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LAW

ENGINEERING AND ENVIRONMENTAL SERVICES

DRAFT
EXPOSURE ASSESSMENT TECHNICAL MEMORANDUM

FOR THE

AQUARIUM SITE
FORT SUMTER NATIONAL MONUMENT

CHARLESTON, SOUTH CAROLINA

PREPARED FOR

NATIONAL PARK SERVICE

DENVER SERVICE CENTER

12795 WEST ALAMEDA PARKWAY

DENVER, COLORADO

PREPARED BY

LAW ENVIRONMENTAL, INC.

GOVERNMENT SERVICES DIVISION

114 TOWNPARK DR.

ATLANTA, GEORGIA

SEPTEMBER 1994

LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

September 23, 1994

National Park Service
Fort Sumter National Monument
1214 Middle Street
Sullivan's Island, SC 29482

Attention: Mr. Carl Wang
Project Manager

Subject: Draft Exposure Assessment Technical Memorandum
Final Screening Criteria Document
Indefinite Quantities Contract No. 1443CX200093019
Task Order No. 17
Fort Sumter National Monument
Package No. FOSU-105A-15A
Project No. 11-4598-2517

Dear Mr. Wang:

Law Environmental, Inc. is pleased to submit the Draft Exposure Assessment Technical Memorandum and the Final Screening Criteria Document for the South Carolina Aquarium Site, Charleston, South Carolina.

The distribution of the report is listed below:

Name	No. Copies
Mr. Carl Wang National Park Service Fort Sumter National Monument 1214 Middle Street Sullivan's Island, SC 29482	2
W. Thomas Brown National Park Service Southeast Regional Office 75 Spring Street, S.W. Atlanta, Georgia 30303	5

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If you have any questions or need additional information, please do not hesitate to call us at (404) 499-6849.

Sincerely,

LAW ENVIRONMENTAL, INC.

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DRAFT
EXPOSURE ASSESSMENT TECHNICAL MEMORANDUM

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AQUARIUM SITE

FORT SUMTER NATIONAL MONUMENT
CHARLESTON, SOUTH CAROLINA

Prepared for:
NATIONAL PARK SERVICE
Denver Service Center
1279 West Alameda Parkway
Denver, Colorado

Prepared by:

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Government Services Division
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Kennesaw, Georgia

September 1994

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

Page

LIST OF TABLES

EXECUTIVE SUMMARY

The purpose of Exposure Assessment Technical Memorandum is to assess potential releases and exposures during construction of the South Carolina Aquarium, Charleston, South Carolina. The assessment includes a review of containment and contingency plans designed to address potential releases and a qualitative evaluation of the impact of construction on future remediation efforts.

The City of Charleston proposes to build the South Carolina Aquarium on a tract of property to be leased from the NPS. Because of the industrial history of the NPS property and the location of a National Priority List site (Calhoun Park Area site) adjacent to the NPS property, the City of Charleston has performed an environmental investigation at the Aquarium site (Killam, 1994a and b). Soil, ground water, surface water, and sediments were sampled in order to assess the presence or absence of chemical contamination in these media which may be released to the environment during construction of the aquarium.

CONSTITUENTS OF CONCERN BY MEDIA

Constituents detected in soils and sediments include metals, several polycyclic aromatic hydrocarbons (PAHs), semivolatile organic compounds, polychlorinated biphenyls (PCBs), and limited amounts of pesticides, dioxin/furans, and volatile organic compounds. Constituents detected in surface water include metals only. Constituents detected in shallow ground water include metals, PAHs, and trace amounts of volatile organic compounds. The constituents detected are consistent with those found at the Calhoun Park Area site and with those that would be anticipated at other former gasification plants.

Constituents of concern were selected for each medium by comparing levels detected to toxicological endpoints designed to be protective of human health and ecological diversity (Appendix A) and to area background levels. Investigations at the Calhoun Park Area site (Chester, 1994) and the NPS property (PSI, 1994) included the collection of area background samples for soil, surface water, sediment, and groundwater. PAHs and metals are expected to be the primary constituents of concern for both human and ecological receptors.

CONSTRUCTION EXPOSURE ASSESSMENT

The construction exposure assessment provides an evaluation of the potential for human or environmental exposure to site constituents that may be attributable to construction of the South Carolina Aquarium Site by identifying potential human and ecological receptors and potential construction-related exposure pathways.

The human populations which may be exposed during construction include on-site workers, nearby residents, off-site workers, and visitors to the site. Site workers are potentially exposed to soil, fugitive dust, volatile emissions from the soil, shallow groundwater, surface water including storm runoff, and sediment. Nearby residents and off-site workers are potentially exposed to fugitive dust and volatile emissions blown off-site. In addition, recreational users of the Cooper River and Charleston Harbor may harvest shellfish or finfish from the Cooper River, and may be exposed through bioaccumulation of constituents in the food chain or by direct contact with surface water and sediments while fishing and wading.

Ecological receptors potentially exposed to site media include terrestrial site dwellers, amphibian and aquatic species, migratory birds, and site flora. Terrestrial and amphibian species may be exposed to site soils, surface water, sediment, and shallow ground water through ingestion of plants and water sources at the site, and through burrowing and preening. Aquatic species and sea birds come into direct contact with surface water and sediments and are potentially exposed to constituents which bioaccumulate within the food chain. Plants take up nutrients and, potentially, contaminants from site soils and sediments.

Baseline exposure pathways were identified for construction-related exposure. No use of engineering controls or health and safety measure was assumed in the identification of complete baseline exposure pathways. Because site concentrations exceeded screening guidelines for several constituents, baseline exposure for identified receptors appeared to present an unacceptable level of health risk.

REVIEW OF CONTAINMENT AND CONTINGENCY PLANNING

Engineering controls have been proposed by the City of Charleston to physically reduce or prevent off-site migration and release during construction (Killam, 1994c). This evaluation does not address the regulatory issues associated with dredge and fill operations which would occur as part of the control measures' construction. The control measures, in most cases, also would serve as a means to limit or eliminate potential site-related exposures. These control measures include installation of a sand blanket, a timber wall, and a silt curtain. These measures would be designed to minimize surface runoff, subsurface discharge, and migration of soil, sediment, and ground water constituents to surface water and to retain affected sediments within the area of construction. Concerns over the potential for causing an increase in migration of contaminants should be reduced with the results of the demonstration programs for pile installation in upland and subtidal areas. The use of an upward hydraulic gradient and alternative pile driving techniques have also been considered to prevent downward migration of constituents to the sand aquifer. Surface soil is to be removed prior to installation of the aquarium foundation. The aquarium itself might serve as a physical barrier to storm-water infiltration.

The exposure to ecological receptors and off-site human receptors would likely be limited by effective use of the proposed engineering control measures. These measures would be designed to reduce or prevent migration, rather than block exposure. Both the contractor and the environmental inspector would be responsible for regular auditing and documentation of the adequacy of the engineering control measures throughout the active construction period. With due diligence, off-site migration and exposure should be held to an acceptable risk level.

On-site workers would be the human receptors most likely to be exposed during construction of the Aquarium. Through the proper use of personal protection clothing, the adoption of safe operating procedures, and the consistent application of on-site air monitoring, exposure to site workers should be within accepted occupational parameters.

POTENTIAL IMPACTS ON REMEDIATION EFFORTS

The potential benefits of construction of the aquarium at this site appear to outweigh potential negative impacts. Removal of existing debris and contaminated soil and "capping" of the site provided by the building and paved areas are forms of remediation in themselves. The flow of ground water through the filled area would be retarded by installation of the lagging wall with its impermeable liner, and a decrease in rainwater infiltration would result from the construction of the large aquarium building and paved parking areas. If the diversion of ground-water around the aquarium site were made a part of remediation efforts at the site, installation of a vertical hydraulic barrier along the northern and western property boundaries could be implemented without interference from the aquarium building. Monitoring wells installed along the south and east boundaries of the site could be converted to extraction wells and would allow extraction of ground water for treatment if required.

SUMMARY

Construction of the aquarium would require the application of currently available technologies in a unique and untried environmental situation. Assumptions have been made concerning the adequacies of the proposed Containment Plan and Exposure Monitoring and Response Plans (Killam, 1994c). Exposure to on-site and off-site receptors could potentially be held to acceptable levels if the planned procedures were followed consistently throughout the project.

1.0 INTRODUCTION

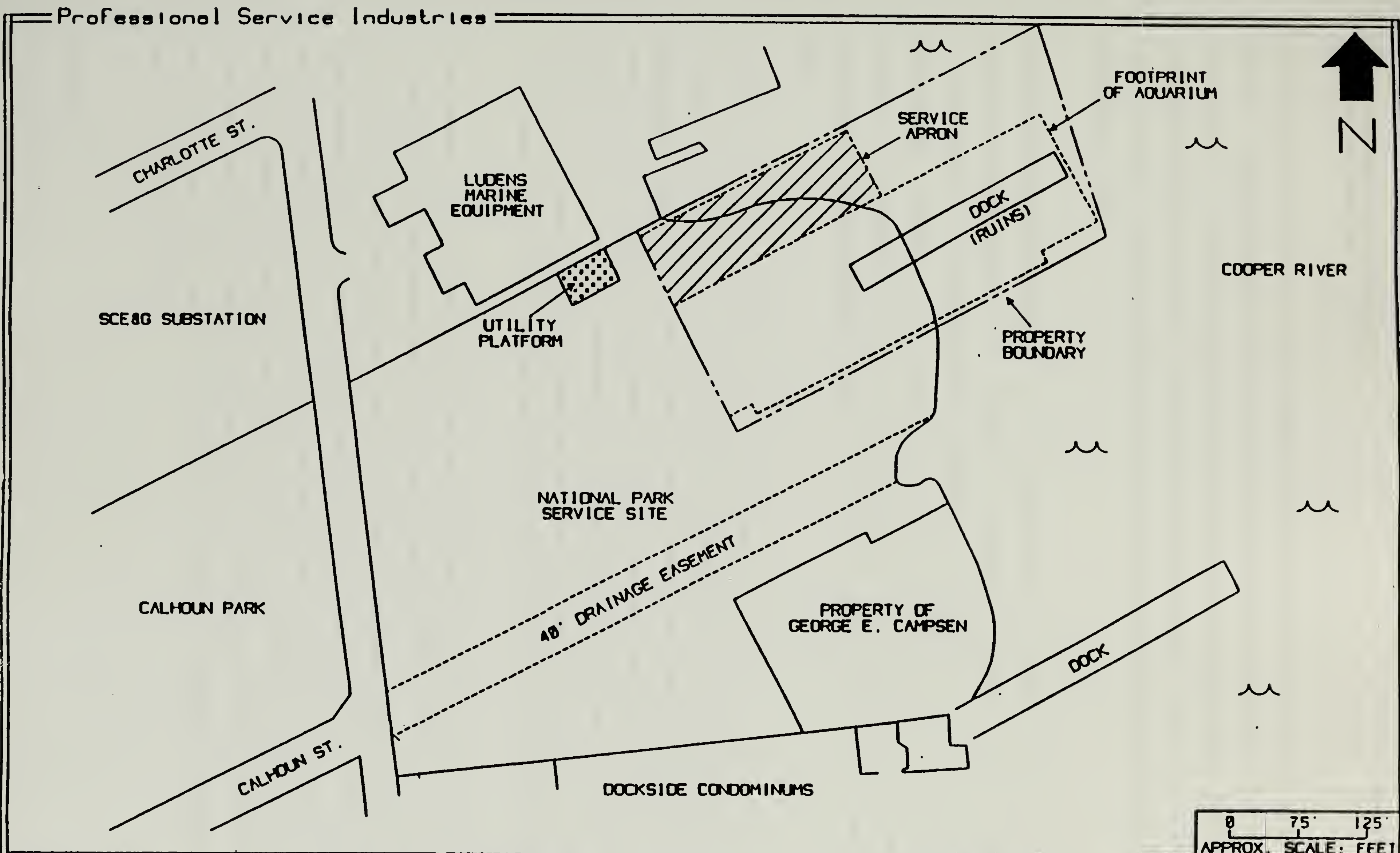
The National Park Service (NPS), under Contract Number 1443CX2000-93-019, has contracted with Law Environmental, Inc. (Law) to provide an Exposure Assessment Technical Memorandum. The purpose of the Memorandum is to assess potential releases and exposures during construction of the South Carolina Aquarium, Charleston, South Carolina. The assessment includes a review of preliminary containment and contingency plans which would be designed to address potential releases and the qualitative evaluation of the impact of construction on future remediation efforts. This draft document is based on data collected by Killam Associates (1994a and 1994b), Professional Service Industries, Inc. (1994), and Chester Engineering (1994). The conclusions and recommendations in this document may be revised as additional data concerning site remediation becomes available.

1.1 SITE HISTORY AND BACKGROUND

The City of Charleston has proposed to build the South Carolina Aquarium on a tract of property to be leased from the NPS. Because of the industrial history of the NPS property and the location of a National Priority List site (Calhoun Park Area site) adjacent to the NPS property, the City of Charleston has performed an environmental investigation at the Aquarium site. Soil, ground water, surface water, and sediments were sampled in order to assess the presence or absence of chemical contamination in these media which might be released to the environment during construction of the aquarium. The draft document, Site Investigation Report and Conceptual Containment Plan (Killam Associates, 1994a), presents the data from the investigation of the Aquarium site and is the primary source for analytical data discussed in the Exposure Assessment Technical Memorandum.

Area background levels for constituents detected in soil, sediments, ground water, and surface water were taken from reports by Chester Engineering (1994) and Professional Service Industries (PSI) (1994). These investigations were performed at sites adjacent to the Aquarium site.

The Aquarium is to be located in the northeastern corner of the NPS property (Figure 1-1) and would be situated partly over the upland portion of the property, partly over the intertidal zone of the Cooper



PROJECT NAME	FIGURE 1-1	PROJECT NO. 513-34002
NATIONAL PARK SERVICE FORT SUMTER NATIONAL MONUMENT CHARLESTON, SOUTH CAROLINA	SITE LAYOUT MAP	DATE 4-7-93

Source: PSI, 1993a

River, and partly over open water. The constructed Aquarium would consist of three floors plus a partial basement. An approximate total of 350 concrete piles would be driven, with 80 piles in the subtidal area of the Cooper River, 25 piles in the intertidal zone, and 255 piles in the upland area. Piles would be driven to approximate depths of 98 to 110 feet below mean sea level (msl). Three to four feet of soil (Horizon A and B) would be removed from the upland portion of the tract during construction (PSI, 1993a; Killam, 1993).

The NPS Charleston Harbor property, as a whole includes four acres of uplands and four acres within the current range of the Cooper River. The proposed Aquarium site includes a 1.5 acre tract (Figure 1-1). Other areas of the NPS property are to be developed as a dock facility for the Fort Sumter National Monument and a restaurant. According to historical records, the NPS property is largely fill and has been used at various times as a commercial wharf, dry dock for ship building, lumber wharf, and for the manufacture of chemicals and paint. Ruins of the old docks are adjacent to the Aquarium site (Killam, 1993).

