-704-1100
3.17 Hay Bales (install, remove, and mat)	500	lf		$6.00	$0.29	$0.10	$0	$3,000	$145	$50	$3,195		m99-022-704-1250
3.18 Turbidity Curtain	500	lf		$7.60	$0.94	$0.00	$0	$3,800	$470	$0	$4,270		past experience, similar site
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	4,585	lcy		$10.00	$0.31	$0.84	$0	$45,850	$1,421	$3,851	$51,123		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	1,529	lcy		$14.63	$0.56	$1.52	$0	$22,369	$856	$2,324	$25,550	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	35,545	lcy		$10.00	$0.31	$0.84	$0	$355,450	$11,019	$29,858	$396,327		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	11,848	lcy		$14.63	$0.56	$1.52	$0	$173,336	$6,635	$18,009	$197,980		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	6,200	lcy		$8.00	$0.31	$0.84	$0	$49,600	$1,922	$5,208	$56,730		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1560	hours		$0.00	$25.00	$0.00	$0	$0	$39,000	$0	$39,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	780	hours		$0.00	$30.00	$0.00	$0	$0	$23,400	$0	$23,400		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,872,109	$424,029	$282,537	$2,578,675		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,909,551	$341,343	$241,569	$2,492,464		
Overhead on Labor Cost @ 0.3									$102,403		$102,403		
G & A on Labor Cost @ 0.1									$34,134		$34,134		

Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
G & A on Material Cost @	0.1							$190,955			$190,955		
Total Direct Cost								$2,100,506	$477,881	$241,569	$2,819,956		
Indirects on Total Direct Labor Cost @	0.75								$358,411		$358,411		
Profit on Total Direct Cost @	0.1										$281,996		
Subtotal											$3,460,362		
Health & Safety Monitoring @	0.005										$17,302		
Total Field Cost											**$3,477,664**		
Subtotal Subcontractor Cost							$643,805				$643,805		
G & A on Subcontract Cost @	0.1						$64,381				$64,381		
Profit on Subcontractor Cost @	0.05										$32,190		
Subcontractor Cost											**$740,376**		
Subtotal											**$4,218,040**		
Contingency on Total Field and Subcontractor Costs @	0.15										$632,706		
Engineering on Total Field Cost @	0.08										$278,213		
TOTAL COST											**$5,128,959**		

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$3,150.00		(2) 4 GW and 3 sediment samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$4,550.00		(2) 7 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$58,700.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year two
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Partial Soil Cover / Slope Stabilization /Further Sediment Evaluation
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$5,128,959		$5,128,958.82	1.000	$5,128,959
1		$68,700.00	$68,700.00	0.935	$64,235
2		$65,700.00	$65,700.00	0.873	$57,356
3		$62,700.00	$62,700.00	0.816	$51,163
4		$58,700.00	$58,700.00	0.763	$44,788
5		$74,700.00	$74,700.00	0.713	$53,261
6		$58,700.00	$58,700.00	0.666	$39,094
7		$58,700.00	$58,700.00	0.623	$36,570
8		$58,700.00	$58,700.00	0.582	$34,163
9		$58,700.00	$58,700.00	0.544	$31,933
10		$74,700.00	$74,700.00	0.508	$37,948
11		$58,700.00	$58,700.00	0.475	$27,883
12		$58,700.00	$58,700.00	0.444	$26,063
13		$58,700.00	$58,700.00	0.415	$24,361
14		$58,700.00	$58,700.00	0.388	$22,776
15		$74,700.00	$74,700.00	0.362	$27,041
16		$58,700.00	$58,700.00	0.339	$19,899
17		$58,700.00	$58,700.00	0.317	$18,608
18		$58,700.00	$58,700.00	0.296	$17,375
19		$58,700.00	$58,700.00	0.277	$16,260
20		$74,700.00	$74,700.00	0.258	$19,273
21		$58,700.00	$58,700.00	0.242	$14,205
22		$58,700.00	$58,700.00	0.226	$13,266
23		$58,700.00	$58,700.00	0.211	$12,386
24		$58,700.00	$58,700.00	0.197	$11,564
25		$74,700.00	$74,700.00	0.184	$13,745
26		$58,700.00	$58,700.00	0.172	$10,096
27		$58,700.00	$58,700.00	0.161	$9,451
28		$58,700.00	$58,700.00	0.150	$8,805
29		$58,700.00	$58,700.00	0.141	$8,277
30		$74,700.00	$74,700.00	0.131	$9,786
				TOTAL PRESENT WORTH	**$5,910,588**

Appendix D-2

Assumptions/Calculations to Support the Cost Estimate

Cost Estimate Assumptions
Draft Feasibility Study
Site/SWMU 3 – Causeway Landfill
CTO0020 – MCRD, Parris Island, South Carolina

The following assumptions were made in estimating the quantities, developing the unit pricing, mark-ups, and post-closure care costs for the above referenced project. Large deviations from these assumptions will impact project cost and present-worth analysis.

Quantities

- The planar extent of waste comprising the causeway landfill is as shown on Figure 2-1.
- The ground surface topography reflected on the drawings titled "Topographic Survey for Tetra Tech NUS, Inc., Site 3 - Causeway Landfill, Marine Corps Recruit Depot, Parris Island, Beaufort County, South Carolina" (5 sheets) prepared by Donaldson, Garrett & Associates, Inc. dated August 6, 1998 was used to calculate the areas.
- Ground surface elevation of -4 MSL assumed on marsh side (marsh bottom at toe of slope). Ground surface elevation of 2 MSL assumed on pond side (pond bottom at toe of slope). Toe of slope on pond side drops 2 feet vertically based on TtNUS May 11, 1999 site visit.
- Erosion protection provided on pond and marsh slopes to 2 feet above assumed high water elevation of 4 feet MSL; in other words, erosion protection provided to elevation 6 feet MSL. Erosion protection from elevation 6 feet MSL to crest of slope provided with upgraded level of erosion protection in steeply slopes areas (2.0 to 2.5H/1V). Crest of slope elevation varies with location. The erosion protection for vegetated slopes is upgraded by including erosion control mat.
- Limits for areas of specific slope stabilization treatment as provided on sheet 2 of the quantity calculation. Limits based on visual observation of degree of steepness of sideslopes based on TtNUS May 11, 1999 site visit and are for cost estimating purposes only. Additional delineation during design is anticipated.
- Existing sideslopes are assumed stable to marginally stable considering surficial (shallow) slope stability modes of failure. Slope stabilization measures are intended to have no effect or slightly increase the factor of safety against surficial slope stability modes of failure.
- **Mitigation of potential deep seated failure planes not addressed as part of cost estimate.** Cost estimate includes provisions for limited geotechnical field investigation and geotechnical laboratory testing. Mitigation of potential surficial failure planes on pond side due to draining pond and excavation of sediments at toe of slope not addressed as part of cost estimate. Mitigation of potential dam/impoundment concerns (e.g. piping, seepage) not included.
- Sediment unit weight assumed 100 lb/ft^3 or 1.35 tons/yd^3 with bulking factor of 1.3. Transfer trailer capacity assumed 20 tons, 40 miles one-way to disposal facility. Southeasterly-most sediment excavation as shown on Figure 3-4 will receive backfill.
- On-site consolidation alternatives assume 2% of total excavated sediment volume must be transported and disposed off-site as this material may not be suitable for use as fill.
- Gabions for slope stabilization on marsh side assumed to require 8 feet wide by 2 foot deep excavation over 100% of area with excavated material placed on sideslope to provide uniform

grade. Leveling base of gravel 8 feet wide by 0.5 feet thick over 100% of area provided beneath gabions. (Excavation depth and level of effort of surface preparation increases for gabions on marsh side due to dual function and criticality of gabions; namely gabions on marsh side will provide erosion protection and gravity retaining wall.)

- Gabions for slope stabilization on pond side assumed to require 5 feet wide by 1 foot deep excavation over 50% of area with excavated material placed on sideslope to provide uniform grade. Leveling base of gravel 5 feet wide by 0.5 feet thick over 50% of area provided beneath gabions.

- Riprap (typically granite) with G_s = 2.7 and porosity, n of 0.30 to 0.35. Riprap unit weight is 110 lb/ft^3 (for 2.7 x 62.4 x (1 - 0.35) = 109.5 lb/ft^3).

- Coarse aggregate (typically granite) with G_s = 2.7 and porosity, n of 0.30 to 0.35. Coarse aggregate unit weight is approximately 120 lb/ft^3 (for 2.7 x 62.4 x (1 - 0.30) = 118 lb/ft^3).

- Gravel and pavement structural fill quantities increased by 10%, and miscellaneous excavated material, topsoil and cover soil quantities increased by 30% for compaction factor (in-place or compacted vs. loose cubic yards).

- Soil, aggregate and riprap quantities do not include an allowance for waste.

- Slopes to receive riprap and/or soil only as required to meet thickness requirements. Final grade assumed to mirror existing grade. Additional fill and/or riprap needed to provide uniform grade not provided.

- Geotextile provided as separation layer beneath riprap and around gravel. Geotextile not provided beneath gabions. Geotextile quantity includes key trench and an increase of 10% for overlap and waste.

- Erosion control mat quantity includes key trench and an increase of 10% for overlap and waste.

- Soil cover quantity assumes placement of 2 feet of additional soil cover. Actual cover thickness will likely vary from 1 to 2.5 feet.

- The partial ("Moderate Risk") soil cover alternatives (Alternatives 2A and 3A) assume revegetation of disturbed surface in areas that do not receive the additional soil cover.

- Roadway assumed 24 feet width, and improved by providing structural fill as required to maintain crown, 4-inch thick subbase, 4-inch thick stabilized base course, and 2-inch thick asphalt wearing course.

- Channel paralleling causeway on marsh side assumed to require 10 feet width, 18-inch thick layer of riprap over length exposed to tidal action and/or noted to be eroded.

Unit Price Development

- The unit prices used in preparing the cost estimate spreadsheets were obtained from one of the following sources:
  Vendor quoted prices;
  ECHOS Environmental Restoration Unit Cost Book, 1999;
  Means Site Work and Landscape Data, 17th Edition, 1999; and
  Past experience on similar projects.

- Unit prices were adjusted using "Sitework Local Area Adjustment" factors obtained from Means and ECHOS for Savannah, Georgia and Charleston, South Carolina.

- The cost estimate was structured based on WBS Categories. Units of measure set forth in the WBS guidance documents were used.

- For purposes of developing this cost estimate, it was assumed that the RAC would either rent all equipment used or subcontractors would provide their own equipment.

- All work will be performed in standard construction uniforms, with the exception of sediment excavation and conditioning (dewatering), and bank stabilization preparation which will be performed in Level D. Excavated sediments managed onsite will be incorporated in the soil cover presumably beneath a minimum of 0.5 feet soil cover. Excavated sediments managed offsite will be at an approved non-hazardous waste management facility. Prior to off-site disposal, the sediments will be permitted to dewater naturally (sediment sampling indicated sands and silty sands). Labor costs for Level D work were increased 18 percent (ECHOS, 1999) to account for decreases in efficiency caused by PPE.

- Erosion and sediment control structures (e.g., silt fence and turbidity curtain) will not be removed until after the site is vegetated and will be disposed off site.

- RAC will sample and analyze material from sediment excavation areas for purposes of contaminant delineation, waste profiling required by disposal facility and confirmatory sampling.

- All impacted sediment will be excavated and transferred to hauling vehicles, hauled to the designated area of the landfill plateau, allowed to drain, and conditioned as required by working with a dozer.

- Geotechnical investigation assumes 15 borings to a depth of 40 feet. Each boring will be continuously sampled with split spoons and periodic Shelby tubes installed over a 7 day period. Laboratory testing assumes moisture content, grain size analysis, Atterberg limits and triaxial shear strength testing.

- Wetland restoration assumed at a 1 to 1 ratio. Wetlands replacement assumes creating wetlands on suitable site near Parris Island. Site requires 2 feet deep excavation and 5 mile maximum RT haul distance. Replacement wetlands assumed at a 3 to 1 ratio.

- Costs for preparing permit applications are included.

- For assumptions on specific estimate line items, refer to the attached calculation worksheets.

Mark-ups

- A 5% markup was applied for subcontractor profit.

- Mark-ups used are as follows:

– Burden	30%	includes FICA, Workmen's Compensation, Unemployment Insurance, Builders Risk Insurance
– Labor	10%	includes Administrative and Handling
– Material	10%	includes Administrative and Handling
– Subcontractor	10%	includes Administrative and Handling
– Profit on Directs	10%	
– Engineering	8%	includes Engineering, Design and Post-Construction Award Services
– Contingency	15%	
– H&S Monitoring	0.5%	includes Personnel and Equipment for Environmental Media Monitoring
– Indirects	75%	on Total Direct Labor. Includes Supervision, Travel, Utilities, Communications, Medical, Supplies, Data Processing, Bond Premium Insurance, Guard Service, Temporary Office and Storage Clerk, Timekeeper, Testing and Analysis, Maintenance, and Clean-up

- Health and Safety PPE Level efficiency multipliers used are as follows (ECHOS, 1999):

H&S PPE Level	Labor Efficiency	Equipment Efficiency
A	37% (10 - 40% range)	50%
B	48% (25 - 60% range)	60%
C	55% (25 - 70% range)	75%
D	82% (50 - 90% range)	100%

Post-Closure Costs

- The post-closure care cost estimate unit costs were developed using the unit costs from the capital construction cost estimate unless stated otherwise below.

- Riprap replacement assumed due to dislodgement caused by erosion. Quantity approximately 1.5% of total riprap quantity on an annual basis.

- Gabion replacement assumed due to dislodgement caused by erosion or differential settlement. Quantity approximately 5% of total gabion quantity (or 2.5% of gabion stone quantity) on an annual basis.

- Topsoil replacement assumed due to erosion caused by run-off, flood and wave run-up action. Quantity approximately 10% of total vegetated area or 0.75 acres for half of layer thickness (3 inches) and bulking factor of 1.3 on an annual basis.

- Vegetation replacement assumed due to erosion. Quantity approximately 1 acre of total vegetated area on an annual basis.

- Wetland replacement vegetation for total of 30% of original plantings at diminishing percentage over three year period.

TELEPHONE MEMO

PROJECT NO.: ND7394

DATE: varies, see below

TIME: varies, see below

CALL BY: Bob Mertz

CALL TO: varies, see below

OF: Tetra Tech NUS, Inc.

OF: varies, see below

SUBJECT: Unit Prices for Cost Estimate
Feasibility Study
Site/SWMU 3 Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carolina

Waste Disposal

6/23/99
Browning-Ferris Industries
281 870-8100 Houston, Texas
Nellie
BFI doesn't have any landfills in South Carolina. BFI has landfills in Atlanta, Buford, and Lithonia, Georgia. Jon Farley and Karen Estapa are landfill representatives. Left voicemail message with Jon Farley.

6/23/99
Waste Management Inc.
713 512-6200 Houston, Texas
Unknown
WMI has 20 facilities in South Carolina. Recommend search for closest facility based on area code. For area code 843 try contacting Ridgeland, SC landfill at 843 987-0710.

6/23/99
Waste Management Inc.
843 987-0710 & 843 987-1385 Ridgeland, SC
Unknown
Waste disposal pricing handled out of Brunswick, Georgia by Sharon Lentz at 912 267-1063.

(H:\MERTZR\PARRISISLAND\CTO0020\M005)

6/23/99, ~4:30 - 5:00 pm
Waste Management Inc.
912 267-1063 Brunswick, Georgia
Sharon Lentz
RM: TtNUS needs unit pricing for waste disposal of non-hazardous material. Source is pond and marsh sediments which may be assumed non-hazardous. Estimate 12,000 cy need to be disposed. Assume sediments dewatered on-site before load-out such that they will pass paint filter test. No waste profiling to date. Assume waste-profile will be provided.
SL: WMI Ridgeland, SC is closest WMI disposal facility. Ridgeland is a Subtitle D landfill with 30 years of airspace remaining. Pricing includes indemnification by WMI of generator. For soil would assume 1 ton/cy, since sediment would assume 1.5 tons/cy. 12,000 cy of sediment therefore weighs 18,000 tons. Assuming the waste profile is provided, material passes paint filter test then cost for disposal would be $22/ton. There is no tax associated with the $22/ton cost, it is all inclusive. For this quantity would use transfer trucks. Assuming owner would load, no demurrage, then $10 to $18/ton would be ballpark estimate for hauling probably assume $15 to $16/ton hauling cost. For larger quantities and if material is suitable for use as cover then disposal cost would decrease significantly. For 250,000 cy unit price may be as low as $10/ton (not suitable for use as cover).

Waste Transportation

6/25/99
TtNUS
NA
Tom Riley
RM: Unit price for hauling waste?
TR: For FS use $3.50 to $4.00/loaded mile/truck which includes paperwork. Weight limits varies dependent on the state but should be less $\leq$ 22 tons.

Sheet Piling

6/22/99
Eastern Pile Driving, Inc.
800 577-5913, 301 577-5913 Baltimore, Maryland
John Rappold
RM: TtNUS needs unit pricing for installation of 1,735 lineal feet of permanent sheet piling w/25 feet driven and 10 feet stick-up for total length of 35 feet (1,735 ft x 35 feet = 60,725 sq ft). Access available for full length from roadway. Sheet piling must retain slope rising approximately 10 feet at slope of 2H:1V, saltwater environment. Please provide unit cost and mob/demob cost.
JR provided information on 6/25/99 2:10 pm.

JR: $1,500,000 total cost including mobilization. No further breakdown available. Assumed 45 lb/running foot, new piling, interlocking sheet. Material is comparable to PZ-27 which is no longer made. Represents middle of road interlocking sheet. Can provide a better number if a site visit is performed.
[PZ-27 is 3/8-inch thick, 40.5 lb/ft, 27.0 lb/sq ft. Ref. Bowles, J. E., Foundation Analysis and Design Third Edition, McGraw-Hill Book Company, New York, 1982]

Soil & Aggregate

6/25/99
3R Construction of Charleston, Inc.
843 747-2369, 843 747-8693 FAX
Jeff Truesdale
RM: TtNUS needs material and transportation unit pricing for soil including topsoil, structural fill, sand and riprap for Parris Island project.
JT: Generally use granite riprap. Closest riprap source is in Columbia, SC out of Martin Marietta quarry. Martin Marietta has stockyard between Columbia, SC and Parris Island off of interstate I-95. Materials are shipped to stockyard via rail. Will contact contractors in Buford/Hilton Head area to identify borrow sources and quarries.
JT provided unit price information on 6/29/99 8:15 am.
JT: The closest borrow pit is owned/operated by Ray Construction 843 846-8161. General fill loaded is $5/cu yd. General fill from Charleston, SC would be $1.75/cu yd loaded but transport to Parris Island would be approximately $5 to $7/ton. The Charleston, SC material would therefore cost more due to the transportation cost.
Riprap would come from Casey(?), SC (near Columbia, SC) out of Martin Marietta. Riprap, including transport to Parris Island, would be approximately $30/ton.
[from internet ... Martin Marietta Materials, Southeast Division, Duluth, GA 770 622-1400 also Carolina Division, Raleigh, NC 919 787-9504]

6/30/99, 11:45 - 11:50 am
Martin Marietta Materials, Columbia, SC
803 779-6500
Dave Jones (sales representative)
RM: TtNUS needs material and transportation unit pricing for coarse aggregate and riprap for Parris Island project. Will need 11,000 tons 1' riprap (quantity may double), 4,100 tons 6" riprap and 4,200 tons coarse aggregate.
DJ: Riprap is produced per SCDOT guidance.
MM makes 12-inch granite riprap called "1-man" or hand placed riprap. MM doesn't make 6" riprap.. 6 inch riprap would be hard to come by.
12-inch riprap material cost for 1999 projects is $12/ton; projected material cost for 2000 projects is $13/ton. The shipping cost from Columbia, SC to Charleston, SC is approximately $8/ton. The shipping cost from Columbia, SC to Parris Island, SC would then

be approximately $10 to $14/ton. Recommend using the $14/ton number. Shipping cost dependent on shipper's work load. Can provide shipper's names and telephone numbers if needed.
6-inch riprap material not manufactured. Provided 200 to 500 tons of 4 to 8-inch riprap in past for use in gabions. Material was surge pile stone (talus) from North Columbia quarry off of Highway 215. Cost for 1999 projects is $12.99/ton; projected material cost for 2000 projects is $13/ton.
Coarse aggregate with 100% passing 2-1/2-inch sieve, 90% passing 2-inch sieve, 0 to 10% passing 3/4-inch sieve (predominantly 1-inch material) is used for CSX railroad ballast (4A railroad ballast). "Mod 4's" material obtained from MM Casey quarry (Columbia, SC). Approximately equivalent to SCDOT No. 4 aggregate. Coarse aggregate material cost for 1999 projects is $7.75/ton; projected material cost for 2000 projects is $8.50/ton. The shipping cost for coarse aggregate is less than for riprap due to heavier truck bodies required to handle riprap.

Miscellaneous Materials

6/30/99 3:10 pm
A. H. Harris, Massachusetts
508 359-7321
John Carmichael
RM: TtNUS needs material costs for gabion baskets. Assume galvanized, not PVC coated, 3' x 3' x 6' size total of 1000 units. Also need estimate on assembly.
JC: $36.00/ea basket, $0.20/ea tack ties, and $0.15/ea fastener. Need about 12 tack ties and 66 fasteners for each 3' x 3' x 6' basket. [$36.00 + ($0.20 x 12) + ($0.15 x 66) = $48.30/ea basket, mat'ls only]. In general unit cost including assembly and filling w/riprap is $125/cy w/open shop labor and $160/cy w/union labor.