A Remedial Investigation/Feasibility Study is currently being completed for the Calhoun Park Area site (Chester, 1994). Background analytical data from the <u>Preliminary Site Investigation Report for the Calhoun Park Area Site</u> have been adopted for the evaluation of the Aquarium site. Environmental remediation of the Calhoun Park Area site may directly or indirectly impact the Aquarium site. The feasibility study of remedial alternatives for the Calhoun Park Area site has not yet been issued. Discussion of potential remediation alternatives and intervention into the NPS property are based on verbal discussions with USEPA and the South Carolina Gas and Electric Company (Meeting, 1994).

Three previous and three recent investigations have included samples collected within the Aquarium site or from the drainage way located south of the Aquarium site (PSI, 1993b, 1994; Chester, 1993, 1994; Killam, 1994a). Constituents detected in soils and sediments include metals, several polycyclic aromatic hydrocarbons (PAHs), semivolatile organic compounds, polychlorinated biphenyls (PCBs), and limited amounts of pesticides, dioxins, and volatile organic compounds. Constituents detected in surface water and shallow ground water include metals, PAHs, and trace amounts of volatile organic compounds. The constituents detected are consistent with those found at the Calhoun Park Area site and other former gasification plants. PAHs and metals are expected to be the primary constituents of concern for both human and ecological receptors.

1.2 OBJECTIVE OF THE EXPOSURE ASSESSMENT

Exposure is defined as the contact of an organism with a chemical or physical agent (USEPA, 1989a). The objective of this exposure assessment is to provide an evaluation of the potential for human or environmental exposure to site constituents that may be attributable to construction of the South Carolina Aquarium Site. Additional objectives include evaluations of the ability to limit or reduce construction-related exposures through the use of engineering controls and of the potential interferences on site remediation by aquarium construction.

1.3 SCOPE OF THE EXPOSURE ASSESSMENT

The scope of the exposure assessment is to identify constituents of potential concern and qualitatively estimate risks for human and ecological receptors potentially exposed to media at the construction site. Five site media were identified as potentially serving as exposure media. These included air, ground water, soils, surface water, and sediments. Food chain exposure pathways are also qualitatively discussed in this assessment.

The first step in the exposure assessment is the identification of constituents of potential concern. Aquarium site constituents detected in soil, ground water, surface water, and sediments are compared to toxicological endpoints designed to be protective of human health and ecological diversity. Constituents detected above site background and toxicological endpoints are considered to be constituents of potential concern for that medium. Constituents associated with the site are metals, PAHs, pesticides, PCBs, and volatile and semi-volatile organic compounds.

The next step is to identify potential human and ecological receptors and potential construction-related exposure pathways. Multiple factors such as the distribution and magnitude of detected concentrations and the frequency and duration of potential exposures will be considered in evaluating site-related risks.

The third step is to consider means to limit or eliminate potential site-related exposures. Engineering controls have been proposed by the City of Charleston to physically reduce off-site migration and release during construction (Killam, 1994c). These control measures include installation of a sand blanket, a

timber wall, and a silt curtain. The use of casings and alternative pile driving techniques have also been considered. Surface soil would be be removed prior to installation of the aquarium foundation. The aquarium itself might serve as a physical barrier to storm-water infiltration. These measures have been qualitatively reviewed (Section 3.4) for their effectiveness in limiting construction-related exposures and releases to the environment.

In addition, the potential impacts of construction on future site remediation have been qualitatively addressed (Section 3.5). Physical alteration of the site by removal of subsurface debris and installation of the support piles might alter subsurface migration or potentially hinder subsurface remediation. The sand blanket and timber wall are both seen as temporary control measures.

1.4 ORGANIZATION OF THE EXPOSURE ASSESSMENT

The exposure assessment information will be presented according to the five steps as outlined below:

1. Identification of chemicals of potential concern

2. Characterization of exposure settings

3. Identification of exposure pathways

4. Evaluation of proposed containment and contingency plans

5. Evaluation of impacts on remediation from construction

This exposure assessment has been conducted in a manner consistent with that presented by the Risk Assessment Guidance for Superfund, Volume I and II (USEPA, 1989a and 1989b), Framework for Ecological Risk Assessment (USEPA, 1992a), and Guidelines for Exposure Assessment (Federal Register, 1992).

2.0 IDENTIFICATION OF CONSTITUENTS OF CONCERN

This section will present a summary of the screening criteria and guidelines, reference the source of site data, including background data, and discuss constituents exceeding screening levels and trends in the distribution of these constituents in site media.

2.1 SUMMARY OF THE SCREENING CRITERIA DOCUMENT

The Final Screening Criteria Document is presented in Appendix A. This document presents screening criteria and guidelines for surface and subsurface soil, surface water, sediments, and ground water. A comparison of analytical values detected at the Aquarium site to the values listed in the Screening Criteria Document will be used as one indicator that a constituent is of potential concern.

Screening criteria and guidelines identified as protective of human health and the environment include federal and state drinking water standards (SCDHEC, 1990; USEPA, 1994a)(for ground water), marine chronic ambient water quality criteria (USEPA, 1986) and Region IV Waste Management Division saltwater quality screening values (USEPA, 1993a)(for surface water and ground water), sediment quality guidelines developed by Long et al. (1993) and Region IV Waste Management Division sediment quality screening values (USEPA, 1994b)(for sediments and surface soil), and Region III Risk-based Concentrations for industrial and residential exposures to soils (USEPA, 1994c) (for surface and subsurface soils). The criteria and guidelines are discussed in detail in Appendix A.

2.2 SOURCES OF SITE DATA

The data collected and presented in the Draft Site Investigation Report and Conceptual Containment Plan (Killam Associates, 1994a) is the source of analytical data for the comparison tables presented in the exposure assessment. The comparison tables present the frequency of detection and the minimum and maximum detected concentrations for the constituents listed in the Site Investigation Report. Killam Associates performed a screening process by which they identified constituents which may require

containment during construction. Therefore, data for constituents exceeding the containment screening criteria were the only data available for toxicological screening in the exposure assessment. Additional constituents potentially presenting a risk to human health or the environment may not be represented in the exposure assessment.

The intention of the exposure assessment is to address the constituent types of greatest concern such as the PAHs, metals, and potentially, volatile organic compounds, dioxins, PCBs, and pesticides. In some instances, the values listed in the comparison tables are taken from the Response to Comments on Site Investigation Report (Killam, 1994b) and were not listed in the summary table included in the Draft Site Investigation Report (Killam, 1994a).

Practical Quantitation Limits for the Aquarium site were presented in the Quality Assurance/Quality Control (QA/QC) Plan (Killam, 1993). Proposed methods for analyses of dioxins and PAHs were amended in "Requirements and Suggestions for QA/QC Plan, Attachment A to Memorandum from J.W. Coleman, Jr., NPS Southeast Regional Director, to J. P. Riley, Jr., Mayor, City of Charleston". In most instances, the sample quantitation limits for the detected constituents were comparable to the screening criteria values. However, several ambient water quality criteria are below the sample quantitation limits. The adoption of more sensitive surface water analytical methods for PCBs is proposed in the Environmental Response and Monitoring Plan (Killam, 1994c).

2.3 BACKGROUND LEVELS FOR SITE CONSTITUENTS

Investigations at the Calhoun Park Area site (Chester, 1994) and the NPS property (PSI, 1994) included the collection of background samples for soil, surface water, sediment, and groundwater. Analytical data for these samples were included in the screening criteria tables after eliminating background samples with outlier points. Outliers were identified by comparing individual background points to two times the average background concentration. If the individual background point exceeded two times the average background, the point was removed from the background data set. Maps showing the background sample locations are included in the Preliminary Site Characterization Report (Chester, 1994) and the Expanded Site Investigation Report (PSI, 1994). Tables which list background results and a description of samples used as background are included in Section 2.5 of the Final Screening Criteria Document which is Appendix A of this document.

2.4 COMPARISON TO SCREENING AND BACKGROUND LEVELS

Maps with sampling locations used during the aquarium site investigation are presented in the Site Investigation Report and Conceptual Containment Plan (Killam, 1994a). Constituent levels have been sorted by media and area of activity and detected concentrations compared to screening criteria levels presented in Appendix A. The comparison tables list the frequency of detection, the minimum and maximum detected concentrations, and the most conservative screening criteria for the media of interest. Maximum concentrations which exceed screening levels are highlighted by blocking, italics, or shading, as described in the footnotes for each table. The number of samples exceeding both background levels and screening criteria per total number of samples is also listed on the tables.

2.4.1 Horizon "A" (Upland Soils)

Table 2-1 compares the soil sampling results collected at Horizon "A" of the Upland Soils to surface soil and sediment screening guidelines. Horizon "A" soil concentrations are compared to both soil and sediment quality guidelines because the soil in this area may wash into the river during construction activities. Thirteen semivolatile organic constituents, ten metal constituents, three pesticides, arochlor-1254, and arochlor-1260 exceed both surface soil background and sediment screening criteria. Seven semivolatile organic constituents, nine metal constituents, arochlor-1264, arochlor-1260, and 2,3,7,8-TCDF are above surface soil background concentrations and the most stringent soil screening level.

2.4.2 Horizon "B" (Upland Soils)

Table 2-2 compares the soil sampling results collected at Horizon "B" of the Upland soils to subsurface soil background levels and soil guidelines. Constituents above subsurface soil background and the most stringent soil screening levels concentrations are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, antimony, arsenic, beryllium, lead, manganese, arochlor-1254, and arochlor-1260.

TABLE 2–1

COMPARISON OF HORIZON "A" (UPLAND SOILS)
SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Surface Soil Background Range (a)	Most Stringent Sediment Level (b)	Frequency Detected Exceeding Sediment Guidelines and Background	Most Stringent Soil Level (c)	Frequency Detected Exceeding Soil Guidelines and Background
Volatile Organics:								
Benzene	3/48	0.0003JD	0.0018	ND	NA	NA	2.5	0/48
Ethylbenzene	5/48	0.00059	0.027	0.046 J	NA	NA	58	0/48
Toluene	9/48	0.00025	0.002	ND	NA	NA	150	0/48
Xylene	2/27	0.001BJ	0.001BJ	0.007 J – 58	NA	NA	97	0/27
Semi–Volatile Organics:								
Acenaphthene	19/36	0.041 J	5.8 J	ND	0.016	16/36	4,700	0/36
Acenaphthylene	10/36	0.016 J	0.54 J	0.0325	0.044	7/36	NA	NA
Anthracene	29/36	0.097 J	100	0.032 J	0.085	29/36	23,000	0/36
Benzo(a)anthracene	25/36	0.091 J	15 D	0.12 J – 0.24 J	0.26	22/36	0.88	19/36
Benzo(a)pyrene	24/36	0.0023 J	13	0.3 J – 0.25 J	0.33	19/36	0.088	19/36
Benzo(b)fluoranthene	34/36	0.0093	29 DX	0.054 J – 0.39	NA	NA	0.88	25/36
Benzo(k)fluoranthene	26/36	0.054	29 DX	0.24 J – 0.17 J	NA	NA	8.8	2/36
Benzo(g,h,i)pyrene	27/36	0.0082 J	4.5 D	0.24 J	NA	NA	NA	NA
Carbazole	8/16	0.071 J	1.2 J	ND	NA	NA	32	0/16
Chrysene	34/36	0.0045	13 D	0.16 J – 0.31 J	0.33	27/36	0.8	24/36
Dibenz(a,h)anthracene	27/36	0.0031	2.6 DJ	0.035 J – 0.053 J	0.063	20/36	0.088	18/36
Fluoranthene	33/36	0.086 J	70	0.26 J – 0.56	0.38	26/36	3,100	0/36
Fluorene	14/36	0.044 J	5.2 J	ND	0.019	14/36	3,100	0/36
Indeno(1,2,3–c,d)pyrene	31/36	0.01	16 D	0.12 J – 0.23 J	NA	NA	0.88	16/36
2–Methylnaphthalene	11/16	0.043 J	16	ND	0.07	9/16	NA	NA
Naphthalene	19/36	0.034 J	4.5	ND	0.16	12/36	52	0/36
Phenanthrene	35/36	0.11 J	33	0.10 J – 0.21 J	0.24	32/36	NA	NA
Pyrene	31/36	0.12 J	43	0.25 J – 0.41	0.33	24/36	2,300	0/36
Total CaPAHs	36/36	0.038	107	0.11 – 1.64	2.9	NA	NA	NA
Total PAHs	36/36	0.34	292	0.11 – 3.13	2.9	13/36	NA	NA
Metals:								
Antimony	26/36	8.3	166	ND	12	24/36	31	13/36
Arsenic	36/36	2	130	2.1 B – 5.8	8	6/36	0.37	6/36
Beryllium	17/36	0.46 B	9.2	0.26 B – 0.37 B	NA	NA	0.15	17/36
Cadmium	24/36	0.97	43.7	ND	1	22/36	39	1/36
Chromium	36/36	3.4	571	6.2 – 11.1	33	30/36	390	2/36

TABLE 2-1

COMPARISON OF HORIZON "A" (UPLAND SOILS)
SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Surface Soil Background Range (a)	Most Stringent Sediment Level (b)	Frequency Detected Exceeding Sediment Guidelines and Background	Most Stringent Soil Level (c)	Frequency Detected Exceeding Soil Guidelines and Background
Copper	36/36	7.6	**11,600**	3.9 B – 33.7	28	33/36	2,900	1/36
Lead	36/36	8.1	**43,600**	36.1 – 304	21	23/36	500	18/36
Manganese	16/16	71.4	2,120	11.9 – 53.6	NA	NA	390	7/16
Mercury	35/36	0.17	**10.5**	0.12 – 0.34	0.1	31/36	23	0/36
Nickel	34/36	6	**1,510**	12.8	20.9	27/36	1,600	0/36
Silver	3/36	3.2	**4.6**	ND	1	3/36	390	0/36
Vanadium	16/16	24.7	13,000	4.3 B – 10.6	NA	NA	550	3/16
Zinc	36/36	21.7	**8,640**	26.3 – 130	68	31/36	23,000	0/36
Pesticides/PCBs/Dioxins:								
Dieldrin	11/16	0.00078 JP	**0.0052**	ND	0.0033	2/16	0.04	0/16
4,4'-DDE	14/16	0.0067 JP	**0.23 JPD**	0.00085 J – 0.0046 P	0.0022	13/16	1.9	0/16
4,4'-DDT	14/16	0.001 JP	**0.46 D**	0.0011 JP – 0.0019 JP	0.00158	13/16	1.9	0/16
Arochlor-1254	5/36	0.07	**12**	ND	0.0227	5/36	0.083	4/36
Arochlor-1260	18/36	0.025	**1.1**	ND	0.0227	5/36	0.083	13/36
2,3,7,8 – TCDF	6/14	2.25E-06	0.000425	1.8E-06	NA	NA	4.1E-06 (d)	5/14
Total PCBs	23/36	0.025	**12**	ND	0.0227	23/36	NA	NA

Units in mg/kg.
B The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.
D Identifies all compounds identified in an analysis at a secondary dilution factor.
J Indicates an estimated value.
ND Not Detected
NA Not available
P Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.
X Other specific flags and footnotes required to properly define the results.