CLIENT	JOB NUMBER
Parris Island	

SUBJECT: Site / SWMU 3- Causeway Landfill FS

BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
RCM 6/3/99	LAB 8/2/99		

SLOPE CODE see sheet 2

A Sheet Piling (or Gabions)

B Gabions

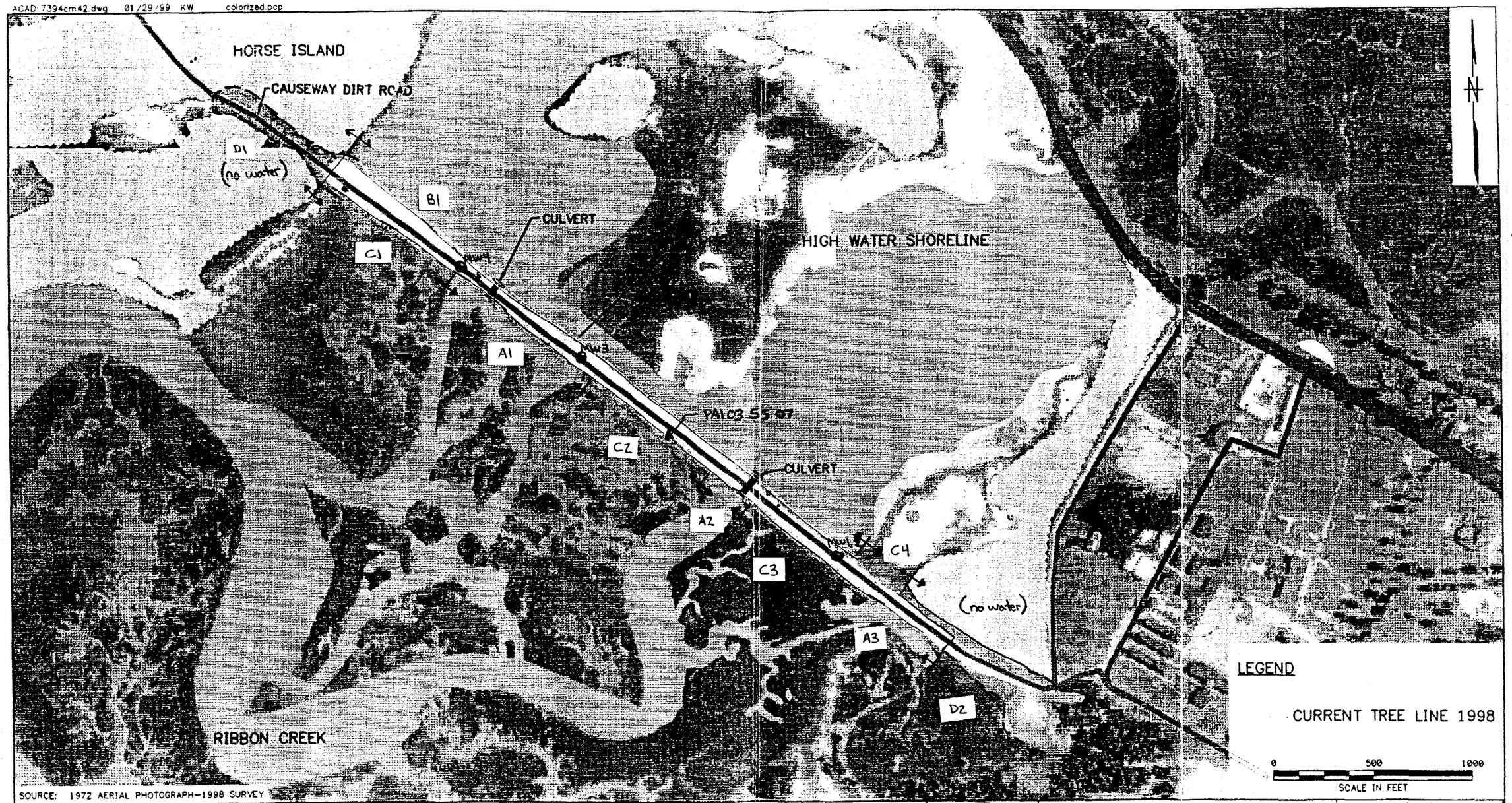
C Rip rap &/or Erosion Control Mat

D Soil Cover

SIDESLOPE AREA IDENTIFICATION	LOCATION	LENGTH (IN @ 1"=500') FT	PERIMETER (In. ft.)
A1	MARSH	(1.72")	860
A2	M	(0.52")	260
A3	M	(1.23")	615
B1	POND	(6.50")	3250
~~B2~~			NA
C1	M	(1.60")	800
C2	M	(1.50")	750
C3	M	(1.70")	850
C4	M	(0.59")	295
D1	NW END (HORSE ISLAND)	(3.1")	1550 (perimeter)
D2	SE END (PARRIS ISLAND)	(4.5")	2250 (perimeter)

Rev 0
03/05/99

ACAD: 7394cm42.dwg 01/29/99 KW colorized.pcp



SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/19/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

SITE LAYOUT
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1-2
REV. 0

FORM CADD NO. CIV_BH.DWG - REV 0 - 1/20/98

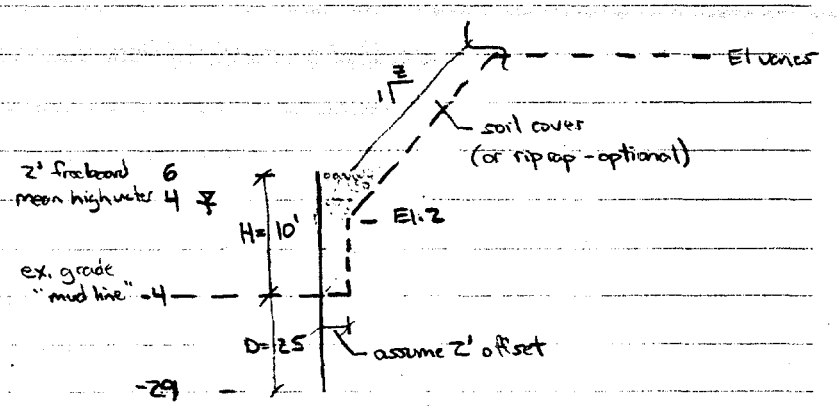
029905/P

D-27 171 A 132

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site/SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 6/3/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

A SHEET PILING (or Gabions) SHEET PILING NOT USED, PROCEED TO SHEET 6A

- includes A1, A2 & A3 on marsh side
- for gabions providing 2' freeboard above mean high water elev., provide piling to same elev.
- on pond side water @ ~ elev. 4 (last contour on DGA survey); assume similar mean high water elevation on marsh side of elev. 4
- elev. @ toe of slope on marsh side is reportedly less than the RCP pipe inverts, assume bottom elevation ("mud" line) of -4



USE - conservatively calc. sheetpile quantity across RCP culvert location

NOT USED - A1 860 lin. ft. x 35 vert. ft = 30,100 ft²

A2 260 " = 9,100 ft²

A3 615 " = 21,525 ft²

Σ 60,725 ft² sheet piling

USE - from DGA topo average side slopes in areas A1, A2 & A3 are as follows:

A1 2H:1V up to elev. 10

A2 2H:1V up to elev. 8

A3 3H:1V up to elev. 7

CLIENT: Parris Island	JOB NUMBER:
SUBJECT: Site / SWMU 3 - Causeway Landfill F5	
BASED ON:	DRAWING NUMBER:
BY: RCM 6/4/99	CHECKED BY: / APPROVED BY: / DATE:

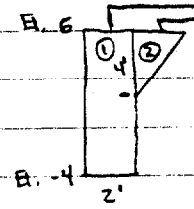
NOT USED - backfill sheetpiling w/ free-draining gravel aggregate (eg AASHTO No. 3)

A1 (860 lin ft x ((2')(6--4') + 0.5(4)² 2)/27 = 1147 cy

A2 (260 x (IBID + 0.5(4)² 2)/27 = 346 cy

A3 (615 x (IBID + 0.5(4)² 3)/27 = 1003 cy

Σ 2495 cy gravel backfill



$A_{①} = BH = B(\Delta elev.)$

$A_{②} = \frac{1}{2} BH = \frac{1}{2}(zH)(H) = \frac{1}{2} H^2 z$

NOT USED - protect steep sideslopes to break in grade w/ riprap (optional)

assume 4" to 6" riprap hand placed to 18" thick (soil cover + ECM may be used in lieu of rip rap)

A1 (860 lin ft x ((10-6)² + ((10-6)2)²)^½ x 1.5) 1/27 = 427 cy

A2 260 8 8 2 = 65

A3 615 7 7 3 = 108

Σ 600 cy riprap

or $\frac{600\,cy\,(27)\,110\,lb/ft^3}{2000}$ = 891 tons

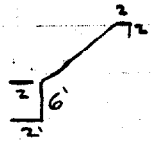
NOT USED - provide geotextile separation layer beneath gravel backfill & riprap

A1 [860 lin ft x ((2+2--4) + ((10-2)² + ((10-2)2)²)^½ + 2 + 2 + 2)] 1/9 x 1.1 = 3352 sy

A2 260 x Δe 8 8 2 = 871

A3 615 x 7 Δe 7 Δe 3 z = 2240

1202 overlapped geotextile Σ 6463



USE - cover soil on plateau, see sheets 18 and 19

USE - channel lining (rip rap) @ toe of slope, see sheet 20

NOT USED - sheetpile installation, preparation of surface (debris & riprap removal)

A1 (860 lin ft x 4' width x 2' deep x 0.3 (void ratio)) 1/27 = 76 cy

A2 (260 = 23

A3 (615 = 55

excavation, disposal Σ 154 cy

CLIENT	JOB NUMBER
Parris Island	

SUBJECT: Site | SWMU 3 - Causeway Landfill

BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
RCM 6/4/99			

NOT USED - protect steep sideslopes to break in grade w/ soil and ECM

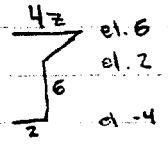
A1 same as riprap, except @ 1' thick multiply by 1/1.5 = 285 cy
A2 43 cy
A3 72 cy
additional 1' soil cover ≲ 400 cy

OR

A1 IBID except 2' thick 570 cy
A2 86
A3 144
additional 2' soil cover ≲ 800 cy
total 2' cover soil see sh. 6

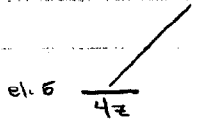
NOT USED - provide geotextile separation layer beneath gravel backfill

A1 860 lin ft x ((2+2--4) + (((6-2)²+((6-2)2)²)^½ + 4(2))] 1/9 x 1.1 = 2622 sy
A2 260 2 = 792 sy
A3 615 3 3 = 2454 sy
geotextile ≲ 5868 sy



NOT USED - provide ECM on soil cover on sideslope area up to crest of slope

A1 [860 lin ft x ((10-6)² + ((10-6)2)²)^½ + 4(2)] 1/9 x 1.1 = 1781 sy
A2 260 (8-6)² + ((8 2 2 = 396
A3 615 (7-6)² + ((7 3 3 = 1140
ECM ≲ 3317 sy



NOT USED - vegetation

A1 IBID ECM -(4(2)(860)/9)1.1 940 sy
A2 -(4(2)(260)/9)1.1 142
A3 -(4(3)(615)/9)1.1 238
1320 sy
vegetation 12 msf

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site / SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 6/4/99	CHECKED BY	APPROVED BY	DATE

NOT USED - protect steep sideslopes to break in grade w/soil & ECM (PA1 03 SS 07 as delineator)

area	location vs. PA1 03 SS 07	cover factor (sheet 16)	avg. cover depth (sheet 16)
A1	NW	0.30	1.2
A2	SE	0.60	1.4
A3	SE	0.60	1.4

A1 from sh. 5 for 1' cover 285 cy × $\frac{1.2}{1}$ × 0.30 = 103 cy
A2 43 cy × $\frac{1.4}{1}$ × 0.60 = 36 cy
A3 72 cy × $\frac{1.4}{1}$ × 0.60 = 168 cy
Option B, complete, total 2' cover soil Σ 307 cy

OR

A1 not applicable for Option A 0
A2 from above 36 cy
A3 from above 168 cy
Option A, cover SS07 to SE, total 2' cover soil Σ 204 cy

NOT USED - protect steep side slopes to break in grade w/soil & ECM (COC Exceedances Against RGOs, No & Moderate Risk Anticipated Cases). see Figures

A1 from sh. 5 for 2' additional cover, no risk 570 cy
A2 86 cy
A3 144 cy
Σ 800 cy

A1 from sh 5 for 2' additional cover, moderate risk 570 cy (125'/860') = 83 cy
A2 86 cy (260'/260) = 86 cy
A3 144 cy (615'/615) = 144 cy
Σ 313 cy

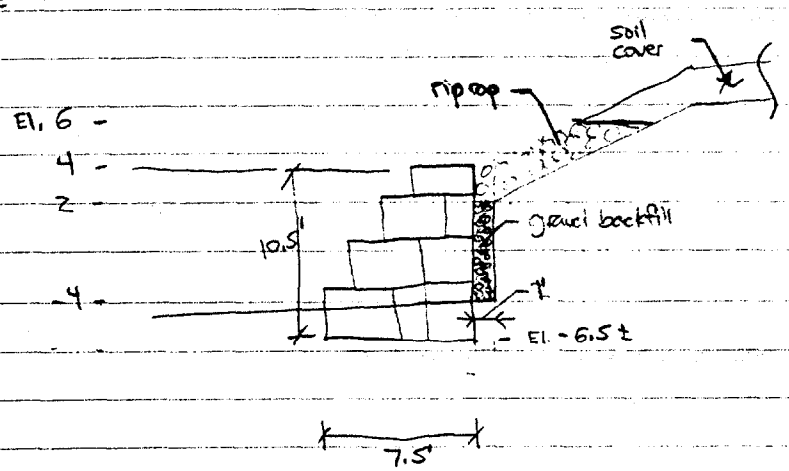
note: may require 0.5' topsoil on A1 not provided w/ 2' additional cover or 570 cy $\left(\frac{0.5}{2.0}\right)\left((860-125)/860\right)$ = 122 cy topsoil

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site 1 SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 7/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

A Sheet Piling (or GABIONS)

USE - same assumptions as sheet 3

USE -



	Area (ft²)
1(3)(0.5) + 0(3)(3) =	1.5
1(3)(0.5) + 1(3)(3) =	10.5
0(3)(0.5) + 2(3)(3) =	18.0
1(3)(0.5) + 2(3)(3) =	19.5
	Σ 49.5 ft²/lin. ft.

USE - conservatively calc. gabion riprap quantity including distance across RCP culvert location

USE - A1 (860 lin. ft. x 49.5 ft²/lin. ft) 1/27 = 1577 cy

A2 (260 lin. ft. x ") 1/27 = 477

A3 (615 lin. ft x ") 1/27 = 1128

gabion riprap Σ 3182 cy

or 3182(27)(110)/2000 = 4725 tons

USE - gabion baskets, conceptually used 3'x3'x6' gabions & 1.5' x 3' x 6' reno mattress

simplify quantity considering gabions only

volume of 1 gabion basket is (3)(3)(6)/27 = 2 cy

A1	1577 cy (1 basket/2 cy)	=	789 baskets
A2	477 "	=	239
A3	1128 "	=	564
	gabion baskets	Σ	1592 baskets

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site / SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 7/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

USE - backfill void between slope and gabion baskets w/ free-draining gravel aggregate (eg AASHTO No. 3)

A1 { 860 lin ft x ((1')(2--4))/27 = 191 cy
A2 { 260 58 cy
A3 { 615 137 cy

gravel backfill Σ 386 cy

USE - protect steep sideslopes w/ rip rap to elev. 6

A1 860 lin ft x $((6-2)^2+((6-2)\,2)^2)^{1/2} \times 1.5)\,1/27$ = 427 cy
A2 260 2 130
A3 615 3 432

riprap erosion protection Σ 989 cy

USE - provide geotextile separation layer beneath gravel backfill, between slope and gravel backfill, and between gravel and riprap

A1 860 lin ft x 8 ft x 1/9 x 1.1 = 841 sy
A2 260 " overlap = 254
A3 615 " = 601

12 oz overlapped geotextile Σ 1696 sy

USE - gabion wall installation, preparation of surface (debris, rip rap & sediment removal)

A1 (860 lin ft x 8 ft width x 2 ft depth (typ. average)) 1/27 = 510 cy
A2 260 x 154 cy
A3 615 x 364 cy

excavation 1028 cy

use rail to provide smooth sideslope grade
not used for soil cover

USE - gabion wall provide level gravel base

A1,A2,A3 (1735 lin ft x 8 ft width x 0.5 ft comp'n x 100%) 1/27 257 cy

gravel base Σ 257 cy

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site 1 SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 7/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

USE - cover soil on plateau, see sheets 18 and 19

USE - channel lining (rip rap) @ toe of slope, see sheet 20

USE - protect steep sideslopes to break in grade w/soil & ECM (COC Exceedances Against RGOs, No & Moderate Risk Anticipated Cases) see Figure 2-1

A1 (860 lin ft x ((10-6)² + ((10-6)(2))²)^½ x 2) ½7 = 570 cy

A2 (260 x ((8-6)² + ((8-6)(2))²)^½ " = 86

A3 (615 x ((7-6)² + ((7-6)(3))²)^½ " = 144

No Risk, 2' additional soil cover ≲ 800 cy

OR

A1 from above 570 cy (125'/860') = 83 cy

A2 86 (260'/260') = 86

A3 144 (615/615) = 144

Moderate Risk, 2' additional soil cover ≲ 313 cy

note: see sh. 6 = 122 cy topsoil

USE - provide ECM

A1 (((570 cy x 27/1)/2') + 4(2)860) 1/9 x 1.1 = 1781 sy

A2 86 " + 4(2)260) 1/9 = 396

A3 144 " + 4(3)615) 1/9 = 1140

ECM ≲ 3317 sy

1944

USE - vegetation

A1 (570 cy x 27/1/2') /9 = 855 sy

A2 (85 cy " /9 = 129

A3 (144 cy " /9 = 216

≲ 1200 sy

vegetation 10.8 msf

CLIENT: Parris Island	JOB NUMBER:
SUBJECT: Site 1 SWMU 3 - Causeway Landfill FS	
BASED ON:	DRAWING NUMBER:
BY: RCM 7/30/99	CHECKED BY: 8/2/99
APPROVED BY:	DATE:

USE - provide geotextile beneath riplap

A1 860 lin ft x $\left(\left((6-2)^2+((6-2)2)^2\right)^{1/2}\right) \times 1/9 \times 1.1$ = 940 sy

A2 260 2 L overlap 284

A3 615 3 951

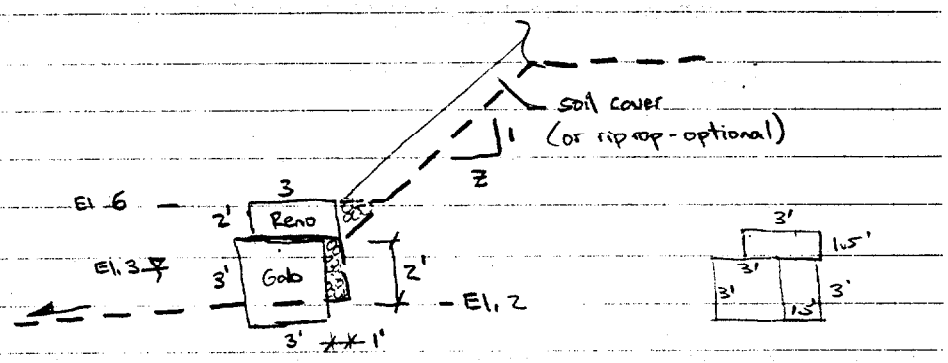
12oz overlapped geotextile 2175 sy

CLIENT: Parris Island		JOB NUMBER	
SUBJECT: Site / SWMU 3- Causeway Landfill FS			
BASED ON		DRAWING NUMBER	
BY: RCM 6/4/99	CHECKED BY: LAB 8/2/99	APPROVED BY	DATE

B

Gabions

- includes B1 on pond side
- for gabions provide 2' freeboard above pond water elevation
- pond side water elevation @ ~ elev. 4 (last contour on DGA survey)
- pond bottom assumed @ elev. 2 w/ 2' vertical face @ toe of sideslope and slope ratio per DGA; based on photos bottom slopes gently away from slope
- from DGA topo average sideslope in Area B1 is 2H:1V up to elev. 10



USE - gabion basket / reno mattress

B1 3250 lin ft × ((3 ft × 3 ft) + 2(1.5 ft × 3 ft)) 1/27 = 2167 cy 4"-6" rip rap in gabions

(~180' of B1 on SE doesn't extend to elev. 10)

or 2167(27)(110)/2000 = 3217 tons

USE - gabion baskets 2167 cy / 2 cy/basket = 1084 baskets

NOT USED - protect steep sideslopes to break in grade w/ riprap

B1 3250 lin ft × ((10-6)² + ((10-6)2)²)^1/2 × 1.5) 1/27 = 1619 cy riprap

(~180' of B1 on SE end doesn't extend to elev. 10)

or = 2404 tons

or 1079 cy if 1' soil

or 2159 cy if 2' soil

USE - backfill void between rip rap filled gabion baskets and slope w/ gravel & provide level gravel base

B1 3250 lin ft × (5(50%)1) 1/27 = 301 cy exc.

width, depth, area

3250 lin ft × ((1)(2) + 0.5(2)(2)(2) + 5(50%)0.5) 1/27 = 873 cy gravel

thickness

CLIENT: Parris Island	JOB NUMBER
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APPROVED BY	DATE

NOT USED - provide geotextile separation layer beneath rip rap & gabions

key in / overlap

B1 $\left[3250 \text{ lin.ft.} \times \left(1+2+\left((10-6)^2+((10-6)2)^2\right)^{1/2}+2+2\right)\right] 1/9 \times 1.1 = 6{,}333$ sy

USE - cover soil on plateau, see sheets 18 and 19

NOT USED - channel lining (rip rap) @ toe of slope NA

NOT USED - ~~protect steep sideslopes to break in grade w/ soil & ECM~~

~~B1 same as riprap, except @ 1' thick multiply by 1/1.5 = 1079 cy~~

~~additional 1' soil cover Σ 1079 cy~~

~~VOID OR~~

~~B1 IBID 2' 2159 cy~~

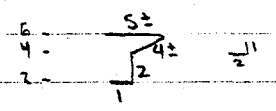
~~additional 2' soil cover Σ 2159 cy~~

total 2' soil cover see sheet 9

USE - provide geotextile separation layer around aggregate

B1 $(3250 \text{ lin.ft} \times (1+2+4+5))\, 1/9 \times 1.1$ = 4767 sy

geotextile Σ 4767 sy



USE - provide ECM on soil cover on sideslope area up to crest of slope

B1 $\left[3250 \text{ lin ft.} \times \left(\left((10-6)^2+((10-6)2)^2\right)^{1/2}+4(2)\right)\right] 1/9 \times 1.1 = 6731$ sy

ECM Σ 6731 sy

USE - vegetation

B1 IBID ECM $(4(2)(3250))/9)1.1 = 3553$ sy

Σ 3553 sy

vegetation 32 ms

CLIENT	Parris Island
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SUBJECT	Site / SWMU3 - Causeway Landfill FS
BASED ON	
DRAWING NUMBER	
BY	RCM
CHECKED BY	LAB 8/2/99
APPROVED BY	
DATE	

NOT USED - protect sideslopes to break in grade w/ soil cover & ECM (see sheets 7 & 8 and sheet 6 for approach) (PA1 03 SS 07 as delineator)

area	location vs. PA1 03 SS07	cover factor (sheet 16)	avg. cover depth (sheet 16)
B1	NW @ 2150 ft.	0.30	1.2
B1	SE @ 1100 ft.	0.60	1.4

1/0/10

B1 from sh. 8 for 1' cover $1079\ cy \left(\frac{2150}{3250}\right)(1.2)(0.30) =$ 257 cy

B1 $1079\ cy \left(\frac{1100}{3250}\right)(1.4)(0.60) =$ 307 cy

Option B complete cover, total 2' cover soil ≤ 564 cy

OR

B1 not applicable for Option A 0

B1 from above 307 cy

Option A, cover SS07 to SE, total 2' cover soil ≤ 307 cy

USE - protect steep sideslopes to break in grade w/ soil & ECM (COC Exceedances Against RGOs, No & Moderate Risk Anticipated Cases) see Figures

B1 from sh. 8 for 2' additional cover, no risk 2159 cy

≤ 2159 cy

OR

B1 from sh. 8 for 2' additional cover, moderate risk

$2159\ cy\ ((125 + 1200)/3250) =$ 880 cy

≤ 880 cy

note: may require 0.5' topsoil on B1 not provided w/ 2' additional cover or $2159\ cy\ (0.5/2.0)((3250-125-1200)/3250) =$ 320 cy

CLIENT	Parris Island
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BASED ON	
DRAWING NUMBER	
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CHECKED BY	LAB 8/2/99
APPROVED BY	
DATE	

C Riprap +/or Erosion Control Mat

USE - includes C1, C2 and C3 on marsh side and C4 on pond side

USE - provide riprap + erosion control mat above mean high water elevation to crest of slope (to elev. 6 and)

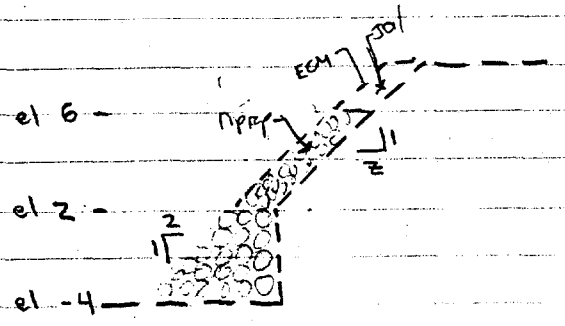
USE - elev. @ toe of slope on marsh side is reportedly less than the RCP pipe inverts, assume bottom elevation ("mud" line) of -4 (same assumption as for "A Sheet Piling" on sheet 3)

pond bottom assumed @ elev. 2 w/ 2' vertical face @ toe of sideslope and slope ratio per DGA; based on photographs bottom slopes gently away from slope (same assumption as for "B Gabions" on sheet 7)

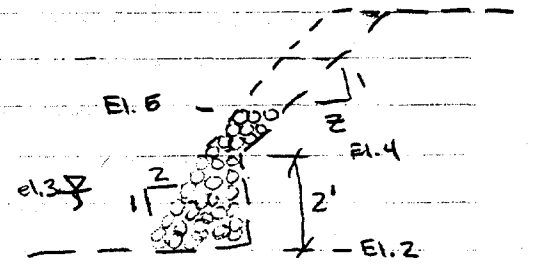
USE - from DGA topo average sideslopes in areas C1 through C4 are as follows:

C1 marsh 2.2H:1V up to elev. 10
C2 marsh 2.4H:1V up to elev. 9
C3 marsh 3.0H:1V up to elev. 7.5
C4 pond 10H:1V up to elev. 8

marsh side



pond side



CLIENT: Parris Island	JOB NUMBER
SUBJECT: Site / SWMU 3 - Causeway Landfill	
BASED ON	DRAWING NUMBER
BY: RCM 6/7/99	CHECKED BY: LAB 8/2/99
APPROVED BY	DATE

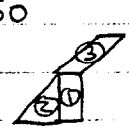
USE - provide riprap to elev. 6 on marsh side & elev. 6 on pond side

C1 [(800 lin ft × ((2)(2--4) + 0.5(2--4)²×2) + ((6-2)² + ((6-2)2.2)²)^½ × 1.5)] ½ 27 = 1851 cy

C2 [750 ① ② ③ 2.4 1767

C3 [850 approx. horiz proj. of riprap 3.0 2108

(2' soil cover) riprap Σ 5726 cy



AND

C4 295 lin ft. × ((2(4-2) + (0.5(4-2)²×2) + (((6-4)² + (6-4)10)²)^½ × 1.5)] ½ 27 = 417 cy

(2' soil cover) riprap 417 cy

USE - provide geotextile beneath & behind riprap

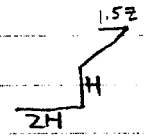
C1 800 lin ft × (2(6) + 6 + ((6-2)² + ((6-2)2.2)²)^½ + 2.2(1.5)) ½ 9 × 1.1 = 3028 sy

C2 750 × (2(6) + 6 + ((6-2)² + ((6-2)2.4)²)^½ + 2.4(1.5)) = 2933

C3 850 × (2(6) + 6 + ((6-2)² + ((6-2)3.0)²)^½ + 3.0(1.5)) = 3647

C4 295 × (2(2) + 2 + ((6-4)² + ((6-4)10)²)^½ + 10(1.5)) = 1481

geotextile Σ 11089 sy



CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site 1 SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 6/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

NOT USED - protect sideslopes to break in grade w/soil

C1 800 lin ft. x $((10-2)^2+((10-2)(2.2))^2)^{1/2}$ x 1' x 1/27 = 573 cy
C2 750 x $((9-2)^2+((9-2)(2.4))^2)^{1/2}$ x = 506 cy
C3 850 x $((7.5-2)^2+((7.5-2)(3.0))^2)^{1/2}$ x = 548 cy
C4 295 x $((8-4)^2+((8-4)(10))^2)^{1/2}$ x = 439 cy
additional 1' soil cover Σ 2066 cy

OR VOID

C1 IBID x 2 = 1146 cy
C2 = 1012
C3 = 1096
C4 = 878
additional 2' soil cover Σ 4132 cy
total 2' soil cover see sheet 13

USE - provide ECM on soil cover on sideslope area up to crest of slope

C1 800 $((10-6)^2+((10-6)(2.2))^2)^{1/2}$ + 3 (2)) 1/9 x 1.1 = 1532 sy
C2 750 $((9-6)^2+((9-6)(2.4))^2)^{1/2}$ + ") 1/9 x 1.1 = 1265 sy
C3 850 $((7.5-6)^2+((7.5-6)(3.0))^2)^{1/2}$ + ") 1/9 x 1.1 = 1116 sy
C4 295 $((8-6)^2+((8-6)(10))^2)^{1/2}$ + ") 1/9 x 1.1 = 941 sy
ECM Σ 4854 sy

USE - vegetation (same as soil cover from sh. 12A converted to area)

C1 IBID soil cover, No Risk Case 573 cy $\left(\frac{27 ft^3}{cy}\right)\left(\frac{1}{2'}\right)(1/9)$ = 860 sy
C2 433 650
C3 299 449
C4 439 659
vegetation 2618 sy
23.6 msf

CLIENT Parris Island	JOB NUMBER
SUBJECT Site 1 SWMU 3 - Causeway Landfill	
BASED ON	DRAWING NUMBER
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USE - protect steep sideslopes to break in grade w/soil cover

C1 $(800 \text{ lin ft} \times 2 \times ((10-6)^2 + ((10-6)(2.2))^2)^{1/2})/27 = 573$ cy

C2 $(750 \times 2 \times ((9-6)^2 + ((9-6)(2.4))^2)^{1/2})/27 = 433$

C3 $(850 \times 2 \times ((7.5-6)^2 + ((7.5-6)(3.0))^2)^{1/2})/27 = 299$

C4 $(295 \times 2 \times ((8-6)^2 + ((8-6)(10))^2)^{1/2})/27 = 439$

X/o Risk Case, Soil Cover 2' additional Σ 1744 cy

OR

C1	573 cy	(0 / 800)	=	0 cy
C2	433	(375 / 750)	=	216
C3	299	(850 / 850)	=	299
C4	439	(295 / 295)	=	439

Moderate Risk Case, Soil Cover 2' additional Σ 954 cy

CLIENT	Parris Island
JOB NUMBER	
SUBJECT	Site / SWMU 3 - Causeway Landfill FS
BASED ON	
DRAWING NUMBER	
BY	RCM 6/9/99
CHECKED BY	
APPROVED BY	
DATE	

NOT USED - provide minimum 2' soil cover (PA103 SS07 as delineator)

C1	from sh. 12 for 1' cover	573 cy	(1.2)(0.30) =	206 cy
C2 to SS07		506 $\left(\frac{475}{750}\right)$	(1.2)(0.30) =	115
SS07 to C2		506 $\left(\frac{275}{750}\right)$	(1.4)(0.60) =	156
C3		548	(1.4)(0.60) =	460
C4		439	(1.4)(0.60) =	369
	Option B, complete, total 2' cover soil			Σ 1306 cy

OR

C1	not applicable for Option A	0
C2 to SS07		0
SS07 to C2		156
C3		460
C4		369
	Option A, cover to SS07 to SE, total 2'	Σ 985 cy

VOID

NOT USED - protect steep sideslopes to break in grade w/soil cover (COC Exceedances Against RGOs, No & Moderate Risk Anticipated Cases) see Figure 2-1

C1	from sh. 12 for 2' additional cover, no risk	1146 cy
C2		1012
C3		1096
C4		878
		Σ 4132 cy

OR

C1	from sh. 12 for 2' additional cover, moderate risk	1146 cy	(0'/800') =	0
C2		1012	(375'/750') =	506
C3		1096	(850'/850') =	850
C4		878	(295'/295') =	878
				Σ 2234

VOID

note: may require 0.5' topsoil on C1 & C2 not provided w/2' additional cover
or 573 cy (0.5/2.0) + 433 cy (0.5/2.0)((750-375)/750) = 197 cy topsoil

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site / SWMU3 - Causeway Landfill		
BASED ON		DRAWING NUMBER	
BY RCM 6/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

D Soil Cover

USE - includes D1 and D2

USE - D1 and D2 essentially not within DGA survey limits

assume D1 2.5H:1V up to elev. 10, area is 50,000 ft² from Figure 1-2 (sheet 2), road length is 700 ft.

assume D2 3H:1V up to elev. 8, area is 200,000 ft² from Figure 1-2 (sheet 2), road length is 600 ft.

NOT USED - assume existing dirt road width and location will remain unchanged, road width is typically 24 feet

- ~~RAI 03 SS 007 selected as limit of partial cover for Options A and B of Alternatives 1 and 2; total minimum cover required is 2 feet; assume areas where existing cover thickness is ≥ 2 feet require no additional cover and any material in excess of 2' from these areas will not be excavated and used as cover elsewhere; assume existing cover thickness data from sediment/surface soil sampling and soil borings provides average and full characterization of site~~

USED - deduct roadway area, assume 10% of nonpavement area is sideslope area to receive ECM

NOT USED - ~~provide minimum 2' soil cover total~~

D1 $((50{,}000\ ft^2 - (700\ ft)(24\ ft\ road)) \times 0.3 \times (2-1.2))\ 1/27 =$ 295 cy

D2 $((200{,}000\ ft^2 - (600\ ft)(24\ ft\ road)) \times 0.6 \times (2-1.4))\ 1/27 =$ 2474 cy

~~Option B total 2' soil cover~~ ~~Σ 2769 cy~~

~~Option A~~ ~~Σ 2474 cy~~

USE - provide ECM on sideslopes see sh. 15

D1 $(50{,}000\ ft^2 - (700)(24))\ 0.10\ 1/9$ = 369 sy

D2 $(200{,}000\ ft^2 - (600)(24))\ 0.10\ 1/9$ = 2062 sy

See 10% assumption above

ECM Σ 2431 sy

USE - vegetation

D1 IBID × 1/0.10 = 3690 sy

D2 = 20620 sy

Σ 24310 sy

vegetation 218 msf

CLIENT	Parris Island
JOB NUMBER	
SUBJECT	Site 1 SWMU 3 - Causeway Landfill F5
BASED ON	
DRAWING NUMBER	
BY	RMartz 6/23/99
CHECKED BY	LAB 8/2/99
APPROVED BY	
DATE	

USE - provide 2' soil cover (COC Exceedances Against RGOs, No. & Moderate Risk Anticipated Cases) see Figure 2-1

No Risk Case, 2' additional cover

D1 ((50000 ft² - (700)(24)) x 2) 1/27 — 2459 cy

D2 ((200,000 - (600)(24)) x 2) 1/27 — 13748 cy

Σ 16207 cy

OR

Moderate Risk Case, 2' additional cover

D1 ((0 ft² - (700)(24)) x 2) 1/27 — 0 cy

D2 ((200,000 ft² - (600)(24)) x 2) 1/27 — 13748 cy

Σ 13748 cy

note 0.5 topsoil on D1 2459 (0.5)(2.0) = 615 cy

Surface Soil Sample No.	Ground Surface Elevation	Depth to Top of Waste (ft)	Elevation of Top of Waste	Depth to Top of Waste < 2ft (ft)
1 PAI03SS012	10.0	3.6	6.4	NA
2 PAI03SS011	11.9	2.2	9.7	NA
3 PAI03SS016	12.5	2.6	9.9	NA
4 PAI03GW004	13.2	1.0	12.2	1.0
5 PAI03SS010	12.8	2.7	10.1	NA
6 PAI03SS015	10.2	3.2	7.0	NA
7 PAI03GW003	13.2	1.0	12.2	1.0
8 PAI03SS009	11.2	2.6	8.6	NA
9 PAI03SS008	10.5	2.6	7.9	NA
10 PAI03SS007	9.9	1.6	8.3	1.6
	SUM	23.1		3.6
	AVG.	2.3		1.2
10 PAI03SS007	9.9	1.6	8.3	1.6
11 PAI03SS006	11.6	3.5	8.1	NA
12 PAI03SS013	9.8	1.9	7.9	1.9
13 PAI03SS014	10.0	2.4	7.6	NA
14 PAI03SS005	10.4	1.9	8.5	1.9
15 PAI03GW002	9.9		9.9	
16 PAI03GW001	10.0	3.0	7.0	NA
17 PAI03SS004	10.2	1.7	8.5	1.7
18 PAI03SS003	9.2	2.5	6.7	NA
19 PAI03SS002	7.6	1.1	6.5	1.1
20 PAI03SS001	7.3	0.0	7.3	0.0
	SUM	19.6		8.2
	AVG.	2.0		1.4

NW of PAI 03 SS 007

3/10 = 0.3 inadequate cover w/ 1.2' average thickness

SE of PAI 03 SS 007

6/10 = 0.6 inadequate cover w/ 1.4' average thickness

NOT USED

Notes:
1. PAI03SS001 depth to waste varies from 0 to 0.5 feet.
2. PAI03GW001, 003 and 004 depth to waste varies from 0 to 6, 0 to 2, and 0 to 2 feet, respectively.

(H:/MERTZR/PARRISISLAND/CTO0020/WSTELEV)

CLIENT	Parris Island	JOB NUMBER	
SUBJECT	Site / SWMU 3 - Causeway Landfill FS		
BASED ON		DRAWING NUMBER	
BY RCM 6/9/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

Plateau Area

USE - includes causeway plateau, D1 and D2 quantified under 'D Soil Cover'

USE - areas are as follows (using S or W sideslope area identification to break out areas):

SIDESLOPE AREA IDENTIFICATION	AREA (YN²)	AREA (FT²)	
D1	NA	NA	700 ft
C1	109.9	98910	800 ft
A1	89.2	80280	860 ft
C2 to PA103SS07	50.8	45,720	750 ft
		subtotal 224,910 ft²	
PA103SS07 to A2	27.5	24750	
A2	30.7	27630	260 ft
C3	46.3	41670	850
A3	59.6	53640	615
D2	NA	NA	600 ft
		subtotal 147690 ft²	
		total 372600 ft²	

- road length

NW of SS07 (excl. D1) = 4.3 in (500 ft/in) = 2150 ft

SE of SS07 (excl. D2) = 3.5 in (500 ft/in) = 1750 ft

3900 ft

CLIENT: Parris Island	JOB NUMBER
SUBJECT: Site / SWMU 3 - Causeway Landfill FS	
BASED ON	DRAWING NUMBER
BY: RCM 6/9/99	CHECKED BY: LAB 8/2/99
APPROVED BY	DATE

NOT USED - cover soil

Option A, cover SS07 to SE, total 2' soil cover - road

$(147{,}690\,ft^2 - 1750\,ft(24\,ft))(2 - 1.4\,ft)(0.6)\,1/27 =$ 1409 cy

VOID

Option B, complete cover, total 2'

$(224{,}910\,ft^2 - 2150(24))(2 - 1.2)(0.3)\,1/27 + 1409\,cy =$ 2950 cy

see sh. 19

USE - vegetation

$(372600\,ft^2 - (2410 + 1725)(24))\,1/1000 =$ 2734 msf

USE - pavement subbase, assume existing adequat, supplement w/ 4" agg.

$(700 + 2410 + 1725 + 600)(24\,ft)(4/12)\,1/27 =$ 1610 cy

USE - pavement base course, assume 4" of BCBC

IBID (4/12) = 1610 cy

USE - pavement wearing course, 2"

(2/12) = 805 cy

5435

USE - pavement structural fill (to maintain same slope & elevation) incl D1 & D2

A,B,C + D1 + D2

$(4135 + 700 + 600\,ft)(2\,ft - \frac{4+4+2}{12})(24\,ft)\,1/27 =$ 5636 cy

No Risk Case structural fill Σ 5636 cy

OR

IB+D - C1 - C2 - D1 (partial)

$(5435 - 800 - 375 - 700)$ " = 3692 cy

Moderate Risk Case structural fill Σ 3692

CLIENT: Parris Island		JOB NUMBER	
SUBJECT: Site / SWMU 3 - Causeway Landfill F5			
BASED ON		DRAWING NUMBER	
BY: RCM 6/28/99	CHECKED BY: LAB 8/2/99	APPROVED BY	DATE

USE - cover soil

No Risk Case, 2' additional cover

(372,600 ft² - (4135 ft)(24 ft))(2 ft) 1/27 = 20,249 cy

≈ 20,249 cy

OR

Moderate Risk Case, 2' additional cover

A1 75 ft NW-SE area included, see Figure ? -75(24)

by planimetry 13,770 ft² (2 ft) 1/27 = 887 cy

C2 375 ft NW-SE area included, see Figure 2.1

by planimetry 38,160 ft² (2 ft) 1/27 = 2160

A2 27630 ft² - (260)(24) 2 1/27 1584

C3 41670 ft² - (850)(24) " 1576

A3 53640 ft² - (615)(24) " 2880

≈ 9,087 cy

-315(24)

Note: 0.5' Topsoil

(20,249 - 9087) 0.5/2 = 2791 cy

CLIENT: Parris Island	JOB NUMBER
SUBJECT: Site / SWMU 3 - Causeway Landfill FS	
BASED ON	DRAWING NUMBER
BY: RCM 6/9/99	CHECKED BY: LAB 8/2/99
APPROVED BY	DATE

Channel

USE - rip rap line channel @ toe of slope on marsh side

USE - assume 10' width, 18" deep, areas C1, A1, C2, A2, C3, A3

USE - rip rap

(800 + 860 + 750 + 260 + 850 + 615 ft)(10 ft)(1.5 ft) 1/27 = 2,297 cy

Encroachment Beyond Toe of Slope (Potential Wetlands Lost)

area id.	area			
A1	860 ft	(8,5)	=	7,310 ft²
A2	260	(8,5)	=	2210
A3	615	(8,5)	=	5228
B1	3250	(5,5)	=	17,875
C1	800	(6)(2)	=	9,600
C2	750	(6)(2)	=	9,000
C3	850	(6)(2)	=	10,200
C4	295	(2)(2)	=	1,180
D1	0		=	0 sf
D2	0		=	0 sf

= 62603 ft² = 1.4 ac

CLIENT	Parris Island	JOB NUMBER	(END OF CALCULATION @ 21 OF 26)
SUBJECT	Site SWMU3 - Causeway Landfill F5		
BASED ON		DRAWING NUMBER	
BY RCM 7/7/99	CHECKED BY LAB 8/2/99	APPROVED BY	DATE

Clearing and Grubbing

USE - assume required in sideslope areas

USE - approx. landfill area is 5435 ft (150 ft) = 815,250 ft²

sideslope area is approx. (815,250 - 372,600 ft²)/43560 = 10 acres

4 Bank Stabilization ("A" Areas on sheet 2 of calculation)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity		Item
Gabion Rip Rap													
A1	860	ln ft			1577	cu yd	2341	tons					
A2	260				477		708						
A3	615				1128		1674						
	0				0		0						
Total	1735	ln ft			3181	cu yd	4724	tons			3181	cu yd	4.4
Gabion Baskets													
A1	860	ln ft							789	ea			
A2	260								239				
A3	615								564				
	0								0				
Total	1735	ln ft							1592	ea	1592	ea	4.3
Gabions (Surface Preparation, Excavation)													
A1	860	ln ft			510	cu yd							
A2	260				154								
A3	615				364								
	0				0								
Total	1735	ln ft			1028	cu yd					1028	cu yd	4.11
Gabions (Gravel Base)													
A1	860	ln ft			127	cu yd	206	tons	140	lcy			
A2	260				39		62		42				
A3	615				91		148		100				
	0				0		0		0				
Total	1735	ln ft			257	cu yd	382	tons	283	lcy	283	lcy	4.2
Gabions (Backfill Void w/Gravel)													
A1	860	ln ft			191	cu yd	310	tons	210	lcy			
A2	260				58		94		64				
A3	615				137		221		150				
	0				0		0		0				
Total	1735	ln ft			386	cu yd	573	tons	424	lcy	424	lcy	4.2
Riprap (above gabions to elev. 6)													
A1	860	ln ft			427	cu yd	634	tons					
A2	260				130		193						
A3	615				432		642						
	0				0		0						
Total	1735	ln ft			989	cu yd	1469	tons			989	cu yd	4.5
Geotextile Separation Layer (gravel envelope)													
A1	860	ln ft	841	sq yd									
A2	260		254										
A3	615		601										
	0		0										
Total	1735	ln ft	1,696	sq yd							1,696	sq yd	4.8
Geotextile Separation Layer (beneath riprap)													
A1	860	ln ft	940	sq yd									
A2	260		284										
A3	615		951										
	0		0										
Total	1735	ln ft	2,175	sq yd							2,175	sq yd	4.8

4 Bank Stabilization ("A" Areas on sheet 2 of calculation) (cont'd.)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity		Item
Soil Cover ("No Risk" Case, entire causeway, 2 ft additional)													
A1	860	ln ft			570	cu yd							
A2	260				86								
A3	615				144								
	0				0								
Total	1735	ln ft			800	cu yd							
			Topsoil Portion		200	cu yd	260	lcy			260	lcy	4.7 (Alt. B's)
			Cover Soil Portion		600	cu yd	780	lcy			780	lcy	4.6 (Alt. B's)
Soil Cover ("Moderate Risk" Case, southeastern portion of causeway, 2 ft additional)													
A1	860	ln ft			83	cu yd							
A2	260				86								
A3	615				144								
	0				0								
Total	1735	ln ft			313	cu yd							
			Topsoil Portion		78	cu yd	102	lcy			102	lcy	4.7 (Alt. A's)
			Cover Soil Portion		235	cu yd	305	lcy			305	lcy	4.6 (Alt. A's)
Optional 0.5 ft Topsoil (on area not covered under "Moderate Case" above)													
Total					*122*	*cu yd*							
			Topsoil Portion		*122*	*cu yd*	*159*	*lcy*			159	lcy	Not Used
			Cover Soil Portion		*0*	*cu yd*	*0*	*lcy*			0	lcy	Not Used
Erosion Control Mat													
A1	860	ln ft	1781	sq yd									
A2	260		396										
A3	615		1140										
	0		0										
Total	1735	ln ft	3317	sq yd							3317	sq yd	4.9
Vegetation													
A1	860	ln ft	855	sq yd									
A2	260		129										
A3	615		216										
	0		0										
Total	1735	ln ft	1200	sq yd	10.8	msf					10.8	msf	4.10

4 Bank Stabilization ("B" Areas on sheet 2 of calculation)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity	Item
Gabion Rip Rap												
B1	3250	ln ft			2167	cu yd	3218	tons				
	0				0		0					
	0				0		0					
	0				0		0					
Total	3250	ln ft			2167	cu yd	3218	tons			2167	cu yd	4.4
Gabion Baskets												
B1	3250	ln ft							1084	ea		
	0								0			
	0								0			
	0								0			
Total	3250	ln ft							1084	ea	1084	ea	4.3
Gabions (Surface Preparation, Excavation)												
B1	3250	ln ft			301	cu yd						
	0				0							
	0				0							
	0				0							
Total	3250	ln ft			301	cu yd					301	cu yd	4.11
Gabions (Gravel Base & Backfill Void))												
B1	3250	ln ft			873	cu yd	1414	tons	960	lcy		
	0				0		0		0			
	0				0		0		0			
	0				0		0		0			
Total	3250	ln ft			873	cu yd	1296	tons	960	lcy	960	lcy	4.2
Riprap (above gabions to elev. 6)												
B1	3250	ln ft										
	0											
	0											
	0											
Total	3250	ln ft									0	cy	4.5
Geotextile Separation Layer												
B1	3250	ln ft	4767	sq yd								
	0		0									
	0		0									
	0		0									
Total	3250	ln ft	4,767	sq yd							4,767	sq yd	4.8

4 Bank Stabilization ("B" Areas on sheet 2 of calculation) (cont'd.)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity		Item
Soil Cover ("No Risk" Case, entire causeway, 2 ft additional)													
B1	3250	ln ft			2159	cu yd							
	0				0								
	0				0								
	0				0								
Total	3250	ln ft			2159	cu yd							
			Topsoil Portion		540	cu yd	702	lcy			702	lcy	4.7 (Alt. B's)
			Cover Soil Portion		1619	cu yd	2105	lcy			2105	lcy	4.6 (Alt. B's)
Soil Cover ("Moderate Risk" Case, southeastern portion of causeway, 2 ft additional)													
B1	3250	ln ft			880	cu yd							
	0				0								
	0				0								
	0				0								
Total	3250	ln ft			880	cu yd							
			Topsoil Portion		220	cu yd	286	lcy			286	lcy	4.7 (Alt. A's)
			Cover Soil Portion		660	cu yd	858	lcy			858	lcy	4.6 (Alt. A's)
Optional 0.5 ft Topsoil (on area not covered under "Moderate Case" above)													
Total					*320*	*cu yd*							
			Topsoil Portion		*320*	cu yd	*416*	*lcy*			416	lcy	Not Used
			Cover Soil Portion		*0*	cu yd	*0*	*lcy*			0	lcy	Not Used
Erosion Control Mat													
B1	3250	ln ft	6731	sq yd									
	0		0										
	0		0										
	0		0										
Total	3250	ln ft	6731	sq yd							6731	sq yd	4.9
Vegetation													
B1	3250	ln ft	3553	sq yd									
	0		0										
	0		0										
	0		0										
Total	3250	ln ft	3553	sq yd	32.0	msf					32.0	msf	4.10

4 Bank Stabilization ("C" Areas on sheet 2 of calculation)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

										Quantity		Item
Riprap												
C1	800	ln ft			1851	cu yd	2749	tons				
C2	750				1767		2624					
C3	850				2108		3130					
C4	295				417		619					
Total	2695	ln ft			6143	cu yd	9122	tons		6143	cu yd	4.5
Geotextile Separation Layer												
C1	800	ln ft	3028	sq yd								
C2	750		2933									
C3	850		3647									
C4	295		1481									
Total	2695	ln ft	11089	sq yd						11089	sq yd	4.8
Soil Cover ("No Risk" Case, entire causeway, 2 ft additional)												
C1	800	ln ft			573	cu yd						
C2	750				433							
C3	850				299							
C4	295				439							
Total	2695	ln ft			1744	cu yd						
			Topsoil Portion		436	cu yd	567	lcy		567	lcy	4.7 (Alt. B's)
			Cover Soil Portion		1308	cu yd	1700	lcy		1700	lcy	4.6 (Alt. B's)
Soil Cover ("Moderate Risk" Case, southeastern portion of causeway, 2 ft additional)												
C1	800	ln ft			0	cu yd						
C2	750				216							
C3	850				299							
C4	295				439							
Total	2695	ln ft			954	cu yd						
			Topsoil Portion		239	cu yd	310	lcy		310	lcy	4.7 (Alt. A's)
			Cover Soil Portion		716	cu yd	930	lcy		930	lcy	4.6 (Alt. A's)
Optional 0.5 ft Topsoil (on area not covered under "Moderate Case" above)												
Total					*197*	*cu yd*						
			Topsoil Portion		*197*	cu yd	*256*	*lcy*		256	lcy	Not Used
			Cover Soil Portion		*0*	cu yd	*0*	*lcy*		0	lcy	Not Used
Erosion Control Mat												
C1	800	ln ft	1532	sq yd								
C2	750		1265									
C3	850		1116									
C4	295		941									
Total	2695	ln ft	4854	sq yd						4854	sq yd	4.9
Vegetation												
C1	800	ln ft	860	sq yd								
C2	750		650									
C3	850		449									
C4	295		659									
Total	2695	ln ft	2618	sq yd	23.6	msf				23.6	msf	4.10