Boxing indicates value exceeds its background range and screening levels(s).
Bolding indicates value exceeds most stringent sediment screening level.
Shading indicates value exceeds most stringent soil screening level.

(a) Chester Environmental, 1994. Preliminary Site characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.
(b) Long et al., 1993. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Draft, Environmental Mgt. (10/93)
USEPA, 1994b. USEPA Region IV Waste Mgt. Division Screening Values
(c) EPA Region III Risk-Based concentration Table, Third Quarter, 1994. July 11, 1994.
USEPA, 1993b. Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response, September 1993.
(d) Value for 2,3,7,8-TCDD, Region III RBC Table.

TABLE 2-2

COMPARISON OF HORIZON "B" (UPLAND SOILS) SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Subsurface Soil Background Range (a)	Most Stringent Soil Level (b)	Frequency Detected Exceeding Soil Guidelines and Background
Volatile Organics:						
Benzene	4/25	0.00022J	0.00086J	ND	2.5	0/25
Ethylbenzene	8/25	0.00039J	0.009J	ND	58	0/25
Toluene	4/25	0.00031JP	0.0016JP	ND	150	0/25
Xylene	1/6	NA	0.01J	ND	97	0/6
Semi-Volatile Organics:						
Acenaphthene	17/25	0.0025 J	15	ND	4,700	0/25
Acenaphthylene	10/25	0.0095	1.7 DJ	ND	NA	NA
Anthracene	19/25	0.021	25	0.028 J	23,000	0/25
Benzo(a)anthracene	16/25	0.0027	18 D	0.18 J	0.88	9/25
Benzo(a)pyrene	14/25	0.004	11 D	0.2 J	0.088	7/25
Benzo(b)fluoranthene	20/25	0.0007 J	19 DX	0.25 J	0.88	9/25
Benzo(k)fluoranthene	24/25	0.00059 J	19 DX	0.099 J	8.8	1/25
Benzo(g,h,i)pyrene	21/25	0.0014	3.4 DJ	0.14 J	NA	NA
Chrysene	20/25	0.011	15 D	0.14 J	0.8	0/25
Dibenz(a,h)anthracene	18/25	0.00014 J	1.7 DJ	0.051 J	0.088	7/25
Fluoranthene	19/25	0.003	36 D	0.14 J	3,100	0/25
Fluorene	13/25	0.0091 J	11 D	ND	3,100	0/25
Indeno(1,2,3-c,d)pyrene	19/25	0.0033	16	0.16 J	0.88	7/25
2-Methylnaphthalene	2/6	0.12 J	2.9 J	ND	NA	NA
Naphthalene	8/25	0.0011 J	2.9	ND	52	0/25
Phenanthrene	24/25	0.0051	40 D	0.088 J	NA	NA
Pyrene	18/25	0.0027	29 D	0.15 J	2,300	0/25
Total CaPAHs	25/25	0.0031	89.3	1.08	NA	NA
Total PAHs	25/25	0.21	239	1.63	NA	NA
Metals:						
Antimony	8/25	5.9	169	ND	31	3/25
Arsenic	25/25	1.2	86.5	2.1 B	0.37	8/25
Beryllium	10/25	0.22	2.7	ND	0.15	10/25
Cadmium	4/25	0.89	5.8 B	ND	39	0/25
Chromium	25/25	8.6	212	6.2	390	0/25
Copper	18/25	1.5 B	1,000	12.5	2,900	0/25
Lead	25/25	3.3	2,960	67	500	5/25
Manganese	6/6	8.5	463	35.2	390	1/6
Mercury	15/25	0.15	13.5	ND	23	0/25
Nickel	13/25	5.5 B	224	ND	1,600	0/25
Vanadium	6/6	11.1 B	261	7 B	550	0/6
Zinc	25/25	5.4	8,880	16.7	23,000	0/25
Pesticides/PCBs/Dioxins:						
Dieldrin	2/6	0.00038 JP	0.0045 JP	ND	0.04	0/6
4,4'-DDE	2/6	0.01	0.024 P	ND	1.9	0/6
4,4'-DDT	3/6	0.001 JP	0.01 P	ND	1.9	0/6
Arochlor-1254	1/25	NA	0.16	ND	0.083	1/25
Arochlor-1260	6/25	0.021 JP	8.9	ND	0.083	5/25
2,3,7,8 - TCDF	1/4	NA	2.2E-06	ND	4.1E-06 (c)	0/4
Total PCBs	5/25	0.021	8.9	ND	0.083	5/25

Units in mg/kg

B The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.

D Identifies all compounds identified in an analysis at a secondary dilution factor.

J Indicates an estimated value.

NA Not Applicable

ND Not Detected

P Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.

X Other specific flags and footnotes required to properly define the results.

Boxing indicates value exceeds background range and screening level.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.

(b) EPA Region III Risk-Based Concentration Table, Third Quarter, 1994. July 11, 1994.

USEPA, 1993b. Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response, September 1993.

(c) Value for 2,3,7,8-TCDD.

horizonb

2.4.3 Horizon "C" (Upland Soils)

Table 2-3 compares the soil sampling results collected at Horizon "C" from the Upland soils to subsurface soil background and soil screening levels. Constituents above subsurface soil background and the most stringent soil screening level concentrations are benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, antimony, arsenic, beryllium, lead, manganese, mercury, arochlor-1254, and arochlor-1260. Constituents which exceeded the soil screening level in less than five percent of the samples include benzene, benzo(k)fluoranthene, naphthalene, antimony, lead, mercury, and arochlor-1254.

2.4.4 Shallow Intertidal Soil

Table 2-4 compares the soil sampling results collected in the shallow intertidal soils (zero to ten feet) to surface soil background, the most stringent sediment guidelines, and the most stringent soil guidelines. Shallow intertidal soil concentrations are compared to both soil and sediment quality guidelines because the soil in this area is under shallow water for a portion of the day and may be released to the river during construction. Semi-volatile constituents above the surface soil background and sediment guidelines are acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, total PAHs and total CaPAHs. Metal constituents above the surface soil background and sediment guidelines are antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Dieldrin, DDT, DDE, arochlor-1254, arochlor-1260, and total PCBs are also above the surface background and sediment guideline concentrations.

Semi-volatile constituents above the surface soil background and soil guidelines are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-c,d)pyrene. Metal constituents above the surface soil background and soil guidelines are antimony, arsenic, beryllium, chromium, copper, lead, manganese, mercury, and vanadium. Other constituents above the surface background and soil guidelines are arochlor-1254, arochlor-1260, and 2,3,7,8-TCDF (e.g., exceeds soil guideline for 2,3,7,8-TCDD).

TABLE 2-3

COMPARISON OF HORIZON "C" (UPLAND SOILS)
SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Subsurface Soil Background Range (a)	Most Stringent Soil Level (b)	Frequency Detected Exceeding Soil Guidelines and Background
Volatile Organics:						
Benzene	28/113	0.00034J	4.3	ND	2.5	1/113
Ethylbenzene	40/113	0.00031J	2.4	ND	150	0/113
Toluene ·	43/113	0.00022J	15	ND	58	0/113
Xylene	11/32	0.003J	46	ND	97	0/32
Semi-Volatile Organics:						
Acenaphthene	82/148	0.0002 J	220	ND	4,700	0/148
Acenaphthylene	42/148	0.00073 J	230	ND	NA	NA
Anthracene	104/148	0.0041	520 D	0.028 J	23,000	0/148
Benzo(a)anthracene	83/148	0.000097 J	440	0.18 J	0.88	15/148
Benzo(b)fluoranthene	116/148	0.00026 J	360 X	0.25 J	0.88	24/148
Benzo(k)fluoranthene	79/148	0.0002 J	360 X	0.099 J	8.8	3/148
Benzo(a)pyrene	64/148	0.00057 J	250	0.2 J	0.088	17/148
Benzo(g,h,i)pyrene	98/148	0.00016 J	140 J	0.14 J	NA	NA
Carbozole	13/39	0.095 J	150 J	ND	32	2/39
Chrysene	104/148	0.00063 J	300	0.14 J	0.8	23/148
Dibenz(a,h)anthracene	75/148	0.00007 J	50 J	0.051 J	0.088	19/148
Fluoranthene	105/148	0.0021	830	0.14 J	3,100	0/148
Fluorene	66/148	0.0039 J	470	ND	3,100	0/148
Indeno(1,2,3-c,d)pyrene	86/148	0.00035 J	160 J	0.16 J	0.88	13/148
2-Methylnaphthalene	19/39	0.081 J	480	ND	NA	NA
Naphthalene	63/148	0.00098 J	1,500	ND	52	4/148
Phenanthrene	112/148	0.0038	1,200	0.088 J	NA	NA
Pyrene	104/148	0.0011 J	690	0.15 J	2,300	0/148
Total PAHs	138/148	0.014	7,580	1.63	NA	NA
Total CaPAHs	131/148	0.00034	1,920	1.08	NA	NA
Metals:						
Antimony	12/148	3	313	ND	31	3/148
Arsenic	147/148	1 B	50.9	2.1 B	0.37	27/148
Beryllium	65/148	0.28 B	2	ND	0.15	64/148
Cadmium	4/148	2.8	8.3	ND	39	0/148
Chromium	148/148	2.8	314	6.2	390	0/148
Copper	118/148	1.7 B	1,420	12.5	2,900	0/148
Lead	147/148	0.67 B	1,670	67	500	4/148
Manganese	38/39	20.7	864	35.2	390	2/39
Mercury	9/148	0.2	33.7	ND	23	1/148
Nickel	74/148	5 B	330	ND	1,600	0/148
Silver	3/149	1	11.2	ND	390	0/148
Vanadium	39/39	3.3 B	355	7 B	550	0/39
Zinc	148/148	5.7	6,420	16.7	23,000	0/148
Pesticides/PCBs/Dioxins:						
Dieldrin	7/39	0.00013 JP	0.028 JP	ND	0.04	0/39
4,4'-DDE	11/39	0.00017 JP	0.21 JP	ND	1.9	0/39
4,4'-DDT	7/39	0.00017 JP	0.0057	ND	1.9	0/39
Arochlor-1254	1/148	NA	0.34	ND	0.083	1/39
Arochlor-1260	12/148	0.0074 J	210 P	ND	0.083	4/39
2,3,7,8-TCDD	2/9	NA	3.3E-07	ND	4.1E-06	0/9
2,3,7,8-TCDF	1/9	NA	3.7E-07	ND	4.1E-06 (c)	0/9
Total PCBs	12/148	0.0074 J	210	NA	0.083	4/39

Units in mg/kg.

B The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.

D Identifies all compounds identified in an analysis at a secondary dilution factor.

J Indicates an estimated value.

NA Not Available

ND Not Detected

P Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.

X Other specific flags and footnotes required to properly define the results.

☐ Boxing indicates value exceeds background range and screening level.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.

(b) EPA Region III Risk-Based Concentration Table, Second Quarter, 1994. April 20, 1994.
USEPA, 1993b. Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response, September 1993.

(c) Value for 2,3,7,8-TCDD.

horizonc

TABLE 2-4

COMPARISON OF SHALLOW (INTERTIDAL SOILS)
SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Concentration	Maximum Concentration	Surface Soil Background Range (a)	Most Stringent Sediment ARAR (b)	Frequency Detected Exceeding Sediment Guidelines and Background	Most Stringent Soil ARAR (c)	Frequency Detected Exceeding Soil Guidelines and Background
Volatile Organics:								
Benzene	19/36	0.00028	3.2	ND	NA	NA	25	0/36
Ethylbenzene	17/36	0.0005	2.8	0.046 J	NA	NA	58	0/36
Toluene	17/36	0.00033	1.4	ND	NA	NA	150	0/36
Xylene	4/14	0.003	7	7 J – 58	NA	NA	97	0/14
Semi-Volatile Organics:								
Acenaphthene	28/36	**0.041 J**	**280**	ND	0.016	28/36	4,700	0/36
Acenaphthylene	12/36	**0.082 J**	**210**	0.032 J	0.044	13/36	NA	NA
Anthracene	29/36	0.052 J	**450**	0.032J	0.085	28/36	23,000	0/36
Benzo(a)anthracene	16/36	**0.3 J**	**110 D**	0.12 J– 0.24 J	0.26	16/36	0.88	14/36
Benzo(b)fluoranthene	27/36	0.12	**80 DX**	0.054 J – 0.39	NA	NA	0.88	22/36
Benzo(k)fluoranthene	20/36	0.18	**81 DX**	0.024 J – 0.17 J	NA	NA	8.8	5/36
Benzo(a)pyrene	15/36	0.073	**47 D**	0.03 J – 0.25 J	0.33	12/36	0.088	12/36
Benzo(g,h,i)pyrene	23/36	0.036	120	0.24 J	NA	NA	NA	NA
Carbazole	5/14	0.5 J	22 DJ	ND	NA	NA	32	0/14
Chrysene	35/36	0.22	**250**	0.16 J – 0.31 J	0.33	35/36	0.8	30/36
Dibenz(a,h)anthracene	19/36	0.037	**38**	0.035 J – 0.053 J	0.063	17/36	0.088	17/36
Fluoranthene	24/36	0.46	**370**	0.26 J – 0.56	0.38	22/36	3,100	0/36
Fluorene	13/36	0.11 J	**700**	ND	0.019	22/36	3,100	0/36
Indeno(1,2,3-c,d)pyrene	30/36	0.087 J	**110**	0.12 J – 0.23 J	NA	NA	0.88	15/36
2-Methylnaphthalene	7/14	**0.094 J**	**59 D**	ND	0.07	7/14	NA	NA
Naphthalene	17/36	0.053 J	**44**	ND	0.16	14/36	52	0/36
Phenanthrene	27/36	0.16 J	**1,700**	0.10 J – 0.21 J	0.24	26/36	NA	NA
Pyrene	28/36	0.4	**800**	0.25 J – 0.41	0.33	26/36	2,300	0/36
Total PAHs	36/36	2.52	**9,518**	0.11 – 3.13	2.9	35/36	NA	NA
Total CaPAHs	36/36	0.86	**1,458**	0.11 – 1.64	2.9	34/36	NA	NA
Metals:								
Antimony	28/36	9.4	**108**	ND	12	23/36	31	11/36
Arsenic	36/36	1.7 B	**125**	2.1 B – 5.8	8	26/36	0.37	26/36
Beryllium	24/36	0.38 B	**10.9**	0.26 B – 0.37 B	NA	NA	0.15	33/36
Cadmium	22/36	0.86	**15**	ND	1	21/36	39	0/36
Chromium	36/36	10.9	**8,020**	6.2 – 11.1	33	34/36	390	2/36