5 Soil Cover ("D" Areas on sheet 2 of calculation)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity		Item
Soil Cover ("No Risk" Case, entire causeway, 2 ft additional)													
D1	700	ln ft			2459	cu yd							
D2	600				13748								
	0				0								
	0				0								
Total	1300	ln ft			16207	cu yd							
			Topsoil Portion		4052	cu yd	5267	lcy			5267	lcy	5.2 (Alt. B's)
			Cover Soil Portion		12155	cu yd	15802	lcy			15802	lcy	5.1 (Alt. B's)
Soil Cover ("Moderate Risk" Case, southeastern portion of causeway, 2 ft additional)													
D1	700	ln ft			0	cu yd							
D2	600				13748								
	0				0								
	0				0								
Total	1300	ln ft			13748	cu yd							
			Topsoil Portion		3437	cu yd	4468	lcy			4468	lcy	5.2 (Alt. A's)
			Cover Soil Portion		10311	cu yd	13404	lcy			13404	lcy	5.1 (Alt. A's)
Optional 0.5 ft Topsoil (on area not covered under "Moderate Case" above)													
Total					*615*	*cu yd*							
			Topsoil Portion		*615*	*cu yd*	*800*	*lcy*			800	lcy	Not Used
			Cover Soil Portion		*0*	*cu yd*	*0*	*lcy*			0	lcy	Not Used
Erosion Control Mat													
D1	700	ln ft	369	sq yd									
D2	600		2062										
	0		0										
	0		0										
Total	1300	ln ft	2431	sq yd							2431	sq yd	5.3
Vegetation													
D1	700	ln ft	3690	sq yd									
D2	600		20620										
	0		0										
	0		0										
Total	1300	ln ft	24310	sq yd	218.8	msf					218.8	msf	5.4

5 through 9 (as indicated)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

										Quantity		Item
Plateau												
Clearing and Grubbing												
Total			442650	sq ft	442.7	msf	10	acre		10	acre	9.1
Soil Cover ("No Risk" Case, entire causeway, 2 ft additional)												
D1	0	ln ft	0	sq ft	0	cu yd						
C1	800		98910		5904							
A1	860		80280		4418							
C2	750		70470		3887							
A2	260		27630		1584							
C3	850		41670		1576							
A3	615		53640		2880							
D2	0		0		0							
Total	4135	ln ft	372600	sq ft	20249	cu yd						
			Topsoil Portion		5062	cu yd	6581	lcy		6581	lcy	5.2 (Alt. B's)
			Cover Soil Portion		15187	cu yd	19743	lcy		19743	lcy	5.1 (Alt. B's)
Soil Cover ("Moderate Risk" Case, southeastern portion of causeway, 2 ft additional)												
D1	0	ln ft	0	sq ft	0	cu yd						
C1	0		98910		0							
A1-#	75		13770		887							
C2-#	375		38160		2160							
A2	260		27630		1584							
C3	850		41670		1576							
A3	615		53640		2880							
D2	0		0		0							
Total	2175	ln ft	273780	sq ft	9087	cu yd						
			Topsoil Portion		2272	cu yd	2953	lcy		2953	lcy	5.2 (Alt. A's)
			Cover Soil Portion		6815	cu yd	8860	lcy		8860	lcy	5.1 (Alt. A's)
Optional 0.5 ft Topsoil (on area not covered under "Moderate Case" above)												
Total					*2791*	*cu yd*						
			Topsoil Portion		*2791*	cu yd	*3628*	*lcy*		3628	lcy	Not Used
			Cover Soil Portion		*0*	cu yd	*0*	*lcy*		0	lcy	Not Used
Vegetation												
D1	0	ln ft	0	sq ft								
C1	800		79710									
A1	860		59640									
C2	750		52470									
A2	260		21390									
C3	850		21270									
A3	615		38880									
D2	0		0									
Total	4135	ln ft	273360	sq ft	273.4	msf				273.4	msf	5.4
Pavement												
Pavement Structural Fill (1.2' thick) ("No Risk Case")												
D1	*700*	*ln ft*	*16800*	*sq ft*	*726*	*cu yd*						
C1	*800*		*19200*		*830*							
A1	*860*		*20640*		*892*							
C2	*750*		*18000*		*778*							
A2	*260*		*6240*		*270*							
C3	*850*		*20400*		*881*							
A3	*615*		*14760*		*638*							
D2	*600*		*14400*		*622*							
Total	*5435*	*ln ft*	*130440*	*sq ft*	*5636*	*cu yd*	*6200*	*lcy*		*6200*	*lcy*	*6.1(Alt. B's)*

5 through 9 (as indicated)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

											Quantity		Item
Pavement (cont'd.)													
Pavement Structural Fill (1.2' thick) ("Moderate Risk Case")													
D1	*700*	*ln ft*	*16800*	*sq ft*	*0*	*cu yd*							
C1	*800*		*19200*		*0*								
A1	*860*		*20640*		*892*								
C2	*750*		*18000*		*389*								
A2	*260*		*6240*		*270*								
C3	*850*		*20400*		*881*								
A3	*615*		*14760*		*638*								
D2	*600*		*14400*		*622*								
Total	*5435*	*ln ft*	*130440*	*sq ft*	*3692*	*cu yd*	*4061*	*lcy*			*4061*	*lcy*	*6.1 (Alt. A's)*
Pavement Subbase (4" thick)													
D1	700	ln ft	16800	sq ft	207	cu yd							
C1	800		19200		237								
A1	860		20640		255								
C2	750		18000		222								
A2	260		6240		77								
C3	850		20400		252								
A3	615		14760		182								
D2	600		14400		178								
Total	5435	ln ft	130440	sq ft	1610	cu yd	1771	lcy			14493	sq yd	6.2
Pavement Base (4" thick)													
D1	700	ln ft	16800	sq ft	207	cu yd							
C1	800		19200		237								
A1	860		20640		255								
C2	750		18000		222								
A2	260		6240		77								
C3	850		20400		252								
A3	615		14760		182								
D2	600		14400		178								
Total	5435	ln ft	130440	sq ft	1610	cu yd	1771	lcy			14493	sq yd	6.3
Pavement Wearing Course (2" thick)													
D1	700	ln ft	16800	sq ft	104	cu yd							
C1	800		19200		119								
A1	860		20640		127								
C2	750		18000		111								
A2	260		6240		39								
C3	850		20400		126								
A3	615		14760		91								
D2	600		14400		89								
Total	5435	ln ft	130440	sq ft	805	cu yd	886	lcy			14493	sq yd	6.4

5 through 9 (as indicated)
Cost Estimate Quantities Summary
Draft Feasibility Study
Site/SWMU 3 - Causeway Landfill, Parris Island, South Carolina

									Quantity		Item
Channel (Marsh side)											
Riprap (10' width, 1.5' thick)											
D1	0	ln ft	0	sq ft	0	cu yd	0	tons			
C1	800		8000		444		660				
A1	860		8600		478		710				
C2	750		7500		417		619				
A2	260		2600		144		215				
C3	850		8500		472		701				
A3	615		6150		342		507				
D2	0		0		0		0				
Total	4135	ln ft	41350	sq ft	2297	cu yd	3411	tons	2297	cu yd	8.1
Wetland Replacement											
A1	860	ln ft	8.5	ft	7310	sq ft					
A2	260		8.5		2210						
A3	615		8.5		5228						
B1	3250		5.5		17875						
C1	800		12		9600						
C2	750		12		9000						
C3	850		12		10200						
C4	295		4		1180						
D1	0		0		0						
D2	0		0		0						
Total	7680	ln ft	71	ft	62603		1.4	acre	1.4	acre	7.2

Slope Stability (Feasibility Study)
Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carolina

By: RCM 05/14/99
Chk'd By: SAN 6/9/99

TtNUS Project No. ND7394
CTO 0020
Contract No. N62467-94-D-0888

PROBLEM STATEMENT:

Estimate the factor of safety for potential critical slope stability failure planes through the native soil/sediments at depth beneath the causeway landfill for existing conditions and for potential closure scenarios.

REFERENCES:

1. Document titled "RCRA Facilities Investigation for Site/SWMU 3 - Causeway Landfill, Marine Corps Recruit Depot, Parris Island, South Carolina, Volume I - Text" dated March 1999 prepared by Tetra Tech NUS, Inc., Pittsburgh, Pennsylvania.

2. Document titled "RCRA Facilities Investigation for Site/SWMU 3 - Causeway Landfill, Marine Corps Recruit Depot, Parris Island, South Carolina, Volume II - Appendices" dated March 1999 prepared by Tetra Tech NUS, Inc., Pittsburgh, Pennsylvania.

3. Drawings titled "Topographic Survey for Tetra Tech NUS, Inc., Site 3 - Causeway Landfill, Marine Corps Recruit Depot, Parris Island, Beaufort County, South Carolina" (5 sheets) prepared by Donaldson, Garrett & Associates, Inc. dated August 6, 1998.

4. Bowles, Joseph E., Foundation Analysis and Design, 3rd Edition, McGraw-Hill, New York, 1982.

5. Soil Mechanics, Design Manual 7.1, NAVFAC DM-7.1, May 1982.

6. Foundations and Earth Structures, Design Manual 7.2, NAVFAC DM-7.2, May 1982.

7. Winterkorn, H. F. and Fang, H.-Y., Foundation Engineering Handbook, Van Nostrand Reinhold, New York, 1975.

APPROACH:

The approach used to estimate the factor of safety for potential critical slope stability failure planes for existing conditions and for potential closure scenarios generally consisted of cutting a cross-section at the PAI-03-GW-04 location, using the stratigraphy from PAI-03-SB-01 and analyzing potential failure planes on the "pond" side of the causeway. The slope stability analysis was developed as follows:

- review existing ground surface topography (sheet 10, ref. 3) and potential closure scenario grades for potential critical cross-section location for use in subsequent analyses;
- review available geotechnical data for representative soil stratigraphy (sheets 11 through 15; Appendix A-2 of ref. 2);
- estimate soil properties for existing cover, fill material, waste/fill, native soil/sediments, and potential cover system materials for use in subsequent analysis;
- approximate water surface elevations adjacent to and within causeway landfill; and,
- perform slope stability analysis using the information determined above using the STABL5 computer software program.

SOLUTION:

Topography

The existing ground surface topography of the causeway landfill (ref. 3) was examined to determine areas where potential critical failure surfaces may develop. Both the "pond" or northeast side of the causeway and "marsh" or southwest side of the causeway were examined. The existing ground surface topography is relatively flat on the plateau of the causeway with maximum elevations varying from approximately 11 to 13. The maximum sideslope, for a relatively limited planar extent, is approximately 1.2H:1V (1.2H:1V and 1.3H:1V on "marsh" side approximately 350 and 190 feet southeast, respectively of surface soil sample location PAI 03 SS 012; sheet 1 of 5 of ref. 3). The maximum sideslope, for an area with fairly large planar extent, is 1.8H:1V on the "pond" side of the causeway near monitoring well PAI-03-GW-04 (sheet 10; sheet 1 of 5 of ref. 3). Based on TtNUS's 5/11/99 site visit portions of the causeway sideslope are vertical.

The maximum 1.2H:1V sideslope is not representative of typical causeway topography and was therefore not evaluated. The area with a sideslope of 1.8H:1V was selected as representative of site conditions. Areas with different subsurface conditions, steeper sideslope, etc. should be evaluated during the design stage. For purposes of the feasibility study these steeper areas may be mitigated, as necessary, to increase the

factor of safety against stability type failures by methods such as flattening the slope, installing sheet piles, installing gravity retaining structure, applying a toe buttress in the form of rip rap, etc.

A cross-section was constructed through the causeway at the PAI-03-GW-04 location using the ref. 3 ground surface topography for topography above the water surface. The topography beyond the water surface was estimated by extrapolating the sideslope topography to the base of the "pond" using the RCP culvert invert elevations. It was assumed that the bottoms of the "pond" and "marsh" are flat and at the invert elevation of the three 78-inch diameter RCP culverts (elevation -2.5 and -3.0, respectively)

The ground surface topography described above was subsequently used in the STABL5 slope stability analysis for existing conditions.

For potential closure scenarios the cross section plateau ground surface elevation was increased by a minimum of 3 feet and sloped a minimum of 3% to account for potential cover/cap placement. It was judged that an increase in the causeway plateau elevations will decrease the factor of safety because the driving forces increase. A cover/cap and/or riprap may be placed on the causeway sideslope and the sideslope ratio decreased which will increase the factor of safety because the resisting forces increase. Increasing only the causeway plateau elevations, therefore conservatively models potential closure scenarios for deep-seated and toe of slope stability failure modes.

The STABL5 software does not accept ground surface elevations below sea level (negative values). The ground surface topography obtained as described above was therefore input into the STABL5 software by increasing each elevation by 100 feet. Increasing the elevation by this amount allows potential critical failure surfaces to develop. The subsurface stratigraphy elevations, described below, were increased by 100 feet as well for purposes of STABL5 software analysis.

Subsurface Stratigraphy

Four soil borings (PAI-03-SB-01 through 04) were installed in the causeway at the locations shown on Figure 3-1 of ref. 1 (sheet 9). Monitoring wells (PAI-03-MW-01 through 04) were installed adjacent to the soil borings. Soil borings 1 and 2 were installed adjacent to each other. The causeway is therefore characterized geotechnically by three soil borings for a length of approximately 4,500 feet. The boring logs (sheets 11 through 15; Appendix A-2 of ref. 2) were reviewed and the stratigraphy conservatively determined considering depth of boring, sampling continuity, and consistency of stratigraphy between soil borings.

All four soil borings encountered soil which is very loose or very soft at varying depths and with varying thickness. Much of this soil was penetrated with the split-barreled sampler with weight of rod (WOR) and weight of hammer (WOH). The standard penetration resistance (N-value) is therefore zero and the corresponding shear strength is low. Note that N-values and shear strength are directly (empirically) related. The consistency of these soils, on a soil boring basis, is as follows:

Soil Boring	Consistency	Elevation Range	Description	Comments
SB-01	very loose/very soft	-8.0 to -26.0	Granular & cohesive	EOB @ elev. -30
	loose	4.0 to -8.0	granular	
SB-02	very loose/very soft	-12.1 to -14.1	granular	3.9 > -12.1 no data
	loose	-14.1 to -18.1	granular	EOB @ elev. -18.1
SB-03	very loose/very soft	3.2 to -0.8	granular	EOB @ elev. -4.8
	loose	NA		
SB-04	very loose/very soft	NA		
	loose	NA		

The WOH and WOR results for SB-01 have recoveries ranging from 6 to 24 inches with an average of 17.8 inches. It is therefore assumed that the penetration resistance is not a function of flowing or liquid conditions at the sampling location.

Soil Type 1: existing causeway cover including granular fill material; peak elevation of 13 and typically 2 feet thick

Soil Type 2: USCS classification SM and SP soil as well as waste; elevation extending down to elevation 4; N-values for this soil type are less than Soil Layer 1, therefore conservatively establish layer for modeling purposes from ground surface down to elevation 4 as Soil Layer 2; Soil Layer 1 properties will be used for the potential closure scenarios (cap/cover only)

Soil Type 3: loose granular and soft cohesive soil including waste; elevation 4 down to -8

Soil Type 4: very loose granular and very soft cohesive soil; elevation -8 down to -26

Soil Type 5: medium clay from -26 to end of boring (EOB) (SB-01 extended 30 bgs, for STABL modeling purposes assume layer extends to infinity)

The soil types with very loose/ very soft consistency from elevation -8.0 to -26.0 feet in SB-01 are sand and clay. Shear strength, τ ($\tau = c + N \tan \phi$) becomes much more dependent on the ϕ-value as depth increases. The very loose/very soft soil layer modeled from elevation. -8.0 to -26.0 is therefore further divided into a very loose granular layer from elevation -8.0 to -18.0 and a very soft clay layer from elevation -18.0 to -26.0 based on soil boring SB-01.

The soil layers derived from the soil borings are input into the STABL5 software as laterally continuous.

Material Properties

Material properties for the stability analysis were determined or estimated for each layer or stratigraphic unit as follows:

Existing Granular Cover/Potential Closure Cover (Soil Type 1 / Soil Layer 1):

The existing cover is granular material with medium to very dense consistency. The ϕ-value for this soil is approximately 35° or greater (sheet 17; ref. 4).

Friction Angle, Φ = 35° (conservative)
Cohesion Intercept, c = 0 lb/ft^2
Cohesion Intercept, c' = 0 lb/ft^2
Moist Unit Weight, γ_m = 110 lb/ft^3 (estimated)
Saturated Unit Weight, γ_{sat} = 130 lb/ft^3 (estimated)

Waste/Fill (Soil Type 2 / Soil Layer 2):

Waste/fill material is visually classified as USCS SM and SP with waste. The soil consistency is typically medium. The ϕ-value for this soil is approximately 30° or greater (sheet 17; ref. 4).

Friction Angle, Φ = 30° (conservative; consider also sheet 19 from ref. 6)
Cohesion Intercept, c = 0 lb/ft^2
Cohesion Intercept, c' = 0 lb/ft^2
Moist Unit Weight, γ_m = 100 lb/ft^3 (estimated)
Saturated Unit Weight, γ_{sat} = 120 lb/ft^3 (estimated)

Waste/Fill (Soil Type 3 / Soil Layer 3):

Waste/fill material is visually classified as clayey sand or clay. The consistency is loose and soft, respectively. If the soil is granular material the ϕ-value is approximately 27° to 32° (sheet 17; ref. 4) and if cohesive the unconfined compressive strength, q_u is 0.5 to 1.0 k/ft^2 or 500 to 1,000 lb/ft^2. The unconfined compression test is considered a special case of the unconsolidated-undrained test with confining pressure equal to zero (p. 115 ref. 7). Cohesion, c equals q_u / 2; cohesion is therefore 250 to 500 lb/ft^2. The soil is treated as a ϕ-c soil with shear strength parameters reduced accordingly.

Friction Angle, Φ = 19° (estimated)
Cohesion Intercept, c >> c' lb/ft^2 (consider also sheet 19 from ref. 6)
Cohesion Intercept, c' = 250 lb/ft^2 (estimated; consider also sheet 19 from ref. 6)
Moist Unit Weight, γ_m = 100 lb/ft^3 (estimated)
Saturated Unit Weight, γ_{sat} = 120 lb/ft^3 (estimated)

Native Soil (Soil Type 4 / Soil Layer 4):

Native soil comprising Soil Layer 4 is very loose sand. The ϕ-value for very loose sand is approximately 25 to 30° (sheet 17; ref. 4). The relative density of very loose sand is less than 20% (sheets 17 and 18; ref. 4 and 7). The ϕ-value may be estimated as 24 to 25° if the relationship between relative density and ϕ-value for sand is linear and can be extrapolated (see sheet 18 ref. 7). The ϕ-value is conservatively reduced.

Friction Angle, Φ = 19° (conservative; alternatively could use 23°)
Cohesion Intercept, c = 0 lb/ft^2
Cohesion Intercept, c' = 0 lb/ft^2
Moist Unit Weight, γ_m = 100 lb/ft^3 (estimated)
Saturated Unit Weight, γ_{sat} = 120 lb/ft^3 (estimated)

Native Soil (Soil Type 4 / Soil Layer 5):

Native soil comprising Soil Layer 5 is very soft clay. The unconfined compressive strength, q_u is less than 0.5 k/ft^2 or 500 lb/ft^2 (sheet 17 ref. 4). Cohesion, c equals q_u / 2; cohesion is therefore less than 250 lb/ft^2.

Friction Angle, Φ = 10° (conservative)
Cohesion Intercept, c >> c' (consider also sheet 19 from ref. 6)
Cohesion Intercept, c' = 250 lb/ft^2 (estimated; consider also sheet 19 from ref. 6)
Moist Unit Weight, γ_m = 125 lb/ft^3 (estimated)
Saturated Unit Weight, γ_{sat} = 130 lb/ft^3 (estimated)

Native Soil (Soil Type 5 / Soil Layer 6):

Native soil comprising Soil Layer 6 is medium clay. The unconfined compressive strength, q_u is ranges from 1.0 to 2.0 k/ft^2 or 1,000 to 2,000 lb/ft^2 (sheet 17 ref. 4). Cohesion, c equals q_u / 2; cohesion therefore ranges from 500 to 1,000 lb/ft^2.

Friction Angle, Φ = 0° (conservative; consider also sheet 19 from ref. 6)
Cohesion Intercept, c >> c' lb/ft^2 (consider also sheet 19 from ref. 6)
Cohesion Intercept, c' = 500 lb/ft^2
Moist Unit Weight, γ_m = 98.2 lb/ft^3 (geotechnical lab test result; Appendix A-5 of ref. 2)
Saturated Unit Weight, γ_{sat} = 105 lb/ft^3 (estimated)

Water Surface Elevations

The water surface elevation on the "pond" side of the causeway is controlled by 78-inch diameter RCP culverts and is tidally influenced. The culverts are obstructed on the "marsh" side to maintain the "pond" elevation. The opening in the culverts reportedly extends from the top of the culverts to approximately 1.5 feet below the top of the culverts (1.4 to 2.3 feet from TtNUS 5/11/99 site visit). The pond water surface is therefore typically at an elevation of approximately 2.7 (culvert invert elevation of -2.3 + (78/12) - 1.5 = 2.7). An elevation of 2.7 feet was used in the STABL5 analysis to represent long-term conditions. The 100-year flood elevation in the causeway area is at elevation 14 or 15 (Figure 2-1 of ref. 1) The ground surface elevation of the southeastern portion of Malecon Drive on the north side of the "pond" is at elevation 7 to 8.

The water surface elevation on the marsh side of the causeway is tidally influenced. For the cross section analyzed the potential critical failure planes occur on the side of the causeway with maximum sideslope or the "pond" side. The marsh water surface elevation therefore does not significantly influence the analysis performed.

The ground water elevation within the causeway generally varies from elevation 2.2 to 3.1 and from 2.5 to 27 in the area of the cross section analyzed at PAI-03-GW-04 (Table 3-10, ref. 1). A groundwater surface elevation of 2.5 was used at the center of the causeway in the analyses.

Analyses

The factor of safety was estimated for the following conditions:

1. existing topography, static loading, long-term conditions, deep failure under the toe encompassing the majority of causeway fill through medium clay (Soil Layer 6) to elevation -35: FS > 1.6 (BBA runs, not provided)
2. existing topography, static loading, long-term conditions, deep failure under toe encompassing almost 1/2 of causeway fill through very loose sand and very soft clay (Soil Layers 4 and 5) to elevation -20: FS ≈ 1.7 (BBB04, not provided)
3. existing topography, static loading, long-term conditions, failure under toe through very loose sand (Soil Layer 4) to elevation -11: FS ≈ 1.4 (BBB06, not provided)
4. existing topography, static loading, short-term conditions (pond surface water breaches and saturates causeway and immediately recedes to pond bottom ...unlikely scenario), deep failure under toe encompassing almost 1/2 of causeway fill through very loose sand (Soil Layer 4) to elevation -23: FS ≈ 1.0 (BBB09, not provided)
5. potential closure scenario, static loading, long-term conditions, deep failure under toe encompassing almost 1/2 of causeway fill through med. clay (Soil Layer 5) to elevation -20: FS ≈ 1.5 (BBC01, sheets 20 through 26)
6. potential closure scenario, static loading, long-term conditions, pond bottom elevation dropped 3 feet to elevation -5.5, deep failure under toe through very loose sand (Soil Layer 4) to elevation -13: FS ≈ 1.1 (BBD03, sheets 27 through 33)

The critical failure planes for the analysis described above are shown on sheet 34.

CONCLUSIONS/RECOMMENDATIONS:

The factors of safety for critical circular slope stability failure planes under and through the native soil/sediments at depth beneath the causeway waste/fill for long- and short-term conditions under existing and potential closure scenarios are judged to range from marginal to acceptable based on the analysis performed. The stability of specific potential closure cover and cap options was not evaluated but are judged to be feasible.

Factors which may directly effect the analyses performed, in order of importance, are as follows:

- shear strength of native very soft to soft clay and very loose to loose sand;
- topography beyond ref. 3 limits (topography below water surface including "pond" and "marsh");
- topography of ref. 3 reportedly generated using coordinate and elevation data for surface soil and sediment sampling locations; sampling locations selected based on accessibility; steeply sloped or vertical faced slopes were not accessible and were therefore not sampled; topography presumably generated using sampling location survey data and by interpolation between these points which may therefore not be representative of site conditions;

- dynamic (seismic) analyses;
- geotechnical characterization of soil/sediment immediately adjacent to causeway;
- effect of potential dredging/sediment removal on topography and stability;
- areas where sideslope ratio is near, or exceeds, 1.8H:1V;
- potential closure scenarios regarding cover system and limits (material thickness, grade, strength, etc.); and
- potential closure scenarios regarding erosion protection, slope stabilization such as rip rap placement.

The analyses presented are based on limited geotechnical data. At a minimum, the very loose, loose, very soft and soft soils underlying the waste/fill should be further geotechnically characterized by 1) advancing borings through the causeway and into the underlying materials, 2) obtaining continuous samples, 3) obtaining undisturbed (Shelby tube) samples where appropriate or conducting in-situ testing, and 4) performing geotechnical laboratory testing including triaxial shear strength tests.

[Note: Based on site reconnaissance performed by TtNUS on May 11, 1999, the causeway sideslopes appear to be steeper than the grades depicted on the topographic survey of reference 3. Portions of the causeway sideslope appear to be vertical or have been undercut by tidal action. In addition, the "marsh" area immediately adjacent to and paralleling the causeway may be undercut to a depth of approximately 1 to 2 feet in some areas.