TABLE 2-4

COMPARISON OF SHALLOW (INTERTIDAL SOILS)
SOIL SAMPLING RESULTS TO SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Concentration	Maximum Concentration	Surface Soil Background Range (a)	Most Stringent Sediment ARAR (b)	Frequency Detected Exceeding Sediment Guidelines and Background	Most Stringent Soil ARAR (c)	Frequency Detected Exceeding Soil Guidelines and Background
Copper	35/36	16.4	**75,100**	3.9 B – 67.7	28	30/36	2,900	5/36
Lead	36/36	8.4	**10,500**	36.1 – 304	21	26/36	500	24/36
Manganese	14/14	9.8	2,650	11.9 – 53.6	NA	NA	390	6/14
Mercury	33/36	0.3	**29.1**	0.12 – 0.34	0.1	32/36	23	2/36
Nickel	35/36	10.5 B	**559**	12.8	20.9	30/36	1,600	0/36
Silver	7/36	**1.3 B**	**6.8**	ND	1	7/36	390	0/36
Vanadium	14/14	15.8	5,380	4.3 B – 10.6	NA	NA	550	4/36
Zinc	36/36	9	**11,600**	26.3 – 130	68	30/36	23,000	0/36
Pesticides/PCBs:								
Dieldrin	8/14	0.00023 JP	**0.017 JP**	ND	0.0033	6/14	0.04	0/16
4,4'-DDE	7/14	0.0042 JP	**0.037 P**	0.00085 J – 0.0046 P	0.0022	7/14	1.9	0/16
4,4'-DDT	4/14	0.00098 JP	**0.0091 P**	0.0011 JP – 0.0019 JP	0.00158	2/14	1.9	0/16
Arochlor-1254	12/36	**0.25 P**	**23**	ND	0.0227	NA	0.083	7/36
Arochlor-1260	16/36	0.044 JP	**6.5**	ND	0.0227	NA	0.083	14/36
2,3,7,8 – TCDF	1/6	NA	0.000959	1.8E-06	NA	NA	4.1E-06	1/6
Total PCBs	20/36	0.044	**23**	ND	0.0227	20/36	NA	NA

Units in mg/kg.
B The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.
D Identifies all compounds identified in an analysis at a secondary dilution factor.
J Indicates an estimated value.
ND Not Detected.
NA Not Available
P Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.
X Other specific flags and footnotes required to properly define the results.
Boxing indicates value exceeds background and screening level(s).
Bolding indicates value exceeds most stringent sediment screening level.
Shading indicates value exceeds most stringent soil screening level.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.
(b) Long et al., 1993. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Draft, Environmental Mgt. (10/93)
USEPA, 1994b. USEPA Region IV Waste Mgt. Division Screening Values
(c) EPA Region III Risk-Based concentration Table, Second Quarter, 1994. April 20, 1994.
USEPA, 1993b. Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response, September 1993.

2.4.5 Deep Intertidal Soil

Table 2-5 compares the soil sampling results collected in the deep intertidal soils (greater than ten feet below ground surface) to subsurface soil background and soil guidance. Volatile and semi-volatile organic constituents above subsurface background and soil guidelines protective of human health are benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene. Metal constituents above subsurface background and soil guidelines include arsenic, beryllium, lead, and manganese. Arochlor-1260 is also above the subsurface background and soil guidelines for total PCBs.

2.4.6 Sediments

Table 2-6 compares the subtidal sediment sampling results to sediment background and sediment quality guidelines protective of aquatic life. Thirteen semivolatile organic constituents, eight metals, three pesticides, arochlor-1254 and arochlor-1260 were detected above background and sediment guidelines. Constituents which exceeded sediment quality guidelines in less than five percent of the samples were cadmium, arochlor-1254, and arochlor-1260.

2.4.7 Ground Water

Table 2-7 compares the groundwater sampling results to ambient water quality criteria, drinking water standards, and Region IV screening values. Constituents above ground-water background and drinking water standards are benzene, antimony, chromium and manganese. Constituents above ground-water background and Region IV screening concentrations for saltwater quality are ethylbenzene, acenaphthene, fluoranthene, naphthalene, arsenic, chromium, copper, and zinc. Constituents above ground-water background and ambient water quality criteria are 2-methylnaphthalene, anthracene, fluorene, phenanthrene, pyrene, arsenic, beryllium, chromium, copper, manganese, and zinc.

TABLE 2-6

COMPARISON OF SEDIMENT SAMPLING RESULTS
TO BACKGROUND AND SCREENING LEVELS, mg/kg

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Background Range (a)	Most Stringent Sediment Level (b)	Frequency Detected Exceeding Sediment Guidelines and Background
Volatile Organics:						
Benzene	21/39	0.00059 JP	0.0077 JP	ND	NA	NA
Toluene .	17/39	0.00016 J	0.015 J	ND	NA	NA
Ethylbenzene	17/39	0.001 J	2	ND	NA	NA
Xylenes	17/39	0.00042 JP	0.78	0.0075 – 0.058	NA	NA
Semi-Volatile Organics:						
Acenaphthene	39/41	0.0075 J	75	ND	0.016	36/41
Acenaphthylene	13/41	0.025 J	5.5 J	ND	0.044	11/41
Anthracene	35/41	0.12	190	ND	0.085	33/41
Benzo(a)anthracene	17/41	0.57	59	ND	0.26	17/41
Benzo(b)fluoranthene	29/41	0.049	46 X	ND	NA	NA
Benzo(k)fluoranthene	17/41	0.12	60 X	ND	NA	NA
Benzo(a)pyrene	17/41	0.56 J	38	ND	0.33	17/41
Benzo(g,h,i)pyrene	38/41	0.061	15	ND	NA	NA
Carbazole	1/10	NA	7.5 J	ND	NA	NA
Chrysene	40/41	0.055	48	ND	0.33	34/41
Dibenz(a,h)anthracene	23/41	0.01 J	3.7 J	ND	0.063	19/41
Fluoranthene	39/41	0.045	160	0.072 J – 0.12 J	0.38	36/41
Fluorene	39/41	0.086 J	110	ND	0.019	37/41
Indeno(1,2,3-c,d)pyrene	37/41	0.069	220	ND	NA	NA
2-Methylnaphthalene	7/10	0.49 J	58	ND	0.07	7/10
Naphthalene	25/41	0.012 J	79	0.22 J	0.16	15/41
Phenanthrene	41/41	0.23	170	0.1 J	0.24	35/41
Pyrene	41/41	0.32	140	0.076 J – 0.083 J	0.33	38/41
Total PAHs	41/41	1.39	1,187	0.52	2.9	37/41
Total CaPAHs	41/41	0.47	451	ND	2.9	36/41
Metals:						
Antimony	1/41	NA	9.1	ND	12	0/41
Arsenic	41/41	13.3	46.6	3 – 13.6	8	41/41
Beryllium	41/41	0.53 B	1.8 B	0.94 B – 1.2 B	NA	NA
Cadmium	1/41	NA	1.5	ND	1	1/41
Chromium	41/41	17	81	7.6 – 46	33	26/41
Copper	41/41	11.3	204	11.2 B – 15.8 B	28	33/41
Lead	41/41	24.2	283	2.9 – 69.9	21	21/41
Manganese	10/10	224	729	75.6 – 540	NA	NA
Mercury	23/41	0.26	20.5	ND	0.1	21/41
Nickel	35/41	9.3	37.5	16.6 – 19 B	20.9	14/41
Vanadium	12/41	45.9	92.4	7.4 B – 60	NA	NA
Zinc	41/41	46.9	685	10.8 – 61.2	68	37/41
Pesticides/PCBs/Dioxins:						
Dieldrin	6/10	0.001 JP	0.018 P	ND	0.0033	3/10
4,4'-DDE	7/10	0.0016 J	0.035 JP	ND	0.0022	5/10
4,4'-DDT	5/10	0.0018 JP	0.015	0.00065 JP	0.00158	5/10
Arochlor-1254	1/41	ND	0.13 P	ND	0.0227	1/41
Arochlor-1260	2/41	0.36 J	0.41 J	ND	0.0227	2/41
2,3,7,8-TCDD	4/4	1.04E-06	4.3E-06	ND	NA	NA
2,3,7,8-TCDF	4/4	6.9E-07	8.0E-06	1.8E-06	NA	NA
Total PCBs	3/41	0.13	0.41 J	NA	0.0227	3/41

Units in mg/kg.

B (inorganic) The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.

J Indicates an estimated value.

ND Not Detected.

NA Not Available

P Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.

X Other specific flags and footnotes required to properly define the results.

Boxing indicates value exceeds background and screening level.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.
Professional Services Industry, Inc. 1994. Draft Report Site Inspection Charleston Harbor Site. Project No. 513-44008, June 1994.

(b) Long et al., 1993. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Draft, Environmental Mgt. (10/93)
USEPA, 1994b. USEPA Region IV Waste Mgt. Division Screening Values

sedtabl

TABLE 2–7

COMPARISON OF GROUND WATER SAMPLING RESULTS TO BACKGROUND AND SCREENING LEVELS, µg/L

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Background Range (a)	Most Stringent MCL (b)	Frequency Detected Exceeding MCL and Background	Most Stringent AWQC (c)	Frequency Detected Exceeding AWQC and Background	Most Stringent Region IV Screening Values (d)	Frequency Detected Exceeding Region IV and Background
Volatile Organics:										
Carbon Disulfide	4/4	3 J	9 J	ND	NA	NA	NA	NA	NA	NA
Benzene	2/4	2 J	$\boxed{14}$	ND	5	1/4	40	0/4	109	0/4
Toluene	2/4	1 J	5 J	ND	1,000	0/4	5,000	0/4	37	0/4
Ethylbenzene	4/4	3 J	$\boxed{5\ J}$	ND	700	0/4	430	0/4	4.3	2/4
Xylene	4/4	11	19	ND	10,000	0/4	NA	NA	NA	NA
Semi-Volatile Organics:										
2-Methylnaphthalene	2/4	$\boxed{12\ DJ}$	$\boxed{74\ D}$	ND	NA	NA	0.031	2/4	NA	NA
Acenaphthene	4/4	1 J	$\boxed{150\ D}$	ND	NA	NA	710	0/4	10	2/4
Anthracene	1/4	NA	$\boxed{13\ DJ}$	ND	NA	NA	0.031	1/4	NA	NA
Carbazole	2/4	8 DJ	34 DJ	ND	NA	NA	NA	NA	NA	NA
Dibenzofuran	2/4	5 DJ	43 DJ	ND	NA	NA	NA	NA	NA	NA
Fluoranthene	1/4	NA	$\boxed{11\ DJ}$	ND	NA	NA	16	0/4	2	1/4
Fluorene	2/4	$\boxed{6\ DJ}$	$\boxed{45\ DJ}$	ND	NA	NA	0.031	2/4	NA	NA
Naphthalene	4/4	1 J	$\boxed{200\ D}$	ND	NA	NA	2350	0/4	23.5	2/4
Phenanthrene	3/4	1 J	$\boxed{54\ DJ}$	2 J	NA	NA	0.031	2/4	NA	NA
Pyrene	1/4	NA	$\boxed{10\ DJ}$	ND	NA	NA	0.031	1/4	NA	NA
Total CaPAHs	3/4	2	14	ND	NA	NA	NA	NA	NA	NA
Total PAHs	4/4	4	540	2 J	NA	NA	NA	NA	NA	NA
Metals:										
Antimony	1/4	NA	$\boxed{61.6}$	ND	6	1/4	45,000	0/4	NA	NA
Arsenic	3/4	10 B	$\boxed{47.6}$	24.9	50	0/4	0.018	2/4	36	2/4
Beryllium	1/4	NA	$\boxed{1.6\ B}$	ND	4	0/4	0.117	1/4	NA	NA
Chromium	1/4	NA	$\boxed{73.6}$	ND	50	1/4	50	1/4	50	1/4
Copper	2/4	$\boxed{9.4\ B}$	$\boxed{13.2\ B}$	7.8 B – 9.1 B	1,300 TT	0/4	2.9	2/4	2.9	2/4
Lead	2/4	8.1	48	1.3 J – 150 J	15 TT	0/4	5.6	0/4	5.6	0/4
Manganese	4/4	88.4	$\boxed{1970}$	83.9 – 800	50 S	2/4	100	2/4	NA	NA
Mercury	2/4	0.23	0.26	0.7	2	0/4	0.025	0/4	0.025	0/4
Vanadium	2/4	5.3 B	83.6	9.2 B – 11.9 B	NA	NA	NA	NA	NA	NA
Zinc	4/4	20.4	$\boxed{112}$	80.5	5,000 S	0/4	86	1/4	86	1/4

Units in µg/L.

AWQC – Ambient Water Quality Criteria

B – The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.

D – Identifies all compounds identified in an analysis at a secondary dilution factor.

J – Indicates an estimated value.

Boxing indicates value exceeds background range and its screening level(s).

Bolding indicates value exceeds the most stringent MCL.

Italics indicate value exceeds the most stringent AWQC.

Shading indicates value exceeds the most stringent region IV screening values.

NA – Not Available/Applicable

ND – Not Detected

MCL – Maximum Contaminant Level

TT – Treatment Technique

X – Other specific flags and footnotes required to properly define the results.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902–05, April 1994.

(b) South Carolina Safe Drinking Water Regulations, Chapter 61 – Department of Health and Environmental Control, Regulation 61–58.5. December 28, 1990.
USEPA, 1994c. Drinking Water Regulations and Health Advisories. USEPA, Office of Water, May 1994.

(c) USEPA, 1986. Quality Criteria for Water. EPA 440/5–86–001, May 1, 1987, USEPA, Office of Water Regulations and Standards.

(d) USEPA, 1993a. Ground Water Information Exchange and Technology Support, Volume II, Issue I. USEPA Region IV, Ground Water Technology Support Unit, January 1993.

ground

2.4.8 Surface Water

Table 2-8 compares the surface water sampling results to ambient water quality criteria protective of human health and aquatic life and Region IV screening values. Constituents above surface-water background and ambient water quality criteria are arsenic and copper. Copper is also above the most stringent Region IV screening value. Only a single surface water sample was collected during the aquarium site investigation.

2.5 CONSTITUENTS OF CONCERN BY MEDIA

Constituents of concern for human and ecological health risks during construction are assumed to be the constituents detected above media-specific background and the most stringent screening criteria levels for human health or aquatic life. Table 2-9 summarizes the constituents of concern for all media sampled during the Aquarium investigation.

2.6 TRENDS IN CONSTITUENT DISTRIBUTION

Horizon C of the Upland Soils, and the shallow and deep intertidal soils had total PAHs at greater than 1,000 mg/kg. Total PAHs were also consistently detected in sediments, and Horizon A and B soils at levels above 100 mg/kg. PAHs were also detected in ground water, but not in surface water.