The preceding calculation did not include a factor of safety estimate for shallow failure circles with initiation points at or near the sideslope toe of slope, sideslope veneer failures, or other shallow failures. The analysis estimated the stability of potential critical slope stability failure planes involving the majority of the causeway waste/fill mass that if failure were to occur would result in relatively large failures (in areal extent). The existing sideslope conditions and stability were not evaluated and should be addressed as part of the closure design. In addition, dynamic (seismic) stability analyses should be performed as well as consideration of sensitivity of clay/liquefaction of sand underlying the causeway.]

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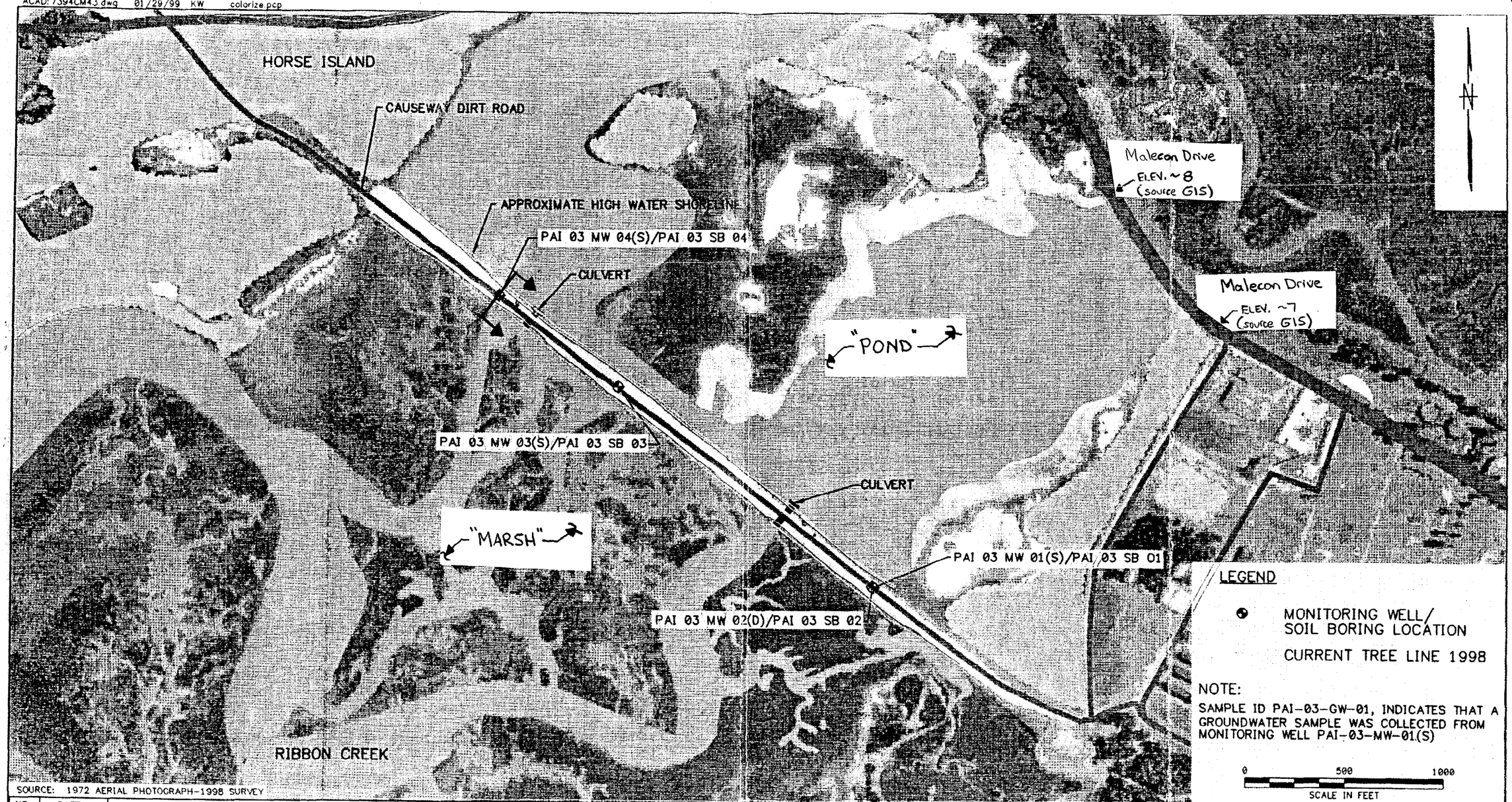


SOURCE: 1972 AERIAL PHOTOGRAPH-1998 SURVEY

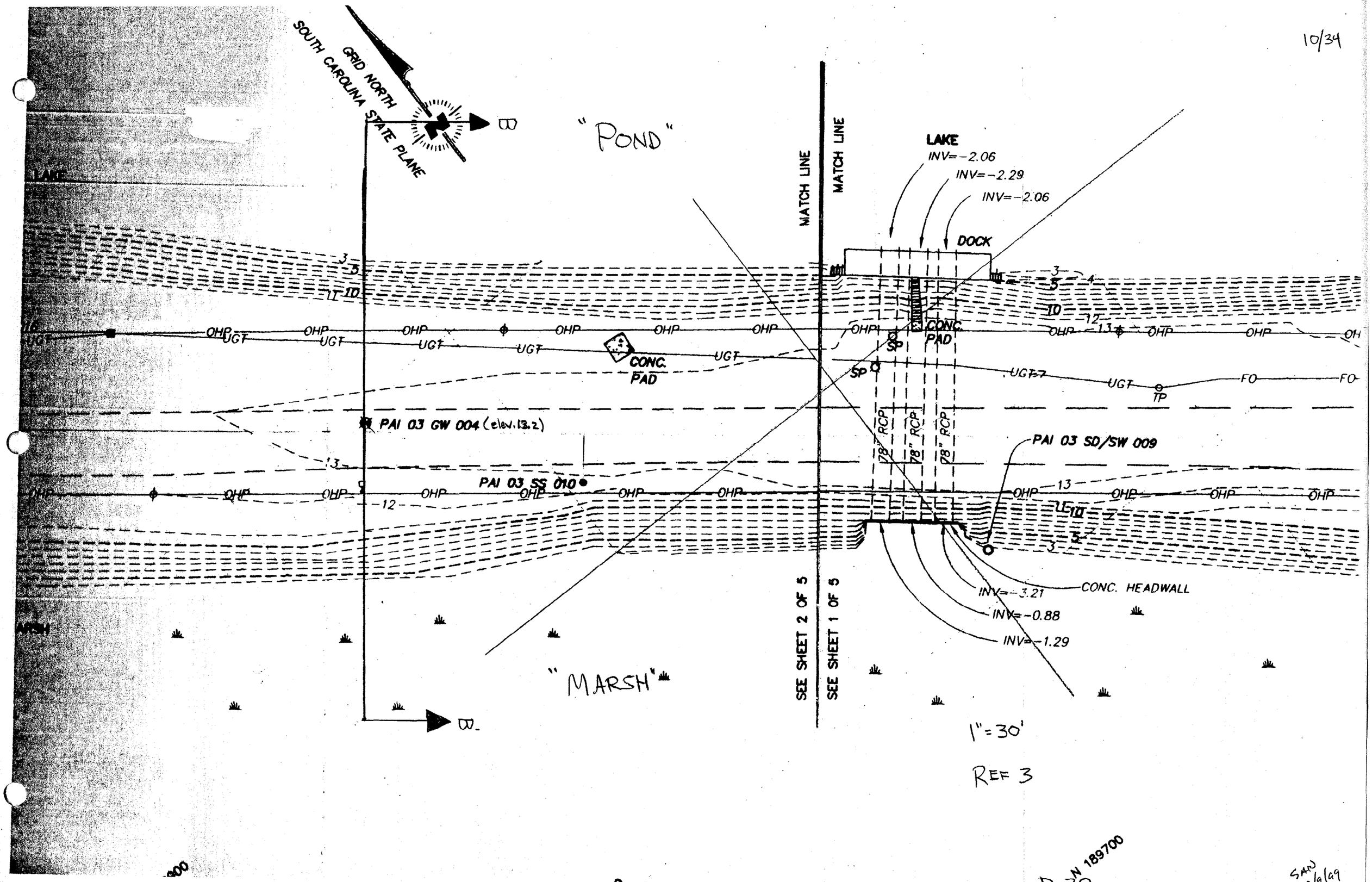
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/30/98
CHECKED BY SAN DATE 6/9/99
COST/SCHED-AREA
SCALE AS NOTED

MONITORING WELL AND SOIL BORING
SAMPLE LOCATION MAP
SITE 3-CAUSEWAY LANDFILL
MCRD PARRIS ISLAND, SOUTH CAROLINA

CONTRACT NO. 7394
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3-1
REV. 0

FORM CADD NO. SDIV_RH.DWG - REV 0 - 1/20/98


GRID NORTH
SOUTH CAROLINA STATE PLANE
E
"POND"
LAKE
MATCH LINE
MATCH LINE
LAKE
INV=-2.06
INV=-2.29
INV=-2.06
DOCK
CONC. PAD
CONC. PAD
SP
SP
TP
OHP
UGT
FO
PAI 03 GW 004 (elev. 13.2)
PAI 03 SS 010
PAI 03 SD/SW 009
78" RCP
78" RCP
78" RCP
CONC. HEADWALL
INV=-3.21
INV=-0.88
INV=-1.29
SEE SHEET 2 OF 5
SEE SHEET 1 OF 5
"MARSH"
W
1"=30'
REF 3
N 189700
D-70
SAW 6/9/99

BORING LOG

PROJECT NAME: MCRD - Parris Island
PROJECT NUMBER: 7394
DRILLING COMPANY: Parratt Wolff
DRILLING RIG: CME 850 TRAC RIG
BORING NUMBER: PAI-03-SB-01
DATE: 7/8/98
GEOLOGIST: G. Gunter
DRILLER: L. LeGrand

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
		7/4	6"										
14	26-28	2/2			V. Loose	Gray	Same	SW		0	0	0	0
		2/2	18"	28									
15	28-30	WOH/WOH			V. Soft	Gray Grn	CLAY	CL	1/8" F Sand Seams	0	0	0	0
		WOH/WOH	24"						Throughout. Dry				
16	30-32	WOH/WOH			V. Soft	Gray Grn	Same	CL	Dry	0	0	0	0
		WOH/WOH	24"										
17	32-34	WOH/WOH			V. Soft	Gray Grn	Same	CL	Dry	0	0	0	0
		WOH/WOH	24"										
18	34-36	WOH/WOH			V. Soft	Gray Grn	Same	CL	1/16" F Sand Seams	0	0	0	0
		WOH/WOH	24"						Throughout, Dry				
19	36-38	2/2			Firm	Gray Grn	CLAY	CL	moist	0	0	0	0
		3/2	24"										
20	38-40	2/2			Soft	Gray Grn	CLAY	CL	Slight moist	0	0	0	0
		2/2	24"	40									

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: SEE Pg 1

Drilling Area Background (ppm): 0

Converted to Well: Yes ✓ No ____ Well I.D. #: ____

BORING LOG

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PROJECT NAME: MCRD - Parris Island
PROJECT NUMBER: 7394
DRILLING COMPANY: Parratt Wolff
DRILLING RIG: CME 850 TRAC RIG
BORING NUMBER: PAI-03-SB01
DATE: 7/8/98
GEOLOGIST: G. GUNTER
DRILLER: L. LEFEVER

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1	0-2	- / 22		0.5			0.5FT Crusher Run		FILL	0	0	0	0
		20 / 15	18"		Firm	Brn	F/med SAND w/Tr. Silt	SP					
2	2-4	6 / 7			Firm	Brn	F SAND w/Tr. Silt	SP	Green mottling	0	0	0	0
		7 / 12	24"	4					Staining Fill				
3	4-6	5 / 5			Firm	Brn	Silty F SAND	SM	Grn mottling, Stain	0	0	0	0
		6 / 3	16"	6					moist Fill				
4	6-8	3 / 3			Loose	Brn	F SAND w/ Garbage	SP	Plastic & Newspaper	0	0	0	0
		6 / 5	6"						Fill				
5	5-10	4 / 4			Loose	Brn	Same	SP	Metal Garbage	0	0	0	0
		3 / 3	4"						Fill				
-	10-12	2 / 1		10.5	Soft	Grn	Clay	CL	2" F Sa Seams @	0	0	[illegible]	[illegible]
		2 / 3	24"	12					11FT & 11.5F				
7	12-14	4 / 5			Loose	Grn	Clayey F SAND	SC		0	0	0	0
		5 / 5	20"										
8	14-16	3 / 1			V. Loose	Grn	Same	SC	Brn mottling	0	0	0	0
		1 / 1	20"	16									
9	16-18	1 / 2			V. Loose	Gray to Brn	F SAND	SP	1/8" Clay Seams	0	0	0	0
		1 / 5	24"						every 3/4" last 8"				
10	18-20	WOH / WOH			V. Loose	Brn to DGray	F/med SAND w/Tr Silt & Clay	SP		0	0	0	0
		WOH / WOH	24"										
11	20-22	WOR / WOR			V. Loose	Gray	F/Co SAND	SW	1/2" Clay Seams	0	0	0	0
		WOR / WOR	10"						in upper 4"				
12	22-24	WOR / 4			Loose	Gray	Same	SW		0	0	0	0
		6 / 7	6"										
13	24-26	WOH / WOH			Loose	Gray	Same	SW	Trace Mica	0	0	0	0

* When rock coring, enter rock brokeness.

[1]Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): [illegible]

Remarks: Boring Abandoned by Grouting to Surface. Soil Log USED For wells PAI-03-MW01 & PAI-03-MW02 Located adjacent to boring

Converted to Well: [1]Yes ____ No ✓ Well I.D. #: ____

SKD 6/9

BORING LOG

PROJECT NAME: MCRD - Parris Island
PROJECT NUMBER: 7394
DRILLING COMPANY: Parratt Wolff
DRILLING RIG: CME 850TRAC RIG
BORING NUMBER: PAI-03-SB-02
DATE: 7/9/98
GEOLOGIST: G GUNTER
DRILLER: L. LEFEVER

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1	0-2	- / 20					0.5 FT CRUSHER RUN			0	0	0	0
		21 / 17	18"		Loose	Brn	F/med SA w/TR SILT	SP					
2	2-4	5 / 8			Firm	Brn	FSA w/TR. Silt	SP	Sm MOTTLED, STAINING	0	0	0	0
		8 / 13	24"										
3	4-6	5 / 5			Firm	Brn	Silty F SAND	SM	Sm mottling	0	0	0	0
		7 / 4	18"						Last 6" moist				
							AUGER BORE to						
							22 FT						
4	22-24	2 / 2			V. Loose	Gray	F/co SAND w/TR SILT	SW		0	0	0	0
		2 / 8	24"										
5	24-26	6 / 5			Loose	Gray	F/co SAND w/TR. CL	SW		0	0	0	0
		3 / 2	18"										
6	26-28	6 / 6			Loose	Gray	F/co SAND	SW		0	0	0	0
		3 / 2	24"										
7	28-30	- / -			-		CLAY	CL	Shelby Tube	-	-	-	-
		- / -											

* When rock coring, enter rock brokeness.

Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks: RESAMPLED INTERVALS FOR SOIL SAMPLING
2 IN. Well set to 29 FT (5 FT Screen) SAND To 22, Bentonite to 20
Grout to Surface

Converted to Well: Yes ✓ No ____ Well I.D. #: PAI-03-MW02

BORING LOG

PROJECT NAME: MCRD - Parris Island
PROJECT NUMBER: 7394
DRILLING COMPANY: Parratt Wolff
DRILLING RIG: CME 850 TRAC RIG
BORING NUMBER: PAI-03-MW03
DATE: 7/10/98
GEOLOGIST: G GUNTER
DRILLER: L. LEFEVER

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1	0-2	- / 7					0.5 FT Crusher Run			0	0	0	0
		18 / 23	8"		Dense	Brn Grn	Si F SAND w/gravel	SM	FILL				
2	2-4	19 / 7			Firm	Brn Grn	Same	SP	Blk Staining,	0	0	0	0
		7 / 9	10"						Pieces of Tin Fill				
3	4-6	8 / 9			Firm	Brn	Same	SP	Tin - FILL	0	0	0	0
		6 / 7	4"										
4	6-8	9 / 9			Firm	Brn	Same	SP	Old Newspaper	2	0	0	0
		8 / 7	4"						FILL				
5	8-10	6 / 5		8	Firm	Gray	F/Co SAND	SW	Pieces of Tin, Shoe	0	0	0	0
		5 / 3	4"						wet FILL				
6	10-12	2 / 2		10	SOFT	Blk Grn	F Sandy SILT w/gravel	SM	w/ Glass & Tin,	2.6	0	0	
		1 / 2	2"						Wet FILL				
7	12-14	1 / 1		12	SOFT	Blk	F/Co Sandy SILT	SM		7.5	0	0	0
		2 / 1	15"										
8	14-16	2 / 2		14	Firm	Gray Grn	F Sandy CLAY	CL		1.2	0	0	0
		4 / 6	18"										
9	16-18	15 / 12		16	Firm	Gray Grn	Clayey F. SAND	SC		0	0	0	0
		14 / 13	15"										
				18									

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks: 2" well set to 15 Ft (0.010 Screen 10 Ft)
Sand to 13 Ft, Bentonite to 4 Ft, Grout to surface.

Converted to Well: Yes ✓ No _____ Well I.D. #: PAI-03-MW03

BORING LOG

PROJECT NAME: MCRD - Parris Island
PROJECT NUMBER: 7394
DRILLING COMPANY: Parratt Wolff
DRILLING RIG: CME 850 TRAC RIG
BORING NUMBER: PAI-03-SB-04
DATE: 7/10/98
GEOLOGIST: G. GUNTER
DRILLER: L. LeFever

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
1	0-2	— / 22					0.5 FT Crusher Run			8.5	0	0	0
		20 / 15	5"	2	Dense	Brn	F/med Sand	SP					
2	2-4	8 / 9			Firm	Brn	Silty F/Co Sand w/	SM	garbage & wood	325	122	0	0
		11 / 12	6"	4			Gravel		debris				
3	4-6	7 / 12			Firm	Tan Brn	F/med Sand	SP	wood debris	241	0	45.6	0
		13 / 8	20"	6									
4	6-8	7 / 7			Firm	Brn	F Sand	SP	Moist	3.2	0	44.5	0
		8 / 20	12"										
5	8-10	22 / 17			Dense	DK Brn	F Sand w/tr. Silt	SP	2" Coarse Sa	75	0	46	0
		19 / 26	18"	10					Seam @ 9 FT				
	10-12	7 / 13			Firm	DK Brn	F/Co Sand w/tr. Silt	SM	wet Sand	0	0	0	0
		14 / 12	19"	12					Brick & wood Frag.				
7	12-14	9 / 9			V. Dense	Blk	Silty F/med Sand	SM	Brick Frag.	0	0	0	0
		50/3" / —	12"	14					wet				
8	14-16	22 / 15			—	Blk	No Soil	—	wood Frag.	3	0	0	0
		50/3" / —	8"										
9	16-18	50/3" / —			—	Blk	No Soil	—	wood Frag.	0	0	0	0
		— / —	3"	18									

* When rock coring, enter rock brokeness.

**Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: 2" well set to 18 FT (0.010 Screen 10 FT). Sand to 5.3 FT, Bentonite — 2.7 FT Grout to Surface

Drilling Area Background (ppm): 0

Converted to Well: Yes ✓ No ____ Well I.D. #: PAI-03-MW-04

Table 7.4 Standard Penetration Test

Relative Density of Sand		Strength of Clay		
Penetration Resistance N (blows/ft)	Relative Density	Penetration Resistance N (blows/ft)	Unconfined Compressive Strength (tons/ft²)	Consistency
0–4	Very loose	<2	<0.25	Very soft
4–10	Loose	2–4	0.25–0.50	Soft
10–30	Medium	4–8	0.50–1.00	Medium
30–50	Dense	8–15	1.00–2.00	Stiff
>50	Very dense	15–30	2.00–4.00	Very stiff
		>30	>4.00	Hard

From Terzaghi and Peck, 1948.

In certain countries, such as Holland, subsoil conditions are such that penetration testing has proved to be a relatively reliable technique. More sophisticated techniques [such as the friction jacket cone (Begemann, 1953)] have been widely used.

The vane test has proved to be a very useful method of determining the shear strength of soft clays and silts. Figure 7.6 shows various sizes and shapes of vanes which have been used for field testing. The vane is forced into the ground and then the torque required to rotate the vane is measured. The shear strength is determined from the torque required to shear the soil along the vertical and horizontal edges of the vane.

As later chapters in this book will show, a proper subsoil investigation should include the determination of water pressure at various depths within the subsoil. Methods of determining pore water pressure are discussed in Part IV. Part IV also notes how the permeability of a subsoil can be estimated from pumping tests.

Various load tests and field compaction tests may be highly desirable in important soil projects. In this type of test, a small portion of the subsoil to be loaded by the prototype is subjected to a stress condition in the field which approximates that under the completed structure. The engineer extrapolates the results of the field tests to predict the behavior of the prototype.

7.7 SUBSOIL PROFILES

Figures 7.7 to 7.17 present a group of subsoil profiles and Table 7.5 gives some information on the geological history of the various profiles. The purposes of presenting these profiles are to:

1. Indicate how geological history influences soil characteristics.
2. Give typical values of soil properties.
3. Show dramatically the large variability in soil behavior with depth.
4. Illustrate how engineers have presented subsoil data.

Three considerations were used in the selection of the profiles: first, examples were chosen with different types of geological history; second, most of the profiles are ones for which there are excellent references giving considerably more detail on the characteristics of the soil and engineering problems involved with the particular profile; and finally, most of the profiles selected have been involved in interesting and/or important soil engineering projects.

Some of the soil characteristics shown in the profiles have already been described in this book. These characteristics include water content, unit weight, void ratio, porosity, Atterberg limits, and particle size. Other characteristics, particularly those referring to strength and compressibility, will be discussed in detail in later portions of this book. Reference will then be made back to these profiles.

The profiles illustrate many concepts presented in the preceding parts of this book; some of them are discussed in the remaining part of this section.

Stress History

In a normally consolidated sedimentary soil both the void ratio and water content decrease with depth in the profile, and the strength therefore increases. This characteristic is illustrated in several of the profiles, e.g., the Norwegian marine clay (Fig. 7.7), the Thames Estuary clay (Fig. 7.10), and the Canadian clay (Fig. 7.11). The London clay is overconsolidated since it was compressed by a greater overburden than now exists. Erosion removed some of the original overburden. As would be expected, the overconsolidated London clay does not

from Lambe, T.W. & Whitman, R.V., Soil Mechanics, Wiley & Sons, N.Y., 1969

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Table 3-2 Empirical values for ϕ, D_r, and unit weight of granular soils based on the standard penetration number with corrections for depth and for fine saturated sands.

Description	Very loose	Loose	Medium	Dense	Very dense
Relative density D_r*	0 — 0.15	0.15 — 0.35	0.35 — 0.65	0.65 — 0.85	0.85 — 1.00
Standard penetration no. N	5–10	8–15	10–40	20–70	> 35
Approx. angle of internal friction ϕ°†	25–30°	27–32°	30–35°	35–40°	38–43°
Approx. range of moist unit weight γ, pcf (kN/m³)	70–100‡ (11–16)	90–115 (14–18)	110–130 (17–20)	110–140 (17–22)	130–150 (20–23)

* Depends on p_o ranging from 70 to 500 kPa. Low value of N corresponds to lesser p_o.

† After Meyerhof (1956). $\phi = 25 + 25D_r$ with more than 5 percent fines and $\phi = 30 + 25D_r$ with less than 5 percent fines. Use larger values for granular material with 5 percent or less fine sand and silt. See also Eq. (4-10) for estimate of ϕ.

‡ It should be noted that excavated material or material dumped from a truck will weigh 70 to 90 pcf. Material must be quite dense and hard to weigh much over 130 pcf. Values of 105 to 115 pcf for nonsaturated soils are common.

Table 3-3 Empirical values for q_u* and consistency of cohesive soils based on the standard penetration number.

Consistency	Very soft	Soft	Medium	Stiff	Very stiff	Hard
q_u, ksf (kPa)	0 — 0.5 (25)	0.5 — 1.0 (50)	1.0 — 2.0 (100)	2.0 — 4.0 (200)	4.0 — 8.0 (400)	
N, standard penetration resistance	0 — 2	2 — 4	4 — 8	8 — 16	16 — 32	
γ_{sat}, pcf (kN/m³)	100–120 (16–19)		110–130 (17–20)		120–140 (19–22)	

* These values should be used as a guide only. Local cohesive samples should be tested, and the relationship between N and the unconfined compressive strength q_u established as $q_u = KN$.

estimated foundation base. Sometimes the borings are extended to bedrock; however, at greater depths the SPT may be done at 5-ft or 2-m increments. The term "estimated" is used extensively here since these data are not precisely known at the time of the exploration.