Horizon A and the shallow intertidal soil had maximum concentrations for individual metal parameters which exceeded 10,000 mg/kg. Horizons B and C and the deep intertidal soils had individual metal parameters which exceeded 1,000 mg/kg. Sediments, ground water, and surface water also contained metals at concentrations exceeding background and screening levels, but at lower levels than detected in surface and subsurface soils.

Volatile aromatic hydrocarbons were detected in Horizon C soils, the deep intertidal soils, and in ground water at concentrations exceeding screening levels. Aromatic hydrocarbons were detected at very low levels in the other media sampled and were not considered to be constituents of concern in these media.

TABLE 2-8

COMPARISON OF SURFACE WATER SAMPLING RESULTS TO BACKGROUND AND SCREENING LEVELS, μg/L

Constituent	Frequency Detected	Minimum Detected Concentration	Maximum Detected Concentration	Background Range (a)	Most Stringent AWQC (b)	Frequency Detected Exceeding AWQC	Most Stringent Region IV Screening Values (c)	Frequency Detected Exceeding Region IV
Metals:								
Arsenic	1/1	NA	$\boxed{\textbf{10.3 B}}$	5.3 B	0.018	1/1	36	0/1
Copper	1/1	NA	$\boxed{\textbf{4.3 B}}$	ND	2.9	1/1	2.9	1/1
Manganese	1/1	NA	32	14.8 B – 18.9	100	0/1	NA	NA
Vanadium	1/1	NA	6.2 B	11.2 B	NA	NA	NA	NA
Zinc	1/1	NA	37.1	20.2 – 29	86	0/1	86	0/1

Units in μg/L.
AWQC – Ambient Water Quality Criteria
B – The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.
ND – Not Detected.
$\boxed{}$ Boxing indicates value exceeds background range and screening level(s).
Bolding indicates value exceeds the most stringent AWQC.
Shading indicates value exceeds the most stringent Region IV screening values.

(a) Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902–05, April 1994.
Professional Services Industry, Inc. 1994. Draft Report Site Inspection Charleston Harbor Site. Project No. 513–44008, June 1994.
(b) USEPA, 1986. Quality Criteria for Water. EPA 440/5–86–001, May 1, 1987, USEPA, Office of Water Regulations and Standards.
(c) USEPA, 1993a. Ground Water Information Exchange and Technology Support, Volume II, Issue I. USEPA Region IV, Ground Water Technology Support Unit, January 1993.

surface

TABLE 2–9

CONSTITUENTS OF CONCERN BY MEDIA

Parameter	Sediments	Intertidal Shallow	Intertidal Deep	Upland Horizon A	Upland Horizon B	Upland Horizon C	Surface Water	Ground Water
<u>Volatiles:</u>								
Benzene			X			X		X
Ethylbenzene								X
<u>Semi–Volatiles:</u>								
Acenaphthene	X	X		X				X
Acenaphthylene	X	X		X				
Anthracene	X	X		X				X
Benzo(a)anthracene	X	X	X	X	X	X		
Benzo(a)pyrene	X	X	X	X	X	X		
Benzo(b)fluoranthene		X	X	X	X	X		
Benzo(k)fluoranthene		X	X	X	X	X		
Carbazole			X			X		
Chrysene	X	X	X	X		X		
Dibenz(a,h)anthracene	X	X	X	X	X	X		
Fluoranthene	X	X		X				X
Fluorene	X	X		X				X
Indeno(1,2,3–cd)pyrene		X	X	X	X	X		
2–Methylnaphthalene	X	X		X				X
Naphthalene	X	X	X	X		X		X
Phenanthrene	X	X		X				X
Pyrene	X	X		X				X
Total PAHs	X	X		X				
Total CaPAHs	X	X		X				
<u>Metals:</u>								
Antimony		X		X	X	X		X
Arsenic	X	X	X	X	X	X	X	X
Beryllium		X	X	X	X	X		
Cadmium	X	X		X				
Chromium	X	X		X				X
Copper	X	X		X			X	X
Lead	X	X	X	X	X	X		
Manganese		X	X	X	X	X		X
Mercury	X	X		X		X		
Nickel	X	X		X				
Silver		X		X				
Vanadium		X		X				
Zinc	X	X		X				X
<u>Pesticides:</u>								
Arochlor–1254	X	X		X	X	X		
Arochlor–1260	X	X	X	X	X	X		
4,4'–DDE	X	X		X				
4,4'–DDT	X	X		X				
Dieldrin	X	X		X				
2,3,7,8–TCDF		X		X	X			
Total PCBs	X	X	X	X	X	X		

Arochlor-1254 and arochlor-1260 were detected in all soil horizons and in sediments. They were not detected in surface or ground water samples. Horizon C had the highest levels of detected PCBs.

Low levels of dioxins and furans were detected in all soil horizons, except deep intertidal soils, and in sediment samples. Dioxins/furans were not detected in surface water or ground water samples. The highest detected concentrations were in the Horizon A soil samples.

3.0 CONSTRUCTION EXPOSURE PATHWAY ANALYSIS

This section presents an assessment of exposures which may be related to construction activities. The section also includes a review of proposed containment features and a qualitative discussion of the potential positive and negative aspects of construction on future remediation at the NPS property.

3.1 CONSTRUCTION EXPOSURE ASSESSMENT

The construction exposure assessment characterizes the populations identified with the site which may be exposed during construction activities. The exposure assessment also identifies pathways by which identified populations may be exposed. Exposure pathways are identified through consideration of on-site sources, potential release mechanisms, trends in the distribution of site constituents, and physical characteristics of the site which influence the frequency and magnitude of potential exposures.

Initially, the exposure assessment considers baseline exposures, e.g., exposures which would be expected if containment or engineering controls were not used during construction. In Section 3.4, reduction of exposure by the containment and emergency response plans will be discussed.

3.1.1 Potential Receptors

Potential human receptors which may be exposed to site constituents during construction of the aquarium were identified. Potential human receptors include the following populations:

- Construction Workers
- Underground Utility Workers
- Landscapers and Aquarium Staff
- Construction Site Visitors
- Recreational Users of the Cooper River
- Occupants of Neighboring Residences and Businesses

After construction, exposure to site media may continue for utility workers, landscapers, aquarium staff, occupants of neighboring businesses and residences, and recreational users of the Cooper River. Recreational users of the Cooper River may include fishermen, waders and swimmers, and shellfish harvesters.

3.1.2 Demographics

The aquarium site is located in the metropolitan area of Charleston, South Carolina, which has approximately 185,000 people. Tourism is an important sector of the economy of Charleston with five million people visiting the Low Country area each year. However, transportation is the major industry. The Port of Charleston ranks first among container cargo ports in the Southeast (Chester, 1994). Both of these commercial/industrial sectors have a large presence within two miles of the site. The vicinity of the site is characterized by transient visitors as well as a permanent work force and long-term residents.

3.1.3 Land Use

The NPS property is located in an area adjacent to Charleston Harbor with a long history of industrial use. Past and present properties in the vicinity of the site include a former coal gasification plant (Calhoun Park Area site), a sawmill and lumber company, chemical manufacturers, a dry fertilizer company, public housing (now closed because of health concerns), condominiums, marine supply and repair, and the State Port Authority.

The South Carolina Port Authority operates a container yard to the north of the site. Directly north of the site is J.J.W. Ludens, a marine supply and boat repair business. A residential development, Dockside Condominiums, is located directly south of the site (Chester, 1994). A power station for South Carolina Electric and Gas Company is located northeast of the NPS property. An additional area east of the site, the Calhoun Park Area site, is under remedial investigation and is currently not utilized for commercial purposes.

Future plans for the NPS property include a docking facility for excursions to Ft. Sumter and a restaurant. With construction of the aquarium, the whole of the NPS property would be dedicated to recreational and tourism use. Property south of the Dockside Condominiums is planned to be developed as a maritime center and storm water pumping station. Therefore, a large part of the property around the aquarium is scheduled for refurbishing or redevelopment.

The human populations which may be exposed during construction include on-site workers, nearby residents, off-site workers, and visitors or trespassers to the site. Site workers are potentially exposed to soil, fugitive dust, volatile emissions from the soil, shallow groundwater, surface water including storm runoff, and sediment. Nearby residents and off-site workers are potentially exposed to fugitive dust and volatile emissions blown off-site. Recreational users of the Cooper River and Charleston Harbor may harvest shellfish or finfish from the Cooper River and may be exposed through bioaccumulation of constituents in the food chain or directly to surface water and sediments while fishing and wading. Visitors and trespassers entering the construction area may be directly exposed to site soils, fugitive dust, volatile emissions from the subsurface, pumped groundwater and storm runoff reserved on site, surface water, and sediments.

3.1.4 Ecological Receptors

Ecological receptors potentially exposed to site media include terrestrial site dwellers, amphibian and aquatic species, migratory birds, and site flora. Because of the nature of the site, terrestrial species are not currently abundant at the site.

According to the Calhoun Park Area Draft Risk Assessment, Volume II (June 1994), the NPS property offers limited terrestrial habitat. The area adjacent to the river is predominantly groundsel bush, seaside goldenrod, and various grasses. A single sparrow was the only species observed during the field survey. It was theorized that the site may function as limited cover and resting areas for songbird species and small mammals (USEPA, 1994d).

Migratory birds in this area may include falcons, eagles, plovers, rails, gulls, sparrows, cormorants, herons, egrets, and crows. Amphibian species would include species which intermittently live on river

banks such as turtles, lizards, and frogs. Mammalian species associated with the harbor include bottlenose dolphin, otter, and manatee (USEPA, 1994d).

During the USEPA field survey, no rare, endangered, or threatened species were noted on NPS property. One Federally endangered species, the brown pelican, was observed on the Cooper River (USEPA, 1994d).

In the vicinity of the site, the Cooper River is a low gradient, tidal system with intrusion by saltwater (NOAA, 1994). There are wetland areas present upstream and downstream of the site. Vegetation observed in wetland areas include cordgrasses and rushes. The wetland located nearest to the site is Shute Folly Island, 1.0 kilometers downstream (NOAA, 1994).

The Cooper River supports diverse species of macrophytes, plankton, macroinvertebrates, and finfish. Table 3-1 lists ecological species which are likely to exist in the river and Charleston Harbor in the vicinity of the site (NOAA, 1994).

The shortnose sturgeon, a federally designated endangered species, has been reported in these waters. Atlantic croaker, spot, and spotted sea trout are also commonly present in the Charleston Harbor. Hard shell clams, American oysters, blue crab, and lesser blue crab are present in the harbor and are particularly associated with wetland areas such as Shutes Folly Island (NOAA, 1994).

Blue crab is the only commercial fishery present in the Charleston Harbor. However, the harbor and river serve as nursery and forage habitats for penaid shrimp which are important offshore commercial fishery species. White and brown shrimp are recreational species which are fished inshore. Sport fish taken for the harbor include croaker, flounder, red drum, spot, spotted sea trout, and white shrimp. No bivalve harvesting is permitted in the harbor (NOAA, 1994).

3.2 POTENTIAL EXPOSURE PATHWAYS

A complete exposure pathway has four essential components. The USEPA's guidance on risk assessment (USEPA, 1989a) defines an exposure pathway as consisting of the following elements:

TABLE 3-1

Notable Aquatic Species
Charleston Harbor
Charleston, South Carolina

Species		Habitat Use			Fisheries	
Common Name	Scientific Name	Spawning Ground	Nursery Ground	Adult Forage	Comm. Fishery	Recr. Fishery
ANADROMOUS/CATADROMOUS SPECIES						
Shortnose sturgeon [a]	*Acipenser brevirostrum*		◆	◆		
Atlantic sturgeon	*Acipenser oxyrhynchus*		◆	◆		
Blueback herring	*Alosa aestivalis*			◆		
Hickory shad	*Alosa mediocris*		◆	◆		
American shad	*Alosa sapidissima*			◆		
American eel	*Anguilla rostrata*		◆	◆		
Striped bass	*Morone saxatilis*		◆	◆		◆
ESTUARINE/MARINE SPECIES						
Bay anchovy	*Anchoa mitchilli*	◆	◆	◆		
Silver perch	*Bairdiella chrysura*	◆	◆	◆		◆
Atlantic menhaden	*Brevoortia tyrannus*		◆	◆		◆
Spotted sea trout	*Cynoscion nebulosus*		◆	◆		◆
Weakfish	*Cynoscion regalis*		◆	◆		◆
Threadfin shad	*Dorosoma petenense*		◆	◆		
Mummichog	*Fundulus heteroclitus*	◆	◆	◆		
Spot	*Leiostomus xanthurus*		◆	◆		◆
Atlantic silverside	*Menidia menidia*		◆	◆		
Southern kingfish	*Menticirrhus americanus*		◆	◆		
Atlantic croaker	*Micropogon undulatus*		◆	◆		◆
Striped mullet	*Mugil cephalus*		◆	◆		
Summer flounder	*Paralichthys dentatus*		◆	◆		◆
Southern flounder	*Paralichthys lethostigma*		◆	◆		◆
Black drum	*Pogonias cromis*		◆	◆		
Bluefish	*Pomatomus saltatrix*		◆			◆
Bighead searobin	*Prionotus tribulus*		◆	◆		
King mackerel	*Scomberomorus cavalla*		◆	◆		
Spanish mackerel	*Scomberomorus maculatus*		◆	◆		
Red drum	*Sciaenops ocellatus*		◆	◆		◆
Star drum	*Stellifer lanceolatus*		◆	◆		◆
Blackcheek tonguefish	*Symphurus plagiusa*	◆	◆	◆		
Hogchoker	*Trinectes maculatus*	◆	◆	◆		◆
Spotted hake	*Urophycis regius*		◆	◆		
INVERTEBRATE SPECIES						
Blue crab	*Callinectes sapidus*	◆	◆	◆	◆	◆
Lesser blue crab	*Callinectes similis*	◆	◆	◆	◆	◆
American oyster	*Crassostrea virginica*	◆	◆	◆		
Hardshell clam	*Mercenaria mercenaria*	◆	◆	◆		
Grass shrimp	*Palaemontes pugio*	◆	◆	◆		
Brown shrimp	*Penaeus aztecus*		◆	◆		◆
Pink shrimp	*Penaeus duorarum*		◆	◆		
White shrimp	*Penaeus setiferus*		◆	◆		◆

[a] Species is federally endangered.

Reference: NOAA, 1994

1. A source and mechanism of chemical release to the environment (i.e., a source of contamination);

2. An environmental transport medium for the released chemical (e.g., ground water, air),

3. A point of potential human or biota contact with the contaminated medium (i.e., an exposure point); and

4. A route of exposure at the exposure point (e.g., ingestion, inhalation, or dermal contact).

Without the presence of all four components, exposure cannot occur. The source of release and pathways of exposure to chemicals detected at the site will be described in the following section.