Empirical correlations, such as Table 3-2, between N and various soil properties have been made for cohesionless soils. The low values for N correspond roughly to p_o of 75 kPa, the higher to about 500 kPa. Tables such as Table 3-2 should always be used with caution.

Table 3-3 is an empirical correlation between N and unconfined compressive strength. These should be used even more cautiously than for cohesionless soils. It is preferable to measure q_u directly on samples than use a table such as this. Alternatively, a table might be developed locally which has some validity by measuring q_u and N and solving

$$q_u = KN$$

for the constant of proportionality K. The reason for poor correlation of q_u versus N tables is that inadvertent changes in water content, excess pore pressures during sampling, and other factors may give very low blow counts, say 6 to 10, on soils where the measured q_u may be on the order of 300 to 600 kPa. Note in Table 3-3 the value of K is approximately 0.25.

Bowles, J.E. Foundation Analysis and Design Third Edition, McGraw-Hill, New York 1982.

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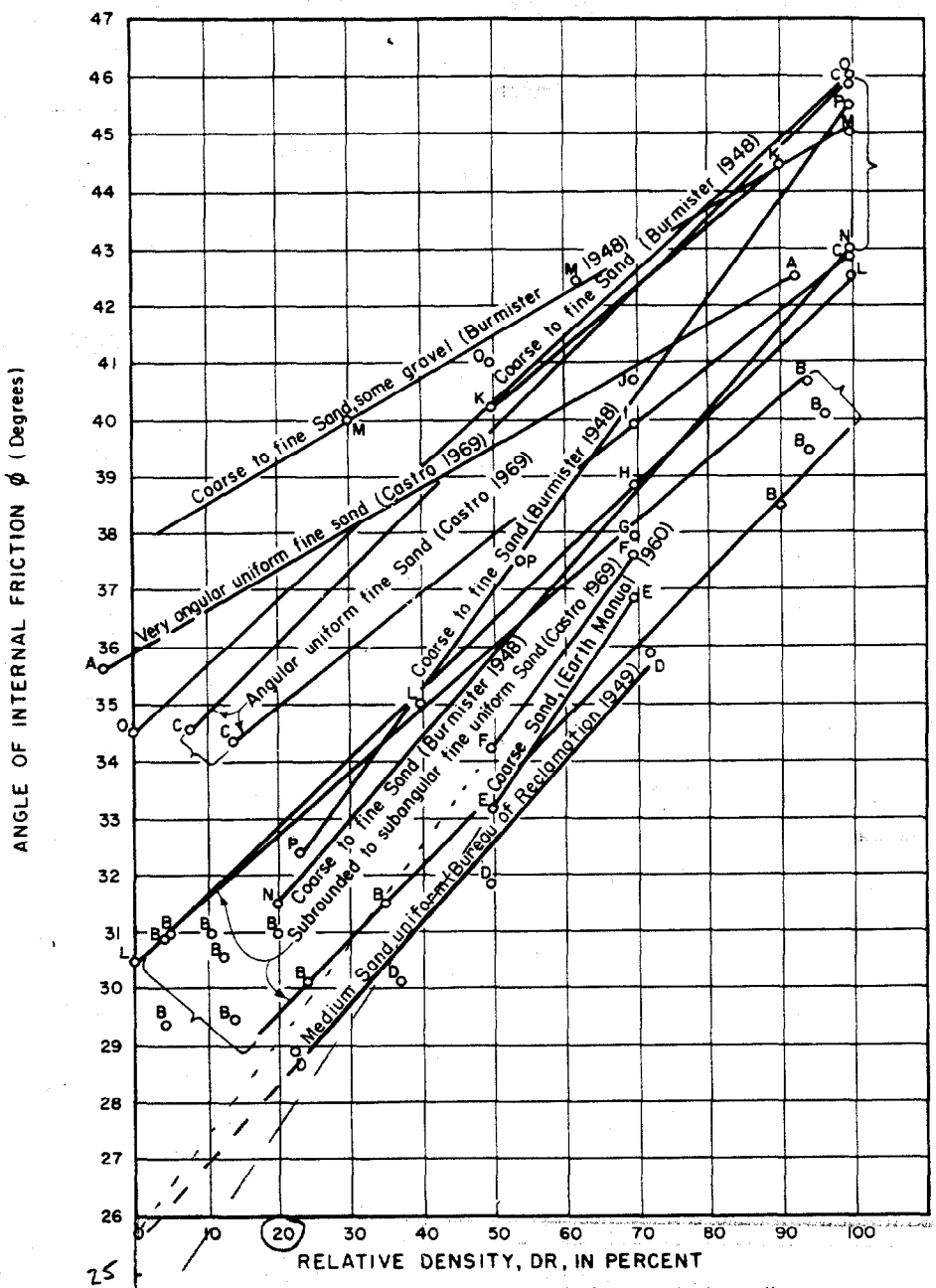

Fig. 7.26 Relative density vs. friction angle for cohesionless soils.

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TABLE 2.43 RELATIONSHIP BETWEEN RELATIVE DENSITY, PENETRATION RESISTANCE, AND ANGLE OF INTERNAL FRICTION OF COHESIONLESS SOILS.

Type of Soil	Penetration Resistance N	Relative Density D_r	Angle of Internal Friction φ: Peck (1974)	Angle of Internal Friction φ: Meyerhof (1956)
Very loose sand	<4	<0.2	<29	<30
Loose sand	4–10	0.2–0.4	29–30	30–35
Medium sand	10–30	0.4–0.6	30–36	35–40
Dense sand	30–50	0.6–0.8	36–41	40–45
Very dense sand	>50	>0.8	>41	>45

Winterkorn, H.F. and Fang, H-Y., Foundation Engineering Handbook, Van Nostrand Reinhold, New York, 1975.

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TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

Foundations and Earth Structures, Design Manual 7.2, NAVFAC DM-7.2, May 1982

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** PCSTABL5 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	5/7/99
Time of Run:	13:32
Run By:	rcm
Input Data Filename:	bbc01in.txt
Output Filename:	bbc01out.txt

PROBLEM DESCRIPTION BBC01IN

BOUNDARY COORDINATES

13 Top Boundaries
21 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	97.50	123.00	97.50	3
2	123.00	97.50	164.10	97.50	3
3	164.10	97.50	174.00	103.00	3
4	174.00	103.00	175.70	104.00	3
5	175.70	104.00	189.00	112.00	2
6	189.00	112.00	196.50	115.00	1
7	196.50	115.00	230.50	116.00	1
8	230.50	116.00	264.00	114.00	1
9	264.00	114.00	272.00	111.00	1
10	272.00	111.00	275.00	110.00	2
11	275.00	110.00	290.00	104.00	2
12	290.00	104.00	307.50	97.00	3
13	307.50	97.00	340.00	97.00	3
14	189.00	112.00	221.50	113.00	2
15	221.50	113.00	233.00	113.20	2
16	233.00	113.20	250.00	113.00	2
17	250.00	113.00	262.00	112.00	2
18	262.00	112.00	272.00	111.00	2
19	.00	92.00	340.00	92.00	4
20	.00	82.00	340.00	82.00	5
21	.00	74.00	340.00	74.00	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	130.0	.0	35.0	.00	.0	

1							
	2	100.0	120.0	.0	30.0	.00	.0
1							
	3	100.0	120.0	250.0	19.0	.00	.0
1							
	4	100.0	120.0	.0	19.0	.00	.0
1							
	5	125.0	130.0	250.0	10.0	.00	.0
1							
	6	98.2	105.0	500.0	.0	.00	.0
1							

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 6 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	102.70
2	174.00	102.70
3	233.00	102.50
4	290.00	101.00
5	307.50	97.00
6	340.00	97.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = .00 ft.
and X = 164.00 ft.

Each Surface Terminates Between X = 220.00 ft.
and X = 307.50 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

12.00 ft. Line Segments Define Each Trial Failure Surface.

The Factor Of Safety For The Trial Failure Surface Defined By The Coordinates Listed Below Is Misleading.

<<DELETED>>

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 10 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	138.11	97.50
2	146.88	89.31
3	157.36	83.47
4	168.93	80.31
5	180.93	80.02
6	192.65	82.63
7	203.39	87.97
8	212.54	95.73
9	219.56	105.46
10	223.72	115.80

*** 1.480 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	138.11	97.50
2	148.59	91.66
3	160.04	88.08
4	171.98	86.90
5	183.92	88.17
6	195.34	91.84
7	205.78	97.75
8	214.80	105.67
9	222.03	115.25
10	222.27	115.76

*** 1.506 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	138.11	97.50
2	148.03	90.76
3	159.12	86.17
4	170.90	83.90
5	182.90	84.07
6	194.62	86.65
7	205.58	91.54
8	215.32	98.55
9	223.45	107.38
10	228.59	115.94

*** 1.516 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	138.11	97.50
2	146.61	89.04

3	156.77	82.65
4	168.08	78.65
5	180.00	77.23
6	191.93	78.47
7	203.31	82.30
8	213.56	88.53
9	222.19	96.87
10	228.78	106.90
11	232.17	115.90

*** 1.532 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	129.47	97.50
2	137.97	89.03
3	147.98	82.41
4	159.11	77.91
5	170.90	75.72
6	182.90	75.91
7	194.62	78.49
8	205.60	83.34
9	215.39	90.28
10	223.60	99.03
11	229.92	109.23
12	232.38	115.89

*** 1.570 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	155.37	97.50
2	165.73	91.45
3	177.30	88.26
4	189.30	88.14
5	200.93	91.10
6	211.41	96.95
7	220.05	105.28
8	226.26	115.55
9	226.35	115.88

*** 1.573 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	155.37	97.50
2	165.36	90.86
3	176.71	86.94
4	188.67	86.00

5	200.48	88.10
6	211.39	93.10
7	220.70	100.68
8	227.79	110.35
9	230.04	115.99

*** 1.609 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	120.84	97.50
2	129.76	89.47
3	140.09	83.35
4	151.41	79.38
5	163.29	77.71
6	175.27	78.40
7	186.88	81.43
8	197.67	86.67
9	207.23	93.94
10	215.16	102.94
11	221.18	113.32
12	222.01	115.75

*** 1.611 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	155.37	97.50
2	164.16	89.33
3	174.86	83.89
4	186.64	81.62
5	198.59	82.68
6	209.79	86.99
7	219.37	94.22
8	226.58	103.80
9	230.88	115.01
10	230.96	115.97

*** 1.615 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	129.47	97.50
2	137.98	89.04
3	147.87	82.24
4	158.81	77.31
5	170.46	74.42
6	182.44	73.66
7	194.35	75.05

8	205.83	78.55
9	216.50	84.05
10	226.01	91.37
11	234.06	100.26
12	240.39	110.46
13	242.30	115.30

*** 1.622 ***

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                    Y           A     X     I     S           F     T

                    .00     42.50     85.00    127.50    170.00
212.50

          X       .00 +---------+------*-*+-**W-----+---------+---------
+
                      -                    ...
                      -                  . ...
                      -                  ....
                      -               .......
                      -              ........
                42.50 +              ........
                      -            ..........
                      -           ...........
                      -           ...........
                      -          ............
                      -         .............
          A     85.00 +          ............
                      -        ..............
                      -        ..............
                      -      ................
                      -      ................
                      -      ...............*
          X    127.50 +      .............8.5
                      -      ............5.1
                      -     ............8...
                      -     ...........5.12.
                      -     ..........541..6
                      -     ..........8..26*
          I    170.00 +     ..........512...
                      -     ..........4.76..*
                      -      ........05132..
                      -      .........4136... *
                      -      ..........9862... *
                      -       ........045132..
          S    212.50 +       ..........947182
                      -        .........0.9471.*
                      -        ..........0.59351
                      -         ............W..*
                      -         ..............00
                      -          ..............*
               255.00 +           ..............
                      -            ...........**
                      -            ...........*.
                      -              .........*
                      -               ........
                      -                .....*.
          F    297.50 +                 .....
                      -                   .*
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                 -
                 -
T      340.00 +                  * *  **
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** PCSTABL5 **
by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 5/7/99
Time of Run: 14:25
Run By: rcm
Input Data Filename: bbd03in.txt
Output Filename: bbd03out.txt

PROBLEM DESCRIPTION BBD03IN

BOUNDARY COORDINATES

13 Top Boundaries
21 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	94.50	123.00	94.50	3
2	123.00	94.50	158.70	94.50	3
3	158.70	94.50	174.00	103.00	3
4	174.00	103.00	175.70	104.00	3
5	175.70	104.00	189.00	112.00	2
6	189.00	112.00	196.50	115.00	1
7	196.50	115.00	230.50	116.00	1
8	230.50	116.00	264.00	114.00	1
9	264.00	114.00	272.00	111.00	1
10	272.00	111.00	275.00	110.00	2
11	275.00	110.00	290.00	104.00	2
12	290.00	104.00	307.50	97.00	3
13	307.50	97.00	340.00	97.00	3
14	189.00	112.00	221.50	113.00	2
15	221.50	113.00	233.00	113.20	2
16	233.00	113.20	250.00	113.00	2
17	250.00	113.00	262.00	112.00	2
18	262.00	112.00	272.00	111.00	2
19	.00	92.00	340.00	92.00	4
20	.00	82.00	340.00	82.00	5
21	.00	74.00	340.00	74.00	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	110.0	130.0	.0	35.0	.00	.0	1

	2	100.0	120.0	.0	30.0	.00	.0
1							
	3	100.0	120.0	250.0	19.0	.00	.0
1							
	4	100.0	120.0	.0	19.0	.00	.0
1							
	5	125.0	130.0	250.0	10.0	.00	.0
1							
	6	98.2	105.0	500.0	.0	.00	.0
1							

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 6 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	102.70
2	174.00	102.70
3	233.00	102.50
4	290.00	101.00
5	307.50	97.00
6	340.00	97.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 130.00 ft.
and X = 150.00 ft.

Each Surface Terminates Between X = 190.00 ft.
and X = 210.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	150.00	94.50
2	154.02	91.52
3	158.50	89.31

4	163.31	87.93
5	168.28	87.44
6	173.27	87.85
7	178.10	89.15
8	182.61	91.29
9	186.68	94.20
10	190.15	97.80
11	192.93	101.95
12	194.91	106.54
13	196.04	111.41
14	196.21	114.88

*** 1.061 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	146.84	94.50
2	150.82	91.46
3	155.21	89.08
4	159.92	87.40
5	164.83	86.47
6	169.83	86.31
7	174.79	86.93
8	179.60	88.30
9	184.14	90.40
10	188.30	93.17
11	191.98	96.56
12	195.09	100.47
13	197.56	104.82
14	199.33	109.49
15	200.36	114.39
16	200.40	115.11

*** 1.062 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	146.84	94.50
2	150.80	91.45
3	155.21	89.08
4	159.94	87.46
5	164.87	86.64
6	169.87	86.62
7	174.81	87.42
8	179.55	89.01
9	183.97	91.35
10	187.95	94.37
11	191.38	98.01
12	194.18	102.15
13	196.27	106.69
14	197.59	111.51
15	197.96	115.04

*** 1.063 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	147.90	94.50
2	151.77	91.34
3	156.09	88.82
4	160.75	87.01
5	165.64	85.96
6	170.63	85.68
7	175.60	86.18
8	180.44	87.46
9	185.01	89.49
10	189.21	92.20
11	192.93	95.53
12	196.09	99.41
13	198.60	103.74
14	200.40	108.40
15	201.45	113.29
16	201.55	115.15

*** 1.067 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	147.90	94.50
2	151.74	91.30
3	156.04	88.75
4	160.69	86.91
5	165.57	85.83
6	170.56	85.53
7	175.54	86.01
8	180.38	87.28
9	184.95	89.29
10	189.16	91.99
11	192.88	95.33
12	196.04	99.21
13	198.54	103.54
14	200.33	108.21
15	201.36	113.10
16	201.47	115.15

*** 1.068 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.95	94.50
2	152.83	91.34
3	157.15	88.83

4	161.81	87.03
5	166.70	85.98
6	171.70	85.71
7	176.67	86.22
8	181.50	87.50
9	186.07	89.52
10	190.27	92.24
11	194.00	95.58
12	197.15	99.45
13	199.66	103.78
14	201.47	108.44
15	202.52	113.33
16	202.62	115.18

*** 1.071 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.95	94.50
2	153.25	91.95
3	157.88	90.06
4	162.73	88.86
5	167.71	88.38
6	172.70	88.63
7	177.61	89.60
8	182.31	91.28
9	186.73	93.63
10	190.75	96.60
11	194.30	100.12
12	197.30	104.12
13	199.69	108.51
14	201.41	113.21
15	201.81	115.16

*** 1.073 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	148.95	94.50
2	153.21	91.88
3	157.80	89.91
4	162.63	88.63
5	167.60	88.06
6	172.60	88.22
7	177.52	89.11
8	182.26	90.70
9	186.72	92.97
10	190.80	95.86
11	194.41	99.31
12	197.49	103.25
13	199.96	107.60
14	201.77	112.26
15	202.44	115.17

*** 1.073 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	147.90	94.50
2	151.69	91.25
3	156.00	88.70
4	160.68	86.95
5	165.59	86.04
6	170.59	86.00
7	175.52	86.83
8	180.23	88.51
9	184.58	90.98
10	188.43	94.17
11	191.66	97.99
12	194.18	102.31
13	195.90	107.00
14	196.79	111.92
15	196.79	115.01

*** 1.074 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	143.68	94.50
2	147.80	91.66
3	152.28	89.44
4	157.03	87.89
5	161.96	87.04
6	166.96	86.91
7	171.93	87.50
8	176.75	88.80
9	181.35	90.78
10	185.60	93.40
11	189.44	96.60
12	192.78	100.33
13	195.54	104.50
14	197.68	109.02
15	199.14	113.80
16	199.34	115.08

*** 1.075 ***

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          Y            A     X     I     S            F     T

           .00     42.50     85.00    127.50    170.00
212.50

X        .00 +---------+------*-*+-*-W-----+---------+---------
+
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                 -
                 -
                 -
                 -
        42.50    +
                 -
                 -
                 -
                 -
                 -
A       85.00    +
                 -
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                 -
                 -
                 -                    *
X     127.50     +                    .
                 -                   ..
                 -                  ..0
                 -                 ..41
                 -                 ..1*
                 -                 .21..
I     170.00     +                 .21..
                 -                 .21..*
                 -                 ..11....
                 -                  ..211.*.
                 -                   ..4211*
                 -                     ....6
S     212.50     +                        ..
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                 -
                 -                      W  *
                 -
                 -                         *
      255.00     +
                 -                        **
                 -                        *
                 -                        *
                 -
                 -                      *
F     297.50     +
                 -                     *
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                 -
                 -
                 -
T     340.00     +              * *  **
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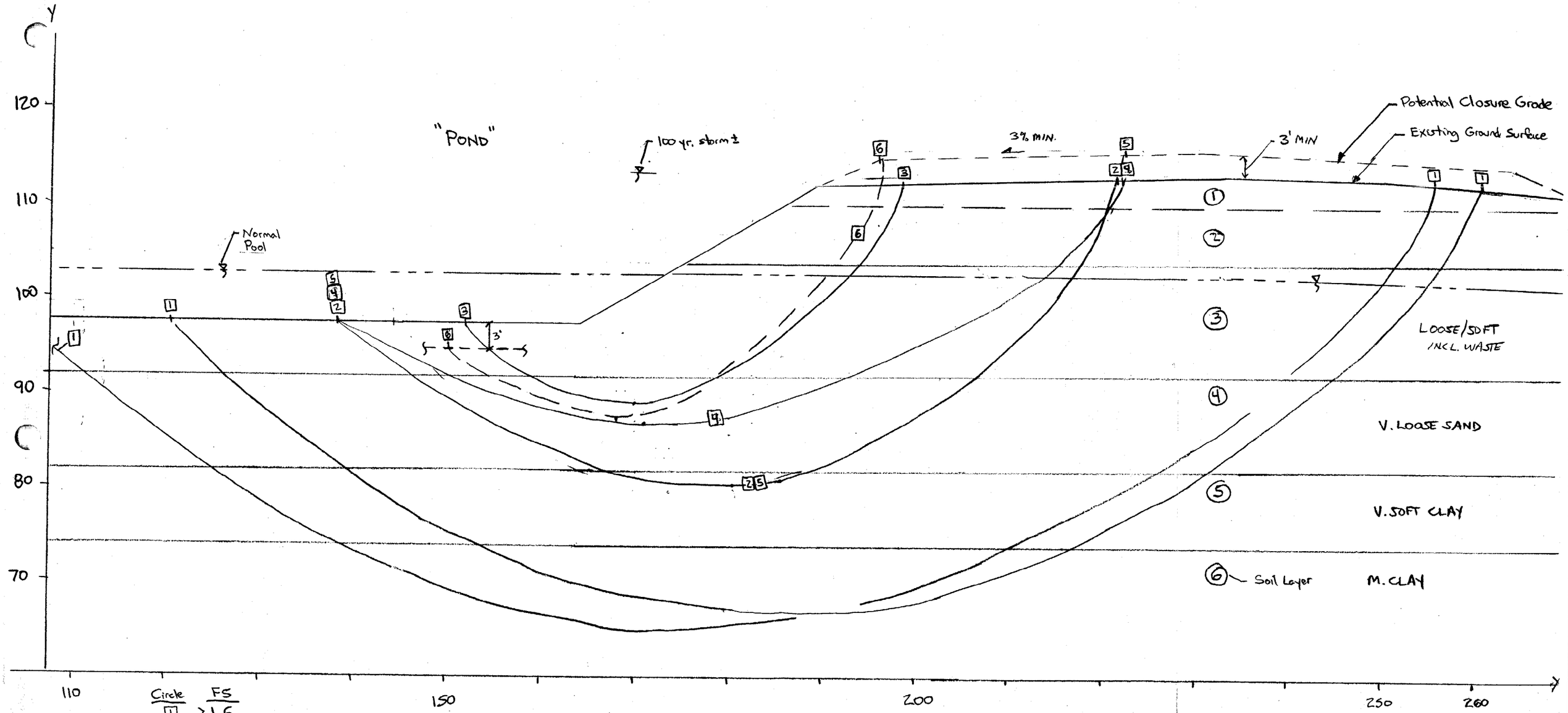

Circle	FS
1	>1.6
2	~1.7
3	~1.4
4	~1.0
5	~1.5
6	~1.1

D-94

171 A 152

Appendix D-3

Proposed Plan Cost Estimate Spreadsheets

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 16 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	0	event	$50,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$5,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including haulin	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	2,093	lcy		$10.00	$0.31	$0.84	$0	$20,930	$649	$1,758	$23,337		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	698	lcy		$14.63	$0.56	$1.52	$0	$10,212	$391	$1,061	$11,664	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	22,264	lcy		$10.00	$0.31	$0.84	$0	$222,640	$6,902	$18,702	$248,244		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	7,421	lcy		$14.63	$0.56	$1.52	$0	$108,569	$4,156	$11,280	$124,005		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	4,061	lcy		$8.00	$0.31	$0.84	$0	$32,488	$1,259	$3,411	$37,158		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,529,430	$319,174	$236,802	$2,085,406		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,560,019	$256,935	$202,466	$2,019,420		
Overhead on Labor Cost @ 0.3									$77,081		$77,081		
G & A on Labor Cost @ 0.1									$25,694		$25,694		
G & A on Material Cost @ 0.1								$156,002			$156,002		
Total Direct Cost								$1,716,021	$359,709	$202,466	$2,278,196		
Indirects on Total Direct Labor Cost @ 0.75									$269,782		$269,782		
Profit on Total Direct Cost @ 0.1											$227,820		
Subtotal											$2,775,797		