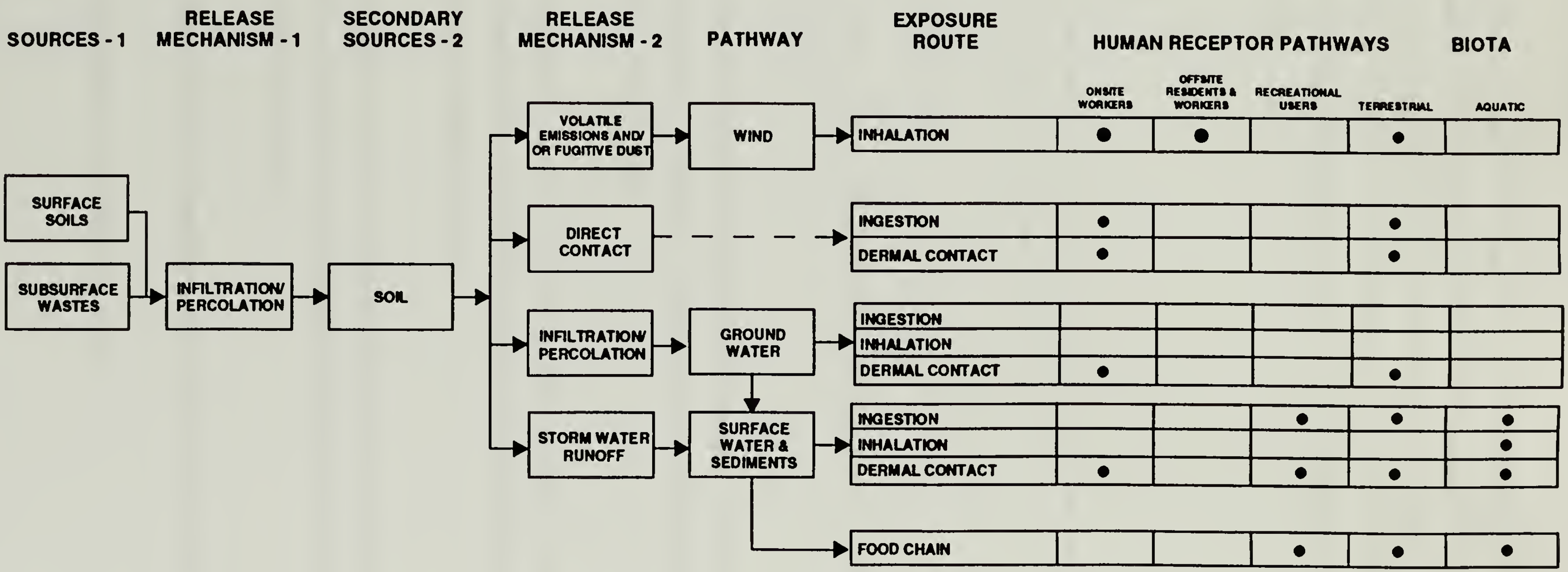
3.2.1 Sources and Receiving Media

Waste and fill materials were historically disposed of on the NPS property. Additional sources of coal tar derivatives detected on the site are thought to originate on the South Carolina Electric and Gas Company (SCE&G) property to the west of the NPS property. Timbers detected in the subsurface are artifacts of the dock and wharfs which formerly occupied the site. The waste and fill materials may leach into surrounding soil and to associated ground water, surface water and sediment.

Five potential contaminant transport media have been identified: surface water, sediment, ground water, air, and soil. The environmental transport pathways are summarized below. A conceptual site model for possible exposure scenarios at the site is presented in Figure 3-1.

Contaminants in the subsurface may be transported via the ground water to surface water. Contaminants in the soil may be transported as dust which can be carried through the air to a potential receptor, or as surface runoff into the Cooper River. It should be noted that the site area is vegetated, leaving only excavated or disturbed areas susceptible to wind erosion or surface runoff. Contaminated soils may also be carried off-site by construction vehicles. Volatile constituents in near surface soils may volatilize to the atmosphere.

FIGURE 3-1
CONCEPTUAL SITE MODEL
AQUARIUM SITE
CHARLESTON, SOUTH CAROLINA



4598-2517.03

Sediments potentially serve as a reservoir of lipophilic contaminants adsorbed to particulate matter in surface water. Contaminated surface water and sediments may potentially be carried away from the site by current and tidal influences, the flushing action of heavy storm-water events, canal dredging, and other traffic-related disturbances in the river. On-site workers may come into direct contact with shallow ground water or surface water during subsurface activities such as excavation or during the management of the water retention basins.

3.2.2 Exposure Routes

There is potential for the constituents in the air, ground water, surface water, soil, and sediments to reach human target populations through several exposure routes.

3.2.2.1 Human Routes of Exposure

The routes of exposure which are potentially complete pathways and, therefore, of primary concern during construction are as follows:

1. Dermal contact with and incidental ingestion (via hand to mouth contact) of potentially contaminated soils; inhalation of fugitive dusts and volatile emissions from potentially contaminated exposed soils.

2. During construction work or recreation, incidental ingestion and dermal contact with surface waters which are potentially recharged by the ground water and receive surface runoff from the construction area.

4. During construction work or recreation, dermal contact with constituents in sediments associated with surface waters potentially recharged by the ground water or receiving surface runoff from site soils.

5. Dermal contact with constituents present in shallow ground water.

6. Ingestion of aquatic biota in surface waters.

Exposure routes for terrestrial and aquatic ecological receptors differ slightly from those identified for human receptors. The primary pathways for ecological receptors are discussed below.

3.2.2.1 Terrestrial Life Forms

The routes of exposure which are potentially complete pathways and, therefore, of primary concern during construction are as follows:

1. Terrestrial plants may be exposed to constituents of potential concern present in sediments (riparian species) and soils, through root uptake.

2. Terrestrial animals may be exposed to constituents present in surface soils through dermal contact, inhalation or incidental ingestion as a result of burrowing activities, ingestion of contaminated foodstuffs, and preening activities.

3. Terrestrial animals may be exposed to constituents present in surface waters and sediments by drinking from the river or storm water basins and by incidentally ingesting disturbed sediments.

4. Exposure of those animals at the upper end of the food chain may be augmented as a result of biomagnification and bioaccumulation. Several constituents present in site media that have the potential to bioaccumulate (bioconcentration factors greater than 100) are as follows: copper, silver, mercury, the PAHS and the PCBs.

3.2.2.3 Aquatic Life Forms

The routes of exposure which are potentially complete pathways and, therefore, of primary concern during construction are as follows:

1. Benthic organisms can be in direct contact with constituents present in sediments and may incidentally ingest sediments during burrowing.

2. Constituents present in surface water and sediments may become progressively accumulated at higher trophic levels in aquatic food chains due to processes of bioaccumulation and biomagnification.

The exposure routes considered for this assessment are summarized in Table 3-2.

3.2.3 Summary of Exposure Pathways by Media

A brief discussion of the potential for exposure via each pathway is provided in this section.

3.2.3.1 Air Exposures

Exposure to contaminants in the ambient air can occur via inhalation of fugitive dust originating from contaminated soil or by exposure to constituents volatilized into ambient air. On-site ambient air exposures at the construction site are expected to be intermittent in nature. Downwind residents would be exposed to concentration levels less than those detected on site after constituents are diluted and dispersed in the atmosphere. Constituents of concern for human health in Horizon A and the shallow intertidal soils include several PAH and metal compounds, PCBs, and 2,3,7,8-TCDF.

3.2.3.2 Soil Exposures

On-site construction workers, utility workers, landscapers, building maintenance workers, and construction site visitors may be exposed to contaminants in the surface and near surface soils. Grading and removal of Horizon A and B soils during foundation excavations will expose soils to the surface. Vehicular traffic during construction will erode surface vegetation and potentially track site soils to neighboring streets. Constituents of concern for human health in Horizons A, B, and C and the shallow and deep intertidal soils include several PAH and metal compounds and PCBs.

Potential exposure to soil constituents may occur through absorption of contaminants through the skin, and from incidental ingestion of soil on the hands by individuals who smoke, drink or eat after visiting the site. The incidental ingestion rate for construction workers and landscapers is assumed to be 480

TABLE 3-2

BASELINE EXPOSURE ROUTES CONSIDERED
Aquarium Site
Charleston, South Carolina

MEDIUM	LOCATION	EXPOSURE ROUTE	POPULATION	COMPLETE (a)	EXPLANATION
Ground Water	On-Site	Dermal Contact	Workers (Invasive Activities)	Yes	Ground water present near ground surface
			Terrestrial	Yes	During burrowing or contact with containment basins
Surface Water	On-Site and Off-Site (Cooper River and Charleston Harbor)	Dermal Contact (wading and swimming)	Recreational Users	Yes	Intermittent exposure
			Site Workers	Yes	Exposure to tidal areas during construction
		Ingestion & Dermal Contact	Terrestrial & Aquatic	Yes	While drinking or subsistence
Exposed Soils	On-Site	Incidental Ingestion	Site Workers	Yes	Hand-to-mouth contact while eating, drinking, smoking
			Terrestrial	Yes	While eating, preening, and burrowing
		Dermal Contact	Site Workers	Yes	Absorption of contaminants on exposed body parts while visiting the site
			Terrestrial	Yes	While burrowing or daily activities
	On-Site and Off-Site	Inhalation of Fugitive Dust	Site Workers Terrestrial Nearby Residents Off-Site Workers	Yes Yes Yes Yes	Exposure to dust from soils disturbed by construction activities

TABLE 3-2

BASELINE EXPOSURE ROUTES CONSIDERED
Aquarium Site
Charleston, South Carolina

MEDIUM	LOCATION	EXPOSURE ROUTE	POPULATION	COMPLETE (a)	EXPLANATION
Sediments	On-Site	Dermal Contact	On-Site Workers	Yes	During construction in tidal areas
			Recreational Users	Yes	During wading, fishing, or swimming
			Terrestrial & Aquatic	Yes	During direct contact
		Incidental Ingestion	Recreational Users	Yes	During swimming
			Terrestrial & Aquatic	Yes	During ingestion of aquatic species
Animal and Plant Life	On-Site and Off-Site	Ingestion	Recreational Users	Yes	During shell fishing or fishing
			Terrestrial and Aquatic	Yes	Animal/Plant species drinking surface water and ingesting or growing in site soils and sediments-bioaccumulation
Ambient Air	On-Site and Off-Site	Inhalation of Volatile Organic Compounds	Site Workers	Yes	Intermittent Exposure
			Occupants of Residences or Businesses	Yes/No	Exposed to dispersed and diluted concentrations

(a) Assume to be complete under baseline conditions, e.g. no containment or engineering controls are used.

milligrams of soil per day (USEPA, 1991). Exposure through ingestion is expected to be the primary route of exposure for site workers.

The amount of constituent in a soil matrix which is absorbed through the skin is dependent on the exposure duration and frequency, exposed skin surface, soil to skin adherence factor, skin thickness, diffusivity of the chemical in skin, and the skin/soil partition coefficient. Because absorption is complicated by many parameters, scientific data concerning dermal absorption of specific chemicals from soil is limited. Based on studies with cadmium, metals are poorly absorbed through the skin (0.1 to 1 percent); based on studies with benzo(a)pyrene, PAHs may be readily absorbed at the rate of 53 to 82 percent over 24 hours (USEPA, 1992c).

Fugitive dust containing adsorbed contaminants can be generated by vehicles on the site and result in inhalation of contaminated soil by workers and occupants of neighboring residences and businesses. Because the surface of the site is close to sea level, dusty conditions during construction should be minimal.

Volatile organic compounds were not detected at levels exceeding human health guidelines except in the deeper Horizon C soils, so volatile emissions in ambient air are expected to be low in volume. However, workers involved in intrusive activities may be incidentally exposed to volatile organic compounds present in the subsurface.

Terrestrial organisms may be exposed to metals, PAHs, pesticides, furans, and PCBs via dermal contact and incidental ingestion of contaminated soils. Site animals may also be potentially exposed to constituents in soils via inhalation of fugitive dusts or volatile emissions.

3.2.3.3 Ground-Water Exposures

Ground water detected above the marl unit is not currently known to be used as a potable water source by the local residents. City water is readily available to residences and businesses. Construction workers will intermittently come into direct contact with shallow ground water as they carry out intrusive subsurface activities because the fill aquifer is encountered only a few feet below ground surface.

Terrestrial species may also come into contact with ground water through burrowing or contact with water containment basins. The primary exposure pathway for ground water is through dermal absorption. Constituents were screened for human toxicity by comparison to MCLs which are based on ingestion rather than dermal absorption. Constituents exceeding MCLs included benzene, antimony, chromium, and manganese. Constituents likely to be absorbed dermally would include the volatile and semivolatile organic compounds which were detected in ground water.

3.2.3.4 Surface Water and Sediment Exposures

Potentially contaminated surface waters and sediments can occur adjacent to the site, particularly in the outfall located on the eastern side of the NPS property. Site constituents may be released into surface water and sediment via surface runoff, soil erosion, and ground-water discharge, and may then settle in sediments. The metals, PAHs, and PCBs detected in soils tend to settle out in sediments because of their low water solubility. Exposure to surface water and sediments can occur via direct contact by site workers or recreational swimmers and waders. Fishermen are also intermittently exposed to surface water and sediment constituents through dermal contact. Parameters which define the extent of dermal absorption include duration and frequency of exposure, the surface area of the body exposed, and chemical-specific characteristics such as polarity, molecular weight, and partitioning between water and octanol. PAHS, PCBs, dioxins/furans, DDT, DDE, and dieldrin are lipophilic and are assumed to be easily absorbed through the skin from an aqueous matrix (e.g., skin permeability constants of 10 to 10^{-2} centimeters/hour). Metals have skin permeability constants which are in the intermediate range (approximately 10^{-4} centimeters/hour) (USEPA, 1992c).

Terrestrial organisms may also be exposed to metals and PAHs by drinking surface waters, and incidentally ingesting contaminated sediments. Finally, terrestrial organisms at the upper end of the food chain may be exposed through the consumption of lower life forms residing in site soils and sediments.

3.2.3.5 Ingestion of Aquatic Life

Recreational fishing and harvesting of shellfish is reported for the Charleston Harbor (NOAA, 1994; Chester, 1994). Several constituents detected, such as PAHs, PCBs, and some metals, have a tendency to bioaccumulate and biomagnify within the foodchain. Therefore, exposure to site constituents through ingestion of aquatic species appears to be a valid exposure pathway. While recreational activities may

currently occur on a routine basis, there is a higher risk of releases during construction and constituent levels present in aquatic species during and after construction may potentially increase over baseline levels.

Lower aquatic forms present in near-site surface waters may potentially be exposed to constituents detected in site surface water and sediments. Metals, PCBs, and PAHs are very likely to accumulate in aquatic or benthic organisms. Bioconcentration is an important mechanism for exposure for environmental receptors, but particularly for higher aquatic organisms which may be exposed both to contaminants through the consumption of surface water and the consumption of lower (benthic) aquatic organisms that live in the sediment.

3.4 REVIEW OF PROPOSED CONTAINMENT AND CONTINGENCY TECHNOLOGIES

Review of the Containment Plan for the South Carolina Aquarium Site proposed by the City of Charleston is based on project documents dated September 1994 (Killam, 1994c), responses to review comments on the Containment and Monitoring and Response Plans (Killam, 1994b), and results of the Interagency Technical Team Meeting (Meeting, 1994). This evaluation does not address the regulatory issues associated with dredge and fill operations which would occur as part of the control measures' construction.

3.4.1 Evaluation of Proposed Containment and Contingency Technologies

Construction activities are planned for upland, intertidal, and subtidal areas at the proposed aquarium site. The Containment Plan presents containment measures to prevent or minimize contamination migration resulting from waterside construction activities, preaugering of boreholes (groundwater containment), and landside construction activities, including dust generation.

3.4.1.1 Waterside Containment

The proposed containment system would consist of three elements designed to limit the potential migration of contaminants during excavation, grading, augering, and pile driving activities. These elements are a silt curtain, a sand blanket, and a timber lagging wall.

The silt curtain, comprised of filter fabric panels (sieve size 70-100) sewn into impermeable PVC sheet sections and, along with an attached floating adsorbent boom, would be installed in the subtidal zone surrounding the entire site. This curtain is intended to be suspended from steel cables attached to the H-piles and would be designed to resist tidal and wave pressures. The intent of the curtain is not to provide a barrier to silt-sized particles that may be suspended by construction activities, but rather to prevent loss of the sand blanket particles from within the contained area, and therefore would more appropriately be called a sand curtain. Although the curtain might provide some measure of resistance to the movement of suspended silt particles, it would not prevent their migration into the main river channel. Any contaminants attached to suspended silt particles, or otherwise associated with turbidity produced as a result of construction activities, would not be prevented from migration into the river channel.

The timber lagging wall, to be constructed in the intertidal zone, would be designed to limit turbidity and the discharge of particulates to the subtidal area during debris excavation in the upland and intertidal areas, and to contain potentially contaminated soils, sediments, and runoff during intrusive activities in the upland and intertidal areas. The greatest degree of disturbance in the upland and intertidal areas prior to the driving of piles would be during excavation and removal of debris which might interfere with pile driving activities. The lagging wall with its elastomeric barrier would be in place prior to excavation activities, and should adequately prevent migration of sediment, soil, and debris into the Cooper River. Because the design and construction of the lagging wall would facilitate raising of the ground surface level in the intertidal zone once debris had been removed, control of the generation and migration of potentially contaminated sediments and fluids could be more easily maintained using common construction practices.

The primary element of the subtidal containment system would be a sand blanket to be placed using a submerged diffuser system. Because the "silt" curtain would not prevent migration of contaminated silts or sediments disturbed during construction, the effectiveness of the sand blanket at preventing disturbance

of sediments would be doubly important. Placement of the sand blanket would disturb sediments which would accumulate on top of the blanket. This accumulation might complicate determination of the effects of construction through the sand layer when turbidity is used as the real-time monitoring approach. However, the sediments likely to be disturbed by sand blanket placement would be just as susceptible to disturbance by river and tidal activities. The net effect of the sand blanket, if effective at preventing release of deeper, more contaminated sediments during construction, would be to decrease the erosion of material from the blanketed area, as long as the sand blanket is maintained. Over time, additional sediments would accumulate on the sand blanket from normal river deposition. It should be noted that, while sand blanket technology has been applied to containment of contaminated sediments in marine environments, documentation of construction through a sand blanket containment and the potential disturbance of contained material has not been provided. A demonstration program will be the only certain way to determine if the sand blanket will perform as designed.

3.4.1.2 Groundwater Containment

The potential exists for the movement of potentially contaminated water from the fill aquifer to the underlying sand aquifer during preaugering of boreholes for pile driving in the upland and intertidal areas. Measures presented for minimization of this migration include maintaining an upward hydraulic gradient, minimization of open time for boreholes, use of the timber lagging wall, methods to minimize pumping during dewatering, and groundwater flow barriers.

Installation of a well point system to lower the groundwater table approximately two feet in the areas of borehole installation was presented as a method for maintaining an upward hydraulic gradient and preventing any downward migration of contamination. Based on the results of the earlier site investigation, and the results of USGS hydrogeological studies for this area, this method would be adequate to cause a gradient reversal during borehole augering. Minimizing the elapsed time between auger removal and pile installation should also minimize the potential for migration of contaminants downward through the pre-augered hole.

The timber lagging wall and its impermeable inner surface lining was presented as a method of retarding flow of any floating hydrocarbon product from the contaminated fill layer to the Cooper River. Because

this barrier would be placed before excavation of debris in the intertidal area, tidal influences would be significantly reduced, thus reducing the potential for migration of contaminants or free product encountered during excavation activities. Once the sand fill was placed against the lagging wall, the impermeable liner should provide an effective restriction to movement of residual floating product and contaminated water from the upland sand and soils toward the Cooper River.

Use of peripheral sheet piling to isolate areas of dewatering should minimize the volume of potentially contaminated water accumulated during dewatering which would require disposal. The planned installation of water stops during construction of slabs, pile caps, and utility corridors should effectively restrict "piping" of groundwater flows beneath and along these constructed features.

While the basic premise of these containment measures appears to be sound, the upland demonstration program during pre-augering and pile installation activities would be the only method for reducing concerns about the increased contaminant migration as a result of pile driving activities.

3.4.1.3 Landside Containment

Use of engineering controls and decontamination procedures have been presented as methods for preventing the spread of potentially contaminated materials to surrounding off-site areas. Effective implementation of an Erosion and Runoff Control Plan would likely prevent migration of contaminants due to surface water from precipitation. Proper decontamination of equipment, and control of decontamination water, should prevent migration of and exposure to contaminants during equipment operation and transfer. The City of Charleston would rely heavily upon the ability of the construction contractor to develop the Erosion and Runoff Control Plan, and adhere to proper procedures for operations at a hazardous waste site. The success of this effort would depend on the experience of the construction contractor in operating under these requirements.

3.4.1.4 Dust Control

Use of engineering controls has also been presented as a method to prevent air-borne migration of contamination. These controls to suppress dust generated from construction activities and wind are standard engineering controls which would be effective and easily implemented. Use of potential

chemical controls should be approved by appropriate regulatory agencies to make certain that potential release will not exceed regulatory levels allowed for the chemicals or their constituents.

3.4.2 Effectiveness in Reduction of Exposure

The following section is based on information provided in the Environmental Response and Monitoring Plan and Containment Plan (Killam, 1994c) and verbal responses made by Killam in the Technical Team Review Meeting (Meeting, 1994). The City has proposed measures which are designed to control and limit migration of constituents to off-site areas or to other media which are minimally influenced by site constituents. As most baseline exposures previously identified in Table 3-2 are on-site exposures, stringent health and safety measures will be required to prevent unacceptable levels of exposure to site workers.

3.4.2.1 Management Practices

The Environmental Inspector is to play an active role in environmental monitoring and documentation of on-site activities during construction. In the Environmental Monitoring and Response Plan, it is unclear who will monitor construction for compliance with the Health and Safety Plan developed by the contractor. This role can be exercised by the Environmental Inspector or a separate health and safety auditor. The use of safe operating procedures and personal protective equipment are the primary means of reducing potential human exposures during construction.

3.4.2.2 Waterside Containment

The waterside containment system is designed to prevent or limit off-site migration of sediments and soil. By limiting migration of constituents, off-site recreational users and aquatic life utilizing the river and Charleston Harbor will have minimal exposure to site constituents. The waterside containment includes the following features:

1. A silt curtain will be constructed to prevent migration of sediments and particulate matter in surface runoff.

2. Booms will be attached along the top of the silt curtain to contain floating product released to surface water.

3. A timber lagging wall will be constructed to prevent upland soil erosion into the river.

4. A sand blanket will placed over the subtidal and intertidal areas to prevent migration of surface soils and sediments. The sand blanket will also serve as a barrier to direct contact with these media during construction activities and will reduce potential soil and sediment exposures for site workers and ecological receptors.

5. Turbidity and surface water monitoring designed to be protective of aquatic life and human health will be performed to serve as a indicator of releases to surface water.

6. A subtidal demonstration will be performed to study potential releases during pile driving. The demonstration will also allow the contractor to practice work procedures and will help to illuminate weaknesses in worker protection, if any, before construction of the aquarium begins.

Response actions to detected releases include installation of a silt fence, additional hay bales, a work slow-down, an increase in the depth of the sand blanket, and modifications in the pile installation procedures. The response actions are designed to mitigate migration of site constituents which will reduce exposures for off-site receptors. The proposed measures should act to physically limit or reduce the level of exposure to on-site workers as well, e.g., the release is contained without intervention by the workers who do not have to utilize a spill kit or other emergency response procedures. Emergency response activities will tend to increase the worker's direct contact with contaminants.

3.4.2.3 Ground-water Containment

The ground-water containment system is designed to prevent lateral discharges of ground water to surface water and to prevent downward migration of site constituents to the sand aquifer. The groundwater containment includes the following features:

1. An upward hydraulic gradient is to be maintained between the sand and fill aquifers to limit downward migration.

2. The timber lagging wall installed in the intertidal area will have an impermeable liner attached which will govern the flow of ground water towards the Cooper River.

3. Following preaugering, the time the borehole is open will be minimized in order to reduce the opportunity for downward migration to the sand aquifer.

4. The volume of pumped water associated with dewatering will be minimized. Pumped water requires on-site retention prior to disposal. By reducing the volume, site workers are less likely to come into contact with water contained on site and terrestrial species are less likely to attempt to use this water as a source of drinking water.

A demonstration project will be completed in the upland area of the site. The project will monitor constituent levels in three sand aquifer monitoring wells before, during and after preaugering.

The project will allow the contractor to adjust work procedures to minimize migration before construction begins. If migration to the sand aquifer is detected during the demonstration, the contractor may use casings around the borehole. If constituent levels increase above acceptable levels, ground-water extraction may be instituted.

While these procedures should serve to limit off-site migration of ground water and, therefore, be protective of off-site receptors, on-site exposures are best limited through personal protective clothing in order to limit dermal contact with ground water. In addition, a barrier or cover on the ground water retention basin should be installed in order to prevent worker or terrestrial receptors from direct contact with retained ground water.

3.4.2.4 Landside Containment

Landside containment is designed to control off-site migration of soil, sediment, and storm water. Landside containment includes the following features:

1. Silt fencing, hay bales, matting, mulching and seeding will be utilized to prevent erosion of soil and surface runoff during construction.

2. Temporary berms, diversions, and channels will be used to carry off-site waters away from the property and limit the potential for surface runoff.

3. On-site runoff is to be collected in a basin. Storm water collected in the basin will be pumped to a publicly operated treatment plant, if possible. Storm-water sediments are to be deposited on the site. Sediments should be containerized and analyzed before final disposal at the site. Otherwise, sediments left on site may serve as a continuing source of exposure for site workers to metals and PAHs. Also, a contingency plan for breaches in the basin should be included in the plans for the project.

4. A vehicle wash pad will be utilized to remove site soils before vehicles leave the site. Vehicle washing should prevent the off-site migration of site constituents through tracking unless constituents are not easily removed by washing procedures. However, the wash fluids may in turn carry constituents downward through site soils if not properly channeled to the retention basin. Personnel performing the high pressure washing or steaming cleaning should be protected against direct contact with contaminated wash fluids.

The landside containment should effectively limit the migration of surface soil to the river. However, the containment should be visually monitored for breaches on a continuous basis to insure effectiveness through the course of construction.

3.4.2.5 Air Monitoring

The air monitoring program during construction is to include monitoring the work area for volatile organic vapors, oxygen content, combustible gases, and respirable dust. Both OSHA and ACGIH issue occupational air monitoring guidance. The lowest of the two sources should be considered the action level for corrective measures. In addition, action levels should be adjusted for unusual work schedules if work exceeds an 8 hour day or 40 hour week. If performed on a routine basis, the air monitoring program should be protective of site workers.

The Environmental Monitoring and Response Plan indicates that monitoring at the perimeter will be performed to document that off-site receptors have not been exposed to air-borne contaminants during construction. However, the plan does not specify whether monitoring will be for dust only or include volatile organic and PAH compounds and does not indicate the frequency of perimeter monitoring. Perimeter monitoring should occur on a scheduled basis and also during periods when work area monitors have elevated readings in order to properly assess potential off-site exposures.

Dust suppression techniques are proposed to limit on-site and off-site exposures to particulates. Physical agents, windscreens, and wind fencing are proposed in the Environmental Monitoring and Response Plan. If effectively applied, these measures should be protective of site workers and off-site receptors. However, HEPA filters should be available for site workers in case dust suppression measures are not effective. In addition, workers should be trained in safe work practices such as the use of protective clothing and hand washing before leaving the work site. Smoking and eating should be limited to designated clean areas and only after decontamination procedures are completed.

3.5 POTENTIAL IMPACTS OF CONSTRUCTION ON FUTURE REMEDIATION EFFORTS

Applicable remediation methods for the contamination present at the Aquarium site might include: excavation of contaminated soil for treatment, in-situ biological treatment, containment by capping to reduce or prevent an increase in vertical and horizontal migration, installation of a vertical barrier to minimize or prevent horizontal migration of contaminants, and extraction by pumping of ground water for ex-situ treatment. Excavation is not a feasible remediation method due to the shallow depth of

groundwater and the extensive area and depths at which contamination has been detected. Likewise, in-situ bioremediation in the salt-water influence area is not considered feasible for the semi-volatile contamination present.

Potential impacts to future remediation of this site can be separated into short-term and long-term categories, and each of these categories may be subdivided into positive and negative influences. First it must be assumed that remediation will be required for this site. Based on that assumption, the above categories and influences are discussed in the following paragraphs.

3.5.1 Short-Term Impacts

Potential positive short-term impacts to the site include:

- Reduction of the quantity of debris present which may hinder remediation efforts;
- Reduction in contamination present in the soils by excavation and removal of soil during site preparation;
- Increasing accessibility to the site by future remediation contractors;
- Increasing the capability of monitoring conditions at the site;
- Providing a surficial barrier or cap by the presence of the aquarium building and paved parking areas, which would substantially decrease the quantity of precipitation infiltration and associated migration of contaminants; and
- Decreasing the migration of contaminants by allowing the sand blanket and timber lagging wall to remain in place.

The site could realize significant positive influences as a result of construction of an aquarium. As indicated in reports by Killam, preparation of the site will involve removal of site debris and a significant

quantity of soils from the site. The soil, and possibly the debris, may contain contamination that would otherwise continue to migrate from the site. By installing the timber lagging wall with its impermeable lining, the elevation of the site would be more uniform and level, and the potential for migration of contaminants through the fill layer would be reduced. Access to the site for monitoring would be increased, as well as access for potential future investigations. Allowing the sand blanket to remain in place may also decrease the quantity of contamination migrating into the Cooper River. Migration of contaminants by the continued infiltration of rainwater would be significantly reduced by the presence of the aquarium building, and paved parking and walkway areas.