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Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Health & Safety Monitoring @	0.005										$13,879		
Total Field Cost											**$2,789,676**		
Subtotal Subcontractor Cost							$501,015				$501,015		
G & A on Subcontract Cost @	0.1						$50,102				$50,102		
Profit on Subcontractor Cost @	0.05										$25,051		
Subcontractor Cost											**$576,167**		
Subtotal											**$3,365,843**		
Contingency on Total Field and Subcontractor Costs @	0.15										$504,876		
Engineering on Total Field Cost @	0.08										$223,174		
TOTAL COST											**$4,093,894**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization for Proposed Plan
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$1,800.00		(2) 4 GW at about $450 per sample including dups, travel, living, and per diem
Analysis	$2,600.00		(2) 4 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$55,400.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2A - Partial Soil Cover / Slope Stabilization for Proposed Plan
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,093,894		$4,093,893.78	1.000	$4,093,894
1		$65,400.00	$65,400.00	0.935	$61,149
2		$62,400.00	$62,400.00	0.873	$54,475
3		$59,400.00	$59,400.00	0.816	$48,470
4		$55,400.00	$55,400.00	0.763	$42,270
5		$71,400.00	$71,400.00	0.713	$50,908
6		$55,400.00	$55,400.00	0.666	$36,896
7		$55,400.00	$55,400.00	0.623	$34,514
8		$55,400.00	$55,400.00	0.582	$32,243
9		$55,400.00	$55,400.00	0.544	$30,138
10		$71,400.00	$71,400.00	0.508	$36,271
11		$55,400.00	$55,400.00	0.475	$26,315
12		$55,400.00	$55,400.00	0.444	$24,598
13		$55,400.00	$55,400.00	0.415	$22,991
14		$55,400.00	$55,400.00	0.388	$21,495
15		$71,400.00	$71,400.00	0.362	$25,847
16		$55,400.00	$55,400.00	0.339	$18,781
17		$55,400.00	$55,400.00	0.317	$17,562
18		$55,400.00	$55,400.00	0.296	$16,398
19		$55,400.00	$55,400.00	0.277	$15,346
20		$71,400.00	$71,400.00	0.258	$18,421
21		$55,400.00	$55,400.00	0.242	$13,407
22		$55,400.00	$55,400.00	0.226	$12,520
23		$55,400.00	$55,400.00	0.211	$11,689
24		$55,400.00	$55,400.00	0.197	$10,914
25		$71,400.00	$71,400.00	0.184	$13,138
26		$55,400.00	$55,400.00	0.172	$9,529
27		$55,400.00	$55,400.00	0.161	$8,919
28		$55,400.00	$55,400.00	0.150	$8,310
29		$55,400.00	$55,400.00	0.141	$7,811
30		$71,400.00	$71,400.00	0.131	$9,353
				TOTAL PRESENT WORTH	**$4,834,573**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization for Proposed Plan

Item	Quantity	Unit	Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 16 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	0	event	$50,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$5,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill)
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	matl cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	4,585	lcy		$10.00	$0.31	$0.84	$0	$45,850	$1,421	$3,851	$51,123		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	1,529	lcy		$14.63	$0.56	$1.52	$0	$22,369	$856	$2,324	$25,550	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	35,545	lcy		$10.00	$0.31	$0.84	$0	$355,450	$11,019	$29,858	$396,327		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	11,848	lcy		$14.63	$0.56	$1.52	$0	$173,336	$6,635	$18,009	$197,980		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	6,200	lcy		$8.00	$0.31	$0.84	$0	$49,600	$1,922	$5,208	$56,730		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.08	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,781,197	$327,671	$259,841	$2,368,708		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,816,821	$263,775	$222,164	$2,302,760		
Overhead on Labor Cost @ 0.3									$79,133		$79,133		
G & A on Labor Cost @ 0.1									$26,378		$26,378		
G & A on Material Cost @ 0.1								$181,682			$181,682		
Total Direct Cost								$1,998,503	$369,285	$222,164	$2,589,952		
Indirects on Total Direct Labor Cost @ 0.75									$276,964		$276,964		
Profit on Total Direct Cost @ 0.1											$258,995		
Subtotal											$3,125,911		

Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Health & Safety Monitoring @	0.005										$15,630		
Total Field Cost											**$3,141,541**		
Subtotal Subcontractor Cost							$501,015				$501,015		
G & A on Subcontract Cost @	0.1						$50,102				$50,102		
Profit on Subcontractor Cost @	0.05										$25,051		
Subcontractor Cost											**$576,167**		
Subtotal											**$3,717,708**		
Contingency on Total Field and Subcontractor Costs @	0.15										$557,656		
Engineering on Total Field Cost @	0.08										$251,323		
TOTAL COST											**$4,526,687**		

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization for Proposed Plan
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$1,800.00		(2) 4 GW at about $450 per sample including dups, travel, living, and per diem
Analysis	$2,600.00		(2) 4 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$55,400.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 2B - Full Soil Cover / Slope Stabilization for Proposed Plan
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,526,687		$4,526,687.16	1.000	$4,526,687
1		$65,400.00	$65,400.00	0.935	$61,149
2		$62,400.00	$62,400.00	0.873	$54,475
3		$59,400.00	$59,400.00	0.816	$48,470
4		$55,400.00	$55,400.00	0.763	$42,270
5		$71,400.00	$71,400.00	0.713	$50,908
6		$55,400.00	$55,400.00	0.666	$36,896
7		$55,400.00	$55,400.00	0.623	$34,514
8		$55,400.00	$55,400.00	0.582	$32,243
9		$55,400.00	$55,400.00	0.544	$30,138
10		$71,400.00	$71,400.00	0.508	$36,271
11		$55,400.00	$55,400.00	0.475	$26,315
12		$55,400.00	$55,400.00	0.444	$24,598
13		$55,400.00	$55,400.00	0.415	$22,991
14		$55,400.00	$55,400.00	0.388	$21,495
15		$71,400.00	$71,400.00	0.362	$25,847
16		$55,400.00	$55,400.00	0.339	$18,781
17		$55,400.00	$55,400.00	0.317	$17,562
18		$55,400.00	$55,400.00	0.296	$16,398
19		$55,400.00	$55,400.00	0.277	$15,346
20		$71,400.00	$71,400.00	0.258	$18,421
21		$55,400.00	$55,400.00	0.242	$13,407
22		$55,400.00	$55,400.00	0.226	$12,520
23		$55,400.00	$55,400.00	0.211	$11,689
24		$55,400.00	$55,400.00	0.197	$10,914
25		$71,400.00	$71,400.00	0.184	$13,138
26		$55,400.00	$55,400.00	0.172	$9,529
27		$55,400.00	$55,400.00	0.161	$8,919
28		$55,400.00	$55,400.00	0.150	$8,310
29		$55,400.00	$55,400.00	0.141	$7,811
30		$71,400.00	$71,400.00	0.131	$9,353
				TOTAL PRESENT WORTH	**$5,267,367**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization / Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr. quant. thicknesses	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilization	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 24 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL / COVER													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	1	event	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$1,500.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0.0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0.0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
3.11 Top Soil (off-site borrow source)	0	cy		$14.63	$0.56	$1.52	$0	$0	$0	$0	$0	labr and equip for on site managemen	m99-022-208-4220
3.12 Mob / Demob of clamshell crane	0	ea	$6,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	includes full set up	estimate based on m-99 mob/demob figures
3.13 150' boom crane (place soil cover in standing water)	0	day	$2,366.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	rental per day including equip and cre	m99-016-460-1400
3.14 Geotextile (450 sy plus 15% for joints and waste)	0	sy		$1.30	$2.24	$0.50	$0	$0	$0	$0	$0	labor 8x for working in stading water	m99-022-412-1550 mat 2x - heavier geotextile
3.15 Vegetation	0	csf		$8.34	$62.12	$0.00	$0	$0	$0	$0	$0	labor 4X for working in stading water	e99-33-05-1533
3.16 Super Silt Fence	0	lf		$1.40	$1.44	$0.00	$0	$0	$0	$0	$0	4x for super silt	m99-022-704-1100
3.17 Hay Bales (install, remove, and mat)	0	lf		$6.00	$0.29	$0.10	$0	$0	$0	$0	$0		m99-022-704-1250
3.18 Turbidity Curtain	0	lf		$7.60	$0.94	$0.00	$0	$0	$0	$0	$0		past experience, similar site
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	2,093	lcy		$10.00	$0.31	$0.84	$0	$20,930	$649	$1,758	$23,337		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	698	lcy		$14.63	$0.56	$1.52	$0	$10,212	$391	$1,061	$11,664	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	22,264	lcy		$10.00	$0.31	$0.84	$0	$222,640	$6,902	$18,702	$248,244		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	7,421	lcy		$14.63	$0.56	$1.52	$0	$108,569	$4,156	$11,280	$124,005		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	4,061	lcy		$8.00	$0.31	$0.84	$0	$32,488	$1,259	$3,411	$37,158		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94	$0.00	$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,529,430	$319,174	$236,802	$2,085,406		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,560,019	$256,935	$202,466	$2,019,420		
Overhead on Labor Cost @ 0.3									$77,081		$77,081		
G & A on Labor Cost @ 0.1									$25,694		$25,694		
G & A on Material Cost @ 0.1								$156,002			$156,002		

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Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization / Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
Total Direct Cost								$1,716,021	$359,709	$202,466	$2,278,196		
Indirects on Total Direct Labor Cost @	0.75								$269,782		$269,782		
Profit on Total Direct Cost @	0.1										$227,820		
Subtotal											$2,775,797		
Health & Safety Monitoring @	0.005										$13,879		
Total Field Cost											**$2,789,676**		
Subtotal Subcontractor Cost							$551,015				$551,015		
G & A on Subcontract Cost @	0.1						$55,102				$55,102		
Profit on Subcontractor Cost @	0.05										$27,551		
Subcontractor Cost											**$633,667**		
Subtotal											**$3,423,343**		
Contingency on Total Field and Subcontractor Costs @	0.15										$513,501		
Engineering on Total Field Cost @	0.08										$223,174		
TOTAL COST											**$4,160,019**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization / Further Sediment Evaluation for Proposed Plan
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$1,800.00		(2) 4 GW samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$2,600.00		(2) 4 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$55,400.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year two
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3A - Partial Soil Cover / Slope Stabilization / Further Sediment Evaluation for Proposed Plan
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,160,019		$4,160,018.78	1.000	$4,160,019
1		$65,400.00	$65,400.00	0.935	$61,149
2		$62,400.00	$62,400.00	0.873	$54,475
3		$59,400.00	$59,400.00	0.816	$48,470
4		$55,400.00	$55,400.00	0.763	$42,270
5		$71,400.00	$71,400.00	0.713	$50,908
6		$55,400.00	$55,400.00	0.666	$36,896
7		$55,400.00	$55,400.00	0.623	$34,514
8		$55,400.00	$55,400.00	0.582	$32,243
9		$55,400.00	$55,400.00	0.544	$30,138
10		$71,400.00	$71,400.00	0.508	$36,271
11		$55,400.00	$55,400.00	0.475	$26,315
12		$55,400.00	$55,400.00	0.444	$24,598
13		$55,400.00	$55,400.00	0.415	$22,991
14		$55,400.00	$55,400.00	0.388	$21,495
15		$71,400.00	$71,400.00	0.362	$25,847
16		$55,400.00	$55,400.00	0.339	$18,781
17		$55,400.00	$55,400.00	0.317	$17,562
18		$55,400.00	$55,400.00	0.296	$16,398
19		$55,400.00	$55,400.00	0.277	$15,346
20		$71,400.00	$71,400.00	0.258	$18,421
21		$55,400.00	$55,400.00	0.242	$13,407
22		$55,400.00	$55,400.00	0.226	$12,520
23		$55,400.00	$55,400.00	0.211	$11,689
24		$55,400.00	$55,400.00	0.197	$10,914
25		$71,400.00	$71,400.00	0.184	$13,138
26		$55,400.00	$55,400.00	0.172	$9,529
27		$55,400.00	$55,400.00	0.161	$8,919
28		$55,400.00	$55,400.00	0.150	$8,310
29		$55,400.00	$55,400.00	0.141	$7,811
30		$71,400.00	$71,400.00	0.131	$9,353
				TOTAL PRESENT WORTH	**$4,900,698**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Full Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	12	mo	$500.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	12	mo	$85.00	$0.00	$0.00	$0.00	$1,020	$0	$0	$0	$1,020		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	12	mo	$1,000.00	$0.00	$0.00	$0.00	$12,000	$0	$0	$0	$12,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	20,000	gal		$0.25	$0.00	$0.00	$0	$5,000	$0	$0	$5,000		
2.3 Decon Water Storage Tank (6,000 gallon)	12	mo	$577.50	$0.00	$0.00	$0.00	$6,930	$0	$0	$0	$6,930		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	12	mo	$472.50	$0.00	$0.00	$0.00	$5,670	$0	$0	$0	$5,670		e99-1903-0403
2.5 PPE (1p * 5 days * 16 weeks)	80	day		$30.00	$0.00	$0.00	$0	$2,400	$0	$0	$2,400		
3 SEDIMENT REMOVAL / COVER													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	1	event	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$1,500.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill)
3.11 Top Soil (off-site borrow source)	0	cy		$14.63	$0.56	$1.52	$0	$1,097	$42	$114	$1,253	labr and equip for on site managemen	m99-022-208-4220
3.12 Mob / Demob of clamshell crane	0	ea	$6,000.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000	includes full set up	estimate based on m-99 mob/demob figures
3.13 150' boom crane (place soil cover in standing water)	0	day	$2,366.00	$0.00	$0.00	$0.00	$11,830	$0	$0	$0	$11,830	rental per day including equip and crew	m99-016-460-1400
3.14 Geotextile (450 sy plus 15% for joints and waste)	0	sy		$1.30	$2.24	$0.50	$0	$670	$1,154	$258	$2,081	labor 8x for working in stading water	m99-022-412-1550 mat 2x - heavier geotextile
3.15 Vegetation	0	csf		$8.34	$62.12	$0.00	$0	$334	$2,485	$0	$2,818	labor 4X for working in stading water	e99-33-05-1533
3.16 Super Silt Fence	0	lf		$1.40	$1.44	$0.00	$0	$560	$576	$0	$1,136	4x for super silt	m99-022-704-1100
3.17 Hay Bales (install, remove, and mat)	0	lf		$6.00	$0.29	$0.10	$0	$2,400	$116	$40	$2,556		m99-022-704-1250
3.18 Turbidity Curtain	0	lf		$7.60	$0.94	$0.00	$0	$3,040	$376	$0	$3,416		past experience, similar site
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including hauling	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	4,585	lcy		$10.00	$0.31	$0.84	$0	$45,850	$1,421	$3,851	$51,123		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	1,529	lcy		$14.63	$0.56	$1.52	$0	$22,369	$856	$2,324	$25,550	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	35,545	lcy		$10.00	$0.31	$0.84	$0	$355,450	$11,019	$29,858	$396,327		m99-022-262-0010
5.2 Top Soil (off-site borrow source)	11,848	lcy		$14.63	$0.56	$1.52	$0	$173,336	$6,635	$18,009	$197,980		m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	6,200	lcy		$8.00	$0.31	$0.84	$0	$49,600	$1,922	$5,208	$56,730		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94		$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1040	hours		$0.00	$25.00	$0.00	$0	$0	$26,000	$0	$26,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	520	hours		$0.00	$30.00	$0.00	$0	$0	$15,600	$0	$15,600		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,789,298	$332,420	$260,253	$2,381,970		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,825,084	$267,598	$222,516	$2,315,198		
Overhead on Labor Cost @ 0.3									$80,279		$80,279		
G & A on Labor Cost @ 0.1									$26,760		$26,760		

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Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Full Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
G & A on Material Cost @	0.1							$182,508			$182,508		
Total Direct Cost								$2,007,592	$374,637	$222,516	$2,604,745		
Indirects on Total Direct Labor Cost @	0.75								$280,978		$280,978		
Profit on Total Direct Cost @	0.1										$260,475		
Subtotal											$3,146,198		
Health & Safety Monitoring @	0.005										$15,731		
Total Field Cost											**$3,161,929**		
Subtotal Subcontractor Cost							$568,845				$568,845		
G & A on Subcontract Cost @	0.1						$56,885				$56,885		
Profit on Subcontractor Cost @	0.05										$28,442		
Subcontractor Cost											**$654,172**		
Subtotal											**$3,816,101**		
Contingency on Total Field and Subcontractor Costs @	0.15										$572,415		
Engineering on Total Field Cost @	0.08										$252,954		
TOTAL COST											**$4,641,470**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Full Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$1,800.00		(2) 4 GW samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$2,600.00		(2) 4 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$55,400.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Option 3B - Full Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,641,470		$4,641,470.32	1.000	$4,641,470
1		$65,400.00	$65,400.00	0.935	$61,149
2		$62,400.00	$62,400.00	0.873	$54,475
3		$59,400.00	$59,400.00	0.816	$48,470
4		$55,400.00	$55,400.00	0.763	$42,270
5		$71,400.00	$71,400.00	0.713	$50,908
6		$55,400.00	$55,400.00	0.666	$36,896
7		$55,400.00	$55,400.00	0.623	$34,514
8		$55,400.00	$55,400.00	0.582	$32,243
9		$55,400.00	$55,400.00	0.544	$30,138
10		$71,400.00	$71,400.00	0.508	$36,271
11		$55,400.00	$55,400.00	0.475	$26,315
12		$55,400.00	$55,400.00	0.444	$24,598
13		$55,400.00	$55,400.00	0.415	$22,991
14		$55,400.00	$55,400.00	0.388	$21,495
15		$71,400.00	$71,400.00	0.362	$25,847
16		$55,400.00	$55,400.00	0.339	$18,781
17		$55,400.00	$55,400.00	0.317	$17,562
18		$55,400.00	$55,400.00	0.296	$16,398
19		$55,400.00	$55,400.00	0.277	$15,346
20		$71,400.00	$71,400.00	0.258	$18,421
21		$55,400.00	$55,400.00	0.242	$13,407
22		$55,400.00	$55,400.00	0.226	$12,520
23		$55,400.00	$55,400.00	0.211	$11,689
24		$55,400.00	$55,400.00	0.197	$10,914
25		$71,400.00	$71,400.00	0.184	$13,138
26		$55,400.00	$55,400.00	0.172	$9,529
27		$55,400.00	$55,400.00	0.161	$8,919
28		$55,400.00	$55,400.00	0.150	$8,310
29		$55,400.00	$55,400.00	0.141	$7,811
30		$71,400.00	$71,400.00	0.131	$9,353
				TOTAL PRESENT WORTH	**$5,382,150**

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Modified 3A - Partial Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
1 MOBILIZATION/DEMOBILIZATION													
1.1 Office Trailer	18	mo	$500.00	$0.00	$0.00	$0.00	$9,000	$0	$0	$0	$9,000		m99-015-904-0350 & 0700
1.2 Storage Trailer	18	mo	$85.00	$0.00	$0.00	$0.00	$1,530	$0	$0	$0	$1,530		m99-015-904-1350
1.3 Construction Survey Services	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000	$0	$0	$0	$40,000	pre-/post-constr, quant., thicknesses, sample locations	m99-013-306-1600, m99-013-306-1300
1.4 Equipment Mobilization/Demobilizatior	1	ls	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
1.5 Site Utilities	18	mo	$1,000.00	$0.00	$0.00	$0.00	$18,000	$0	$0	$0	$18,000	including temporary set-up/tear-down	
2 DECONTAMINATION													
2.1 Equipment Decon Pad (Installation and Removal)	1	ls		$5,900.00	$6,700.00	$700.00	$0	$5,900	$6,700	$700	$13,300		past experience, similar site
2.2 Decontamination Water	30,000	gal		$0.25	$0.00	$0.00	$0	$7,500	$0	$0	$7,500		
2.3 Decon Water Storage Tank (6,000 gallon)	18	mo	$577.50	$0.00	$0.00	$0.00	$10,395	$0	$0	$0	$10,395		e99-1903-0405
2.4 Clean Water Storage Tank (4,000 gallon)	18	mo	$472.50	$0.00	$0.00	$0.00	$8,505	$0	$0	$0	$8,505		e99-1903-0403
2.5 PPE (1p * 5 days * 24 weeks)	120	day		$30.00	$0.00	$0.00	$0	$3,600	$0	$0	$3,600		
3 SEDIMENT REMOVAL / COVER													
3.1 Storm Water Management	0	event	$25,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.2 Contaminant Delineation Sampling & Analysis	1	event	$50,000.00	$0.00	$0.00	$0.00	$50,000	$0	$0	$0	$50,000		
3.3 Excavation (2 cy, hydraulic excavator, Level D)	0	cy		$0.00	$1.96	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260 plus level D adjustment
3.4 Haul Sediment (12 cy trucks, 0.5 mile)	0	lcy		$0.00	$3.96	$8.44	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-266-0320 plus level D adjustment
3.5 Condition Waste (5 cy, track loader)	0	lcy		$0.00	$1.24	$3.78	$0	$0	$0	$0	$0	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
3.6 Waste Profiling	0	event	$1,500.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.7 Structural Fill (off-site borrow source, place)	0	lcy		$8.00	$1.64	$3.92	$0	$0	$0	$0	$0	labor & equipment 4x for 25 % prod	m99-022-238-0260
3.8 Confirmatory Sampling	0	event	$15,000.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
3.9 Haul to Landfill (40 miles, 27 cy/trip)	0.0	tons	$7.49	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0	$3.75/loaded mile x 40 miles	vendor quote
3.10 Disposal (Non-Haz Landfill)	0.0	tons	$22.00	$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		vendor quote (Ridgeland SC Subtitle D landfill
3.11 Cover Soil (off-site borrow source, 18")	3,017	cy		$10.00	$0.31	$0.84	$0	$30,170	$935	$2,534	$33,640		m99-022-262-0010
3.12 Mob / Demob of clamshell crane	1	ea	$6,000.00	$0.00	$0.00	$0.00	$6,000	$0	$0	$0	$6,000	includes full set up	estimate based on m-99 mob/demob figures
3.13 150' boom crane (place soil cover in standing water)	30	day	$2,366.00	$0.00	$0.00	$0.00	$70,980	$0	$0	$0	$70,980	rental per day including equip and cre	m99-016-460-1400
3.14 Geotextile (450 sy plus 15% for joints and waste)	12,067	sy		$1.30	$2.24	$0.50	$0	$15,687	$27,030	$6,034	$48,751	labor 8x for working in stading water	m99-022-412-1550 mat 2x - heavier geotextile
3.15 Rip Rap	1,676	cy		$20.20	$27.60	$8.40	$0	$33,855	$46,258	$14,078	$94,191	labor 4X for working in stading water	m99-022-712-0100
3.16 Super Silt Fence	500	lf		$1.40	$1.44	$0.00	$0	$700	$720	$0	$1,420	4x for super silt	m99-022-704-1100
3.17 Hay Bales (install, remove, and mat)	500	lf		$6.00	$0.29	$0.10	$0	$3,000	$145	$50	$3,195		m99-022-704-1250
3.18 Turbidity Curtain	500	lf		$7.60	$0.94	$0.00	$0	$3,800	$470	$0	$4,270		past experience, similar site
4 BANK STABILIZATION													
4.1 Geotechnical Investigation & Laboratory Testing	1	ls	$30,000.00	$0.00	$0.00	$0.00	$30,000	$0	$0	$0	$30,000		estimated
4.2 Coarse Aggregate	1,667	lcy		$11.25	$6.26	$4.90	$0	$18,754	$10,435	$8,168	$37,357	labor & equipment 2x for 50 % prod	m99-022-254-3060 plus gravel
4.3 Gabion (baskets)	2,676	ea		$50.00	$10.73	$0.00	$0	$133,800	$28,713	$0	$162,513		vendor quote
4.4 Gabions (stone)	5,348	cy		$20.20	$0.82	$1.96	$0	$108,030	$4,385	$10,482	$122,897	labor & equipment 2x for 50 % prod	m99-022-238-0260
4.5 Rip Rap	7,132	cy		$20.20	$6.90	$8.40	$0	$144,066	$49,211	$59,909	$253,186	mat'l cost adjusted including haulin	m99-022-712-0100
4.6 Cover Soil (off-site borrow source)	2,093	lcy		$10.00	$0.31	$0.84	$0	$20,930	$649	$1,758	$23,337		m99-022-262-0010
4.7 Top Soil (off-site borrow source)	698	lcy		$14.63	$0.56	$1.52	$0	$10,212	$391	$1,061	$11,664	labor & equipment 2x for 50 % prod	m99-022-208-4220 see comment for grading
4.8 Geotextile	19,727	sy		$1.30	$0.28	$0.00	$0	$25,645	$5,524	$0	$31,169	labor & equipment 2x for 50 % prod	m99-022-412-1550 mat 2x - heavier geotextile
4.9 Erosion Control Mat	14,902	sy		$3.85	$1.48	$0.52	$0	$57,373	$22,055	$7,749	$87,177	labor & equipment 2x for 50 % prod	m99-022-704-0060
4.10 Vegetation	66.4	msf	$75.00	$0.00	$0.00	$0.00	$4,980	$0	$0	$0	$4,980		
4.11 Miscellaneous Excavation / Surface Preparation	1329	cy		$0.00	$1.64	$3.92	$0	$0	$2,180	$5,210	$7,389	labor & equipment 4x for 25 % prod	m99-022-238-0330 plus level D adjustment
4.12 Haul Material (12 cy trucks, 1 mile)	1728	lcy		$0.00	$3.96	$8.44	$0	$0	$6,843	$14,584	$21,427	labor & equipment 4x for 25 % prod	m99-022-266-0330 plus level D adjustment
4.13 Condition Waste (5 cy, track loader)	1728	lcy		$0.00	$1.24	$3.78	$0	$0	$2,143	$6,532	$8,675	labor & equipment 2x for 50 % prod	m99-022-262-0400 plus level D adjustment
5 SOIL COVER													
5.1 Cover Soil (off-site borrow source)	22,264	lcy		$10.00	$0.31	$0.84	$0	$222,640	$6,902	$18,702	$248,244	1000 cy additional for modified cover	m99-022-262-0010
5.2 Top Soil (off-site borrow source)	8,421	lcy		$14.63	$0.56	$1.52	$0	$123,199	$4,716	$12,800	$140,715	1000 cy additional for modified cover	m99-022-208-4220
5.3 Erosion Control Mat	2431	sy		$3.85	$0.74	$0.26	$0	$9,359	$1,799	$632	$11,790		m99-022-704-0060
5.4 Vegetation	492.2	msf	$75.00	$0.00	$0.00	$0.00	$36,915	$0	$0	$0	$36,915		
6 PAVEMENT													
6.1 Structural Fill	4,061	lcy		$8.00	$0.31	$0.84	$0	$32,488	$1,259	$3,411	$37,158		m99-022-262-0010
6.2 Pavement Subbase (4")	14,493	sy		$2.06	$0.30	$0.60	$0	$29,856	$4,348	$8,696	$42,899		m99-022-308-0302 plus vendor quote
6.3 Pavement Base (4")	14,493	sy		$5.40	$0.50	$0.43	$0	$78,262	$7,247	$6,232	$91,741		m99-025-104-0200
6.4 Pavement Wearing Course (2")	14,493	sy		$29.00	$3.33	$2.95	$0	$420,297	$48,262	$42,754	$511,313		m99-025-104-0852
7 WETLAND RESTORATION / REPLACEMENT													
7.1 Wetland Mitigation	0	acre	$15,000.00				$0	$0	$0	$0	$0		
7.2 Wetland Replacement	4.5	acre	$65,000.00				$292,500	$0	$0	$0	$292,500		
8 E&S CONTROL MEASURES													
8.1 Marsh Channel Rip Rap	2,297	cy		$20.20	$10.35	$12.60	$0	$46,399	$23,774	$28,942	$99,116	labor & equipment 1.5x for decr prod	m99-022-712-0100
8.2 Silt Fence	11,000	lf		$0.35	$0.36	$0.00	$0	$3,850	$3,960	$0	$7,810	silt fence in adverse conditions	m99-022-704-1100
8.3 Turbidity Curtain	6,000	lf		$7.60	$0.94	$0.00	$0	$45,600	$5,640	$0	$51,240	Cherry Pt. Site 16 cost	past experience, similar site
9 MISCELLANEOUS SITE WORK													
9.1 Clearing and Grubbing	10	acres	$1,500.00	$0.00	$0.00	$0.00	$15,000	$0	$0	$0	$15,000		past experience, similar site
9.2 Relocate Telephone Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
9.3 Relocate Electric Utility	1	event		$0.00	$0.00	$0.00	$0	$0	$0	$0	$0		
10 OFFICE SUPPORT/FIELD SUPPORT													
10.1 Field Oversight Personnel (1 person - 1/2 time)	1560	hours		$0.00	$25.00	$0.00	$0	$0	$39,000	$0	$39,000		
10.2 Office Oversight Personnel (2 people - 1/8 time)	780	hours		$0.00	$30.00	$0.00	$0	$0	$23,400	$0	$23,400		
11 PROJECT DOCUMENTATION													
11.1 Pre- and Post-Construction Submittals	200	hours		$0.00	$30.00	$0.00	$0	$0	$6,000	$0	$6,000		
11.2 Permitting/Planning Documents	500	hours			$50.00		$0	$0	$25,000	$0	$25,000		
Subtotal Direct Costs less Subcontract								$1,634,972	$416,092	$261,019	$2,312,083		
Local Area Adjustments								102.0%	80.5%	85.5%			m99- Savannah, GA and Charleston, SC
Subtotal								$1,667,672	$334,954	$223,171	$2,225,797		
Overhead on Labor Cost @ 0.3									$100,486		$100,486		
G & A on Labor Cost @ 0.1									$33,495		$33,495		

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Marine Corps Recruit Depot
Parris Island, South Carlolina
Modified 3A - Partial Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments	Source
G & A on Material Cost @	0.1							$166,767			$166,767		
Total Direct Cost								$1,834,439	$468,936	$223,171	$2,526,545		
Indirects on Total Direct Labor Cost @	0.75								$351,702		$351,702		
Profit on Total Direct Cost @	0.1										$252,655		
Subtotal											$3,130,902		
Health & Safety Monitoring @	0.005										$15,655		
Total Field Cost											**$3,146,556**		
Subtotal Subcontractor Cost							$643,805				$643,805		
G & A on Subcontract Cost @	0.1						$64,381				$64,381		
Profit on Subcontractor Cost @	0.05										$32,190		
Subcontractor Cost											**$740,376**		
Subtotal											**$3,886,932**		
Contingency on Total Field and Subcontractor Costs @	0.15										$583,040		
Engineering on Total Field Cost @	0.08										$251,724		
TOTAL COST											**$4,721,696**		

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Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Modified 3A - Partial Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Plan
Annual Cost

Item	Item Cost Annually	Item Cost per 5 Years	Notes
Site Maintenance			
landscaping / grass cutting	$12,000.00		based on 2 cuts per month for 12 months mob/demob, equipment (truck, mowers, etc.), misc. materials and hand tools
rip rap	$8,000.00		annual rip rap repair/replacement (100 cy/yr at $38.00 per year)
gabions	$10,000.00		annual gabion basket replacement (100 /yr at $100 ea.)
top soil	$7,000.00		annual top soil replacement (400 lcy/yr at $17.00/lcy)
vegetation	$4,000.00		annual vegetation replacement (50 msf at $75/msf)
wetlands vegetation	(1) ***see note below***		wetland vegetation cost of about $15,000/acre and assume more replacement early, tapering off to none after year five - see note below
Sampling	$3,150.00		(2) 4 GW and 3 sediment samples at about $450 per sample including dups, travel, living, and per diem
Analysis	$4,550.00		(2) 7 samples at about $650 per sample including dups, blanks, shipping, etc.
Annual Report	$10,000.00		Yearly Site Inspection Report (not inclusive of sampling and analysis costs)
Site Review		$16,000.00	Prepare Site Conditions Report for years 5, 10, 15, 20, 25, and 30
TOTALS	$58,700.00	$16,000.00	

(1) * Wetlands Vegetation costs by year**

Year	Area (acres)	Cost	
1	0.675	$10,000	assumes approximately 15% of total will need replaced after year one
2	0.450	$7,000	assumes approximately 10% of total will need replaced after year twc
3	0.250	$4,000	assumes approximately 5% of total will need replaced after year three
4	0.000	$0	assumes approximately 0% of total will need replaced after year four
5	0.000	$0	assumes 0% of total will need replaced from year 5 out

(2) **Sampling and Analysis occurs every year for the first 5 years.

Site/SWMU 3 - Causeway Landfill
Marine Corps Recruit Depot
Parris Island, South Carlolina
Modified 3A - Partial Soil Cover / Slope Stabilization / With Further Sediment Evaluation for Proposed Pl
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$4,721,696		$4,721,696.24	1.000	$4,721,696
1		$68,700.00	$68,700.00	0.935	$64,235
2		$65,700.00	$65,700.00	0.873	$57,356
3		$62,700.00	$62,700.00	0.816	$51,163
4		$58,700.00	$58,700.00	0.763	$44,788
5		$74,700.00	$74,700.00	0.713	$53,261
6		$58,700.00	$58,700.00	0.666	$39,094
7		$58,700.00	$58,700.00	0.623	$36,570
8		$58,700.00	$58,700.00	0.582	$34,163
9		$58,700.00	$58,700.00	0.544	$31,933
10		$74,700.00	$74,700.00	0.508	$37,948
11		$58,700.00	$58,700.00	0.475	$27,883
12		$58,700.00	$58,700.00	0.444	$26,063
13		$58,700.00	$58,700.00	0.415	$24,361
14		$58,700.00	$58,700.00	0.388	$22,776
15		$74,700.00	$74,700.00	0.362	$27,041
16		$58,700.00	$58,700.00	0.339	$19,899
17		$58,700.00	$58,700.00	0.317	$18,608
18		$58,700.00	$58,700.00	0.296	$17,375
19		$58,700.00	$58,700.00	0.277	$16,260
20		$74,700.00	$74,700.00	0.258	$19,273
21		$58,700.00	$58,700.00	0.242	$14,205
22		$58,700.00	$58,700.00	0.226	$13,266
23		$58,700.00	$58,700.00	0.211	$12,386
24		$58,700.00	$58,700.00	0.197	$11,564
25		$74,700.00	$74,700.00	0.184	$13,745
26		$58,700.00	$58,700.00	0.172	$10,096
27		$58,700.00	$58,700.00	0.161	$9,451
28		$58,700.00	$58,700.00	0.150	$8,805
29		$58,700.00	$58,700.00	0.141	$8,277
30		$74,700.00	$74,700.00	0.131	$9,786
				TOTAL PRESENT WORTH	**$5,503,326**

Appendix E

Calculations To Support
The Detailed Analysis Of Alternatives

Appendix E-1

Food-Chain Modeling
Modified HQ Calculations
PAH Hot Spot

UCL calculations for Sediment Hot Spot Areas

Assumptions
- One-half the non-detected values for sediment were used. These values are italicized.

Area of Hot Spot	1 acre	
Forage Areas		Home Range Factor
Raccoon	96 acres	0.01042
Heron	2500 acres	0.0004
Eagle	2500 acres	0.0004

PAH Hot Spot

	SW-22	SD-22	SD-29[1]	SD-30	SD-31	Mean	SD	95% UCL
Anthracene	0	770	4	*3.3*	*1.2*	194.625	383.6	570.5
Benzo(a)Anthracene	0	1200	18	*8*	8.9	308.725	532.3	830.4
Benzo(a)Pyrene	0	1200	20	22	8.2	312.55	530.7	832.6
Chrysene	0	1900	13.25	*8*	6.1	481.8375	846.2	1311.1
Fluoranthene	0.1	3500	39	21	13	893.25	1556.7	2418.8
Phenanthrene	0.05	2400	8.15	24	9.6	610.4375	1068.2	1657.3
Pyrene	0	2700	35.5	24	15	693.625	1198.8	1868.4

sediment results in ug/kg, surface water results in ug/L
[1]Average of sample and duplicate.

Raccoon

Body Weight	3.9900000 kg		
Food Ingestion Rate	0.8560000 kg/day	% prey	0.906
Water Ingestion Rate	0.1710000 L/day		
Sed Ingestion Rate	0.8560000 kg/day	% sed	0.094
Home Range Factor	0.0104167		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL mg/kg/day	NOAEL HQ_n	LOAEL HQ_l
SVOCs								
Anthracene	0.570531011	0	0.413634983	0.091903766	1.3	2.6	7.36E-04	3.68E-04
Benzo(a)anthracene	0.830399802	0	0.602039857	0.13376463	1	10	1.39E-03	1.39E-04
Benzo(a)pyrene	0.832578064	0	0.603619097	0.134115514	1	10	1.40E-03	1.40E-04
Chrysene	1.311104626	0	0.950550854	0.211198779	1	10	2.20E-03	2.20E-04
Fluoranthene	2.418777968	0.0001	1.753614027	0.389632195	1	10	4.06E-03	4.06E-04
Phenanthrene	1.657276453	0.00005	2.690174002	0.556312388	1.3	2.6	4.46E-03	2.23E-03
Pyrene	1.868382657	0	1.354577426	0.300967694	1	10	3.14E-03	3.14E-04

Raccoon Summary Table - PAH Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL with HR)[2]	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL with HR)[2]
SVOCs						
Anthracene	9.54E-02	6.82E-03	7.36E-04	4.77E-02	3.41E-03	3.68E-04
Benzo(a)anthracene	1.93E-01	2.27E-02	1.39E-03	1.93E-02	2.27E-03	1.39E-04
Benzo(a)pyrene	1.93E-01	1.71E-02	1.40E-03	1.93E-02	1.71E-03	1.40E-04
Chrysene	3.06E-01	2.39E-02	2.20E-03	3.06E-02	2.39E-03	2.20E-04
Fluoranthene	5.64E-01	3.62E-02	4.06E-03	5.64E-02	3.62E-03	4.06E-04
Phenanthrene	6.20E-01	3.95E-02	4.46E-03	3.10E-01	1.97E-02	2.23E-03
Pyrene	4.35E-01	3.62E-02	3.14E-03	4.35E-02	3.62E-03	3.14E-04
Totals	2.41E+00	1.82E-01	1.74E-02	5.27E-01	3.68E-02	3.82E-03

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Great Blue Heron

Body Weight	2.2290000 kg		
Food Ingestion Rate	0.4010000 kg/day	% fish	1
Water Ingestion Rate	0.0800000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
Home Range Factor	0.0004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
SVOCs								
Anthracene	0.570531011	0	0.413634983	0.07441347	10	100	2.98E-06	2.98E-07
Benzo(a)anthracene	0.830399802	0	0.602039857	0.10830775	10	100	4.33E-06	4.33E-07
Benzo(a)pyrene	0.832578064	0	0.603619097	0.10859186	10	100	4.34E-06	4.34E-07
Chrysene	1.311104626	0	0.950550854	0.17100534	10	100	6.84E-06	6.84E-07
Fluoranthene	2.418777968	0.0001	1.753614027	0.31548103	10	100	1.26E-05	1.26E-06
Phenanthrene	1.657276453	0.00005	2.690174002	0.4839676	10	100	1.94E-05	1.94E-06
Pyrene	1.868382657	0	1.354577426	0.24369024	10	100	9.75E-06	9.75E-07

Heron Summary Table - PAH Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL with HR)[2]	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL with HR)[2]
SVOCs						
Anthracene	1.00E-02	7.18E-04	2.98E-06	1.00E-03	7.18E-05	2.98E-07
Benzo(a)anthracene	1.57E-02	1.83E-03	4.33E-06	1.57E-03	1.83E-04	4.33E-07
Benzo(a)pyrene	1.57E-02	1.38E-03	4.34E-06	1.57E-03	1.38E-04	4.34E-07
Chrysene	2.48E-02	1.93E-03	6.84E-06	2.48E-03	1.93E-04	6.84E-07
Fluoranthene	4.57E-02	2.93E-03	1.26E-05	4.57E-03	2.93E-04	1.26E-06
Phenanthrene	7.01E-02	4.47E-03	1.94E-05	7.01E-03	4.47E-04	1.94E-06
Pyrene	3.52E-02	2.93E-03	9.75E-06	3.52E-03	2.93E-04	9.75E-07
Totals	2.17E-01	1.62E-02	6.02E-05	2.17E-02	1.62E-03	6.02E-06

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Bald Eagle

Body Weight	3.7500000 kg		
Food Ingestion Rate	0.4500000 kg/day	% fish	1
Water Ingestion Rate	0.0000000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
Home Range Factor	0.0004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Red Drum Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
SVOCs								
Anthracene	0.570531011	0	0.118181424	0.01418177	10	100	5.67E-07	5.67E-08
Benzo(a)anthracene	0.830399802	0	0.172011388	0.02064137	10	100	8.26E-07	8.26E-08
Benzo(a)pyrene	0.832578064	0	0.172462599	0.02069551	10	100	8.28E-07	8.28E-08
Chrysene	1.311104626	0	0.271585958	0.03259031	10	100	1.30E-06	1.30E-07
Fluoranthene	2.418777968	0.0001	0.501032579	0.06012391	10	100	2.40E-06	2.40E-07
Phenanthrene	1.657276453	0.00005	0.768621144	0.09223454	10	100	3.69E-06	3.69E-07
Pyrene	1.868382657	0	0.387022122	0.04644265	10	100	1.86E-06	1.86E-07

Eagle Summary Table - PAH Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL and HR)[2]	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL and HR)[2]
SVOCs						
Anthracene	1.91E-03	1.37E-04	5.67E-07	1.91E-04	1.37E-05	5.67E-08
Benzo(a)anthracene	2.98E-03	3.50E-04	8.26E-07	2.98E-04	3.50E-05	8.26E-08
Benzo(a)pyrene	2.98E-03	2.64E-04	8.28E-07	2.98E-04	2.64E-05	8.28E-08
Chrysene	4.72E-03	3.69E-04	1.30E-06	4.72E-04	3.69E-05	1.30E-07
Fluoranthene	8.70E-03	5.59E-04	2.40E-06	8.70E-04	5.59E-05	2.40E-07
Phenanthrene	1.34E-02	8.51E-04	3.69E-06	1.34E-03	8.51E-05	3.69E-07
Pyrene	6.71E-03	5.58E-04	1.86E-06	6.71E-04	5.58E-05	1.86E-07
Totals	4.14E-02	3.09E-03	1.15E-05	4.14E-03	3.09E-04	1.15E-06

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Appendix E-2

Food-Chain Modeling
Modified HQ Calculations
PCB Hot Spot

UCL calculations for Sediment Hot Spot Areas

Assumptions
- One-half the non-detected values for sediment were used. These values are italicized.

Area of Hot Spot	1 acre	
Forage Areas		Home Range Factor
Raccoon	96 acres	0.01042
Heron	2500 acres	0.0004
Eagle	2500 acres	0.0004

PCB Hot Spot

	SW-20	SD-20	SD-32	SD-33	SD-34[1]	Mean	SD	95% UCL	
Aroclor-1254	0	250	76	9	250	146.25	122.9	250.0	(max conc)

sediment results in ug/kg, surface water results in ug/L
[1]Average of sample and duplicate.

Raccoon

Body Weight	3.9900000 kg		
Food Ingestion Rate	0.8560000 kg/day	% prey	0.906
Water Ingestion Rate	0.1710000 L/day		
Sed Ingestion Rate	0.8560000 kg/day	% sed	0.094
HR Ratio	0.0104167		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PCBs								
Aroclor-1254	0.25	0	1.15625	0.22978183	0.068	0.68	3.52E-02	3.52E-03

Raccoon Summary Table - PCB Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)
PCBs						
Aroclor-1254	3.38E+00	3.84E-01	3.52E-02	3.38E-01	3.84E-02	3.52E-03

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Great Blue Heron

Body Weight	2.2290000 kg		
Food Ingestion Rate	0.4010000 kg/day	% fish	1
Water Ingestion Rate	0.0800000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
HR Ratio	0.0004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PCBs								
Aroclor-1254	0.25	0	1.15625	0.20801088	0.18	1.8	4.62E-04	4.62E-05

Heron Summary Table - PCB Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)
PCBs						
Aroclor-1254	1.16E+00	1.31E-01	4.62E-04	1.16E-01	1.31E-02	4.62E-05

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Bald Eagle

Body Weight	3.7500000 kg		
Food Ingestion Rate	0.4500000 kg/day	% fish	1
Water Ingestion Rate	0.0000000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
HR Ratio	0.0004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Red Drum Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PCBs								
Aroclor-1254	0.25	0	0.330357143	0.03964286	0.18	1.8	8.81E-05	8.81E-06

Eagle Summary Table - PCB Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)
PCBs						
Aroclor-1254	2.20E-01	2.51E-02	8.81E-05	2.20E-02	2.51E-03	8.81E-06

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Appendix E-3

Food-Chain Modeling
Modified HQ Calculations
Pesticide Hot Spot

UCL calculations for Sediment Hot Spot Areas

Assumptions
- One-half the non-detected values were used. These values are italicized.

Area of Hot Spot	10 acre	
Forage Areas		Home Range Factor
Raccoon	96 acres	0.104167
Heron	2500 acres	0.004
Eagle	2500 acres	0.004

Pesticide Hot Spots (4 and 5 combined)

	SW-14	SD-14	SD-35	SD-36	SD-37	SD-28	SD-38	SD-39	SD-40[1]	Mean	SD	95% UCL
alpha-Chlordane	0	*13.5*	*6.5*	*11.5*	*6.5*	28	*13*	*7*	*6*	11.5	7.4	16.6
gamma-Chlordane	0	*13.5*	*6.5*	*11.5*	*6.5*	28	*13*	*7*	*6*	11.5	7.4	16.6
4,4'-DDE	0	*45*	*13.5*	75	*12.5*	*29.5*	60	*14*	*12*	32.6875	24.6	49.8
4,4'-DDD	0	290	*13.5*	62	*12.5*	40	70	*14*	*12*	64.25	94.2	129.5

sediment results in ug/kg, surface water results in ug/L
[1]Average of sample and duplicate.

Raccoon
(Conservative Inputs)

Body Weight	3.9900000 kg		
Food Ingestion Rate	0.8560000 kg/day	% prey	0.906
Water Ingestion Rate	0.1710000 L/day		
Sed Ingestion Rate	0.8560000 kg/day	% sed	0.094
HR Ratio	0.1041667		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PESTICIDES								
4,4'-DDD	0.129516788	0	0.090661752	0.020233807	0.8	4	2.63E-03	5.27E-04
4,4'-DDE	0.049763942	0	0.957955886	0.187201374	0.8	4	2.44E-02	4.88E-03
Alpha-Chlordane	0.016598859	0	0.197941399	0.038808594	4.6	9.2	8.79E-04	4.39E-04
Gamma-Chlordane	0.016598859	0	0.09212367	0.01824081	4.6	9.2	4.13E-04	2.07E-04

Raccoon Summary Table - Pesticide Hot Spot

ECOC	NOAEL			LOAEL		
	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL and HR)[2]	HQ(max)[1]	HQ(avg)[1]	HQ (95% UCL and HR)[2]
PESTICIDES						
4,4'-DDD	5.66E-02	8.07E-03	2.63E-03	1.13E-02	1.61E-03	5.27E-04
4,4'-DDE	2.12E-01	1.37E-01	2.44E-02	4.23E-02	2.75E-02	4.88E-03
Alpha-Chlordane	1.42E-02	7.41E-02	8.79E-04	7.12E-03	3.70E-02	4.39E-04
Gamma-Chlordane	6.69E-03	3.48E-02	4.13E-04	3.34E-03	1.74E-02	2.07E-04
Total	2.89E-01	2.54E-01	2.83E-02	6.41E-02	8.35E-02	6.05E-03

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Great Blue Heron
(Conservative Inputs)

Body Weight	2.2290000 kg		
Food Ingestion Rate	0.4010000 kg/day	% fish	1
Water Ingestion Rate	0.0800000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
HR Ratio	0.004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Mummichog Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PESTICIDES								
4,4'-DDD	0.129516788	0	0.090661752	0.01631017	0.0028	0.028	2.33E-02	2.33E-03
4,4'-DDE	0.049763942	0	0.957955886	0.17233751	0.0028	0.028	2.46E-01	2.46E-02
Alpha-Chlordane	0.016598859	0	0.197941399	0.03560992	2.14	10.7	6.66E-05	1.33E-05
Gamma-Chlordane	0.016598859	0	0.09212367	0.01657317	2.14	10.7	3.10E-05	6.20E-06

Heron Summary Table - Pesticide Hot Spot

	NOAEL			LOAEL		
ECOC	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)
PESTICIDES						
4,4'-DDD	1.30E+01	1.86E+00	2.33E-02	1.30E+00	1.86E-01	2.33E-03
4,4'-DDE	5.57E+01	3.61E+01	2.46E-01	5.57E+00	3.61E+00	2.46E-02
Alpha-Chlordane	2.81E-02	1.46E-01	6.66E-05	5.61E-03	2.92E-02	1.33E-05
Gamma-Chlordane	1.31E-02	6.80E-02	3.10E-05	2.61E-03	1.36E-02	6.20E-06
Total	6.87E+01	3.82E+01	2.70E-01	6.88E+00	3.84E+00	2.70E-02

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations

Bald Eagle
(Conservative Inputs)

Body Weight	3.7500000 kg		
Food Ingestion Rate	0.4500000 kg/day	% fish	1
Water Ingestion Rate	0.0000000 L/day		
Sediment Ingestion Rate	0.0000000 kg/day		
HR Ratio	0.004		

HQs calculated using 95% UCL Concentrations and Home Range Considerations

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Red Drum Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
PESTICIDES								
4,4'-DDD	0.129516788	0	0.025903358	0.0031084	0.0028	0.028	4.44E-03	4.44E-04
4,4'-DDE	0.049763942	0	0.273701682	0.0328442	0.0028	0.028	4.69E-02	4.69E-03
Alpha-Chlordane	0.016598859	0	0.056554685	0.00678656	2.14	10.7	1.27E-05	2.54E-06
Gamma-Chlordane	0.016598859	0	0.026321049	0.00315853	2.14	10.7	5.90E-06	1.18E-06

Eagle Summary Table - Pesticide Hot Spot

	NOAEL			LOAEL		
ECOC	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)	HQ(max)(1)	HQ(avg)(1)	HQ (95% UCL and HR)(2)
PESTICIDES						
4,4'-DDD	2.49E+00	3.54E-01	4.44E-03	2.49E-01	3.54E-02	4.44E-04
4,4'-DDE	1.06E+01	6.88E+00	4.69E-02	1.06E+00	6.88E-01	4.69E-03
Alpha-Chlordane	5.35E-03	2.78E-02	1.27E-05	1.07E-03	5.57E-03	2.54E-06
Gamma-Chlordane	2.49E-03	1.30E-02	5.90E-06	4.98E-04	2.59E-03	1.18E-06
Total	1.31E+01	7.28E+00	5.14E-02	1.31E+00	7.32E-01	5.14E-03

1. HQs calculated with site maximum and mean concentrations (from the 1999 RI/RFI for Site 3).
2. HQs calculated using a the 95% UCL as the exposure concentration and factoring in home range considerations