Potential negative short-term impacts to the site include:

- Construction of surface and subsurface structures at the site which might interfere with potential future investigations; and

- Increases in the migration of contaminants through construction methods, thereby increasing the area impacted by contamination.

Migration of contamination could potentially be increased as a result of construction activities, primarily pile installation. The potential would be evaluated during the implementation of demonstration programs for upland and subtidal pile installations. If future site investigations were deemed necessary as part of a remediation effort, the existence of structures, both above and below ground, could potentially complicate the investigations.

3.5.2 <u>Long-Term Impacts</u>

Potential positive long-term impacts to the remediation efforts include the following, many of which were discussed as short-term impacts:

- Reduction in contamination present in the soils (and potentially debris) through removal during construction might improve the site condition in the long-term;

- Increase in the ability of regulatory agencies and owners to monitor conditions at the site;

- Provision for an effective surficial barrier or cap by the construction of the aquarium building and paved parking areas, which would decrease precipitation infiltration and potential migration of contaminants; and

- Implementation of potential ground-water remediation simplified through conversion of monitoring wells to extraction wells.

The overall site condition would be substantially improved by the construction of surface structures and pavements, because a large quantity of potentially contaminated soil and debris would have already been removed, and the site would benefit from a reduction in the volume of rainfall infiltration. Construction of a vertical barrier at this site, if deemed necessary, would be possible around the northern and western boundaries of the site and building and should not be negatively impacted by the presence of structures at the site. Conversion of monitoring wells to extraction wells could be performed with appropriate well sizing during monitoring well installation, and should not be affected by construction. A potential negative long-term impact to the site would be contamination of the deeper sand aquifer as a result of pile installation, which could complicate any groundwater remediation efforts.

4.0 CONCLUSIONS

Constituents of potential health concern for human and ecological receptors have been detected at the proposed construction site of the South Carolina Aquarium. The constituents were found widely dispersed in site soils and sediments. Surface water and shallow ground water appears affected to a lesser degree. Without engineering controls during construction, exposure to site and off-site receptors is expected to exceed acceptable risk levels. With the proper use of engineering controls and safety and health procedures, exposure during construction is expected to be reduced to acceptable levels.

In some ways, the construction of the aquarium is expected to improve the site conditions from those currently observed at the site. Potential improvements include:

1. removal of surface soils with elevated levels of metals and PAHs and replacement with "clean" soil in landscaped areas;

2. control of the quantity of surface runoff discharged to the Cooper River;

3. reduction in exposure of aquatic receptors, especially benthic organisms, to sediments with elevated levels of PAHs, metals, and PCBs through the installation of the sand blanket;

4. removal of subsurface debris at intermediate depth which may serve as a source of soil contamination or as artificial conduits of subsurface migration to the river;

5. retardation of ground-water flow from the site to the river; and

6. limited storm-water infiltration after the aquarium and the adjacent parking lot are in place.

Constituents of concern were detected in the deeper site soils. The remediation of subsurface soils or the removal of deep source materials such as timbers is not feasible, and the construction of the aquarium

would not be expected to hinder potential remediation in the area. Construction of the aquarium is not expected to hinder remediation of site ground water, if required in the future. Measures to extract and treat ground water, with the aquarium in place, are considered feasible.

The limitation or control of exposure related to construction of a major recreational facility before the area is remediated poses a unique situation. While similar engineering control measures have been used in other marine construction projects, their use in an area with contaminants detected in surface and subsurface media are apparently not documented. Many assumptions were made in the design of the containment plans which may not be accurate in practice. Inadequacies due to incorrect assumptions should be identified and corrected during the demonstration programs.

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APPENDIX A

FINAL
SCREENING CRITERIA DOCUMENT

FOR THE
AQUARIUM SITE
FORT SUMTER NATIONAL MONUMENT
CHARLESTON, SOUTH CAROLINA

PREPARED FOR

NATIONAL PARK SERVICE
DENVER SERVICE CENTER
12795 WEST ALAMEDA PARKWAY
DENVER, COLORADO

PREPARED BY
LAW ENVIRONMENTAL, INC.
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SEPTEMBER 1994

FINAL
SCREENING CRITERIA DOCUMENT

FOR THE

AQUARIUM SITE

FORT SUMTER NATIONAL MONUMENT
CHARLESTON, SOUTH CAROLINA

Prepared for:
NATIONAL PARK SERVICE
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September 1994

TABLE OF CONTENTS

FIGURE

LIST OF TABLES

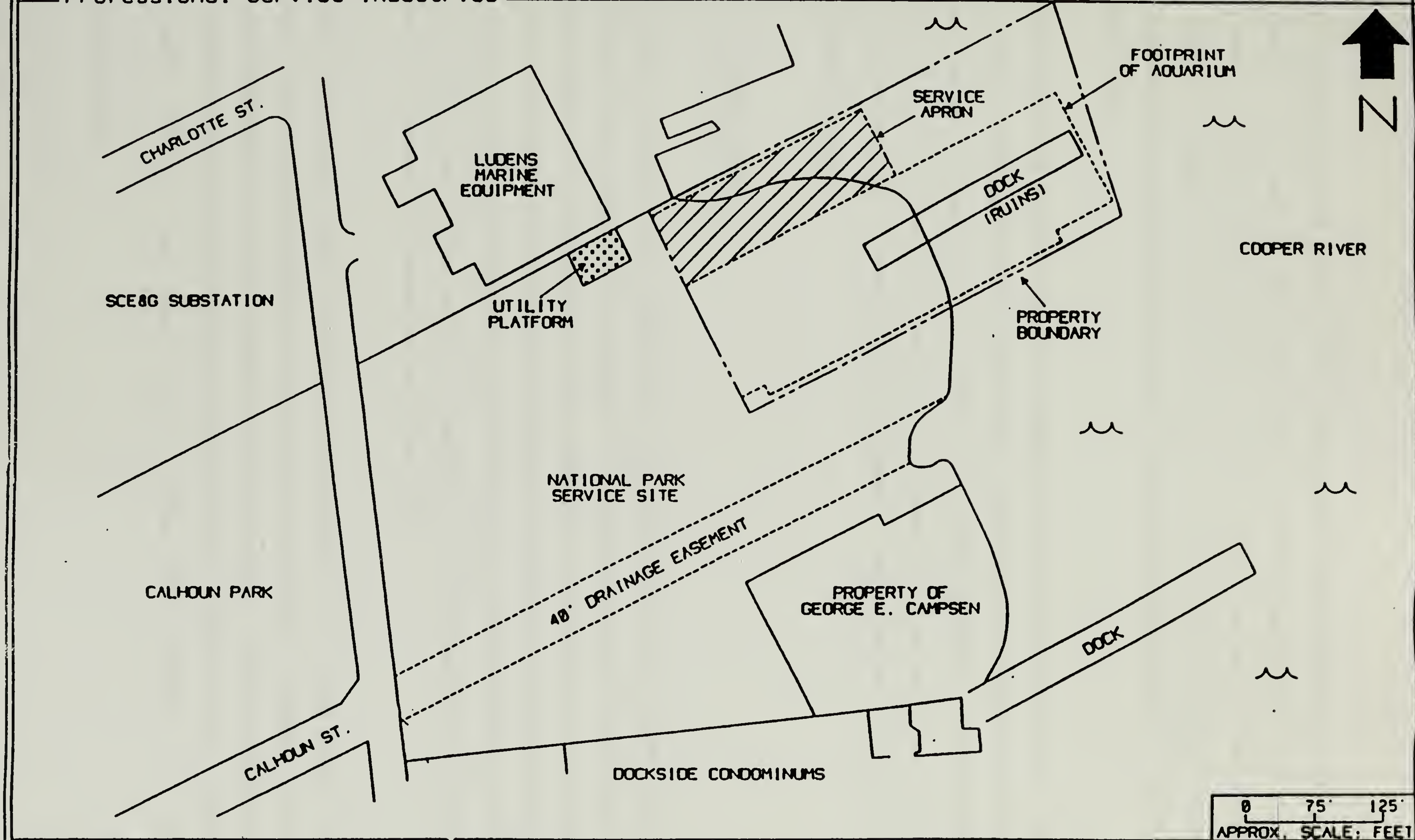
1.0 INTRODUCTION

The National Park Service (NPS), under an indefinite quantity contract task order, has contracted with Law Environmental, Inc. to provide technical support in the area of human health and ecological exposure assessment during the environmental investigation of the Aquarium site, Fort Sumter National Monument, Charleston, South Carolina. This draft document is intended to support an Exposure Assessment Technical Memorandum for the Aquarium site which is to be developed by Law Environmental, Inc. Historical data and analytical data collected by Killam Associates served as the basis for identification of chemicals of potential concern at the Aquarium site (Chester Environmental, 1993; Killam, Associates, 1994).

1.1 SITE BACKGROUND

The City of Charleston proposes to build an Aquarium on a tract of property to be leased from the NPS. Because of the industrial history of the NPS property and the location of a National Priority List site (Calhoun Park Area site) adjacent to the NPS property, the City of Charleston investigated evidence of chemical contamination at the Aquarium site in soil, ground water, surface water, and sediment that may cause adverse effects to human health and the environment during proposed construction at the site. The investigation of the Aquarium site was performed by Killam Associates for the City of Charleston. The data are presented in the Site Investigation Report and Conceptual Containment Plan (Killam Associates, 1994).

The Aquarium is to be located in the northeastern corner of the NPS property (Figure 1-1) and will be situated partly over the upland portion of the Aquarium site, partly over the intertidal zone of the Cooper River, and partly over open water. The constructed Aquarium will consist of three floors plus a partial basement. A total of 350 concrete piles will be driven with 80 piles in the subtidal area of the Cooper River and 270 piles in the upland area. Approximately 25 of the 270 upland piles will be placed in the intertidal region. Piles will be driven to depths of 98



PROJECT NAME	FIGURE 1-1	PROJECT NO.
NATIONAL PARK SERVICE FORT SUMTER NATIONAL MONUMENT CHARLESTON, SOUTH CAROLINA	SITE LAYOUT MAP	513-34002
		DATE 4-7-93

Source: PSI, 1993a

to 110 feet below mean sea level. The number of piles and driven depths may differ in the final design of the Aquarium. Three to four feet of soil will be removed from approximately 95 percent of the upland portion of the tract. The City of Charleston has developed a Contingency Plan which presents what controls will be used to prevent a release during construction and the steps that will be taken if a release occurs (Professional Service Industries (PSI), 1993a; Killam, 1993; 1994).

The objective of the environmental investigation by the City of Charleston is to assess the potential for a release of contaminants during construction of the Aquarium and to provide information to help address the issue of the potential liability assumed by the NPS by leasing the tract to the City of Charleston. The NPS and other agencies with the Department of Interior will utilize the results of the environmental investigation to make a decision regarding the lease of the tract to the city.

1.2 SITE HISTORY

The NPS Charleston Harbor property, as a whole includes four acres of uplands and four acres within the current range of the Cooper River. The proposed Aquarium site includes a 1.5 acre tract (Figure 1-1). Other areas of the NPS property are to be developed as a dock facility for the Fort Sumter National Monument and a restaurant. According to historical records, the NPS property is largely fill and has been used at various times as a commercial wharf, dry dock for ship building, lumber wharf, and for the manufacture of chemicals and paint. Ruins of the old docks are adjacent to the Aquarium site (Killam, 1993).

The NPS property is located in an area of Charleston Harbor with a long history of industrial use. Past and present properties in the vicinity of the site include a former coal gasification plant (Calhoun Park Area site), a sawmill and lumber company, chemical manufacturers, a dry fertilizer company, public housing (now closed because of health concerns), condominiums, Luddens Marine (boat repair), and the State Port Authority. A Remedial

Investigation/Feasibility Study (RI/FS) is currently being completed for the Calhoun Park Area site (PSI, 1993b; Chester Engineering, 1994). Environmental investigation and restoration of the Calhoun Park Area site may directly or indirectly impact use of the Aquarium site.

Three previous investigations have included samples collected within the Aquarium site or from the drainage way located south of the Aquarium site (PSI, 1993b; Chester, 1993). Constituents detected in soils and sediments have included metals, several polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and trace amounts of volatile and other semi-volatile organic compounds. Constituents detected in surface water and shallow ground water include metals and PAHs. Based on historical and current analytical data from the Aquarium site, a listing of detected constituents was compiled (Table 1-1). Based on the frequency of detection, the PAHs and metals are expected to be the primary constituents of concern for both human and ecological receptors.

1.3 OBJECTIVE

The objective of this document is to identify the chemical-specific health-based criteria which will be applied in the qualitative evaluation of chemicals detected in media sampled during the Aquarium site investigation. These criteria will be used to identify constituents which may contribute an unacceptable level of risk for human and ecological receptors present on and in the immediate vicinity of the Charleston Harbor Aquarium site. These criteria are not intended to serve as generic cleanup goals or as a substitute for a baseline risk assessment. The focus of this document is guidance established on the basis of health risks and does not address potential location-specific or action-specific regulatory requirements.

TABLE 1-1

LISTING OF DETECTED CONSTITUENTS
BASED ON HISTORICAL AND CURRENT ANALYTICAL DATA

Constituents detected in Sediments (outfall to Cooper River):

Metals:

Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Copper
Manganese
Mercury
Nickel
Silver
Lead
Zinc

Volatile Organics:

Benzene
Ethylbenzene
Toluene
Xylenes

Pesticide/PCBs/Dioxins:

Dieldrin
4,4'-DDE
4,4'-DDT
Arochlor-1254
Arochlor-1260
2,3,7,8 -TCDD
2,3,7,8-TCDF

Semivolatile Organics:

Acenaphthene
Anthracene
Benzo(a)anthracene
Benzo(g,h,i)perylene
*Butylbenzyl phthalate
*Bis(2-ethylhexy) phthalate
Carbazole
Chrysene
Dibenzofuran
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
2-Methylnapthalene
N-nitrosophenylamine
Naphthalene
Nitrobenzene
Pyrene

Constituents Detected in Surface Water (outfall to Cooper River):

Metals:

Arsenic
Lead
Manganese
Vanadium
Zinc

Semivolatile Organics:

2-Methylnapthalene
Naphthalene

Constituents Detected in Ground Water (Northern Third of NPS Property):

Metals:

Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Copper
Lead
Manganese
Mercury
Sodium
Vanadium
Zinc

Volatile Organics:

Benzene
Ethylbenzene
Toluene
Xylenes

Other Organics:

Dibenzofuran
PCB-1248
PAHS

TABLE 1-1

PRELIMINARY LISTING OF CONSTITUENTS OF CONCERN BASED ON HISTORICAL ANALYTICAL DATA (Cont).

Constituents Detected in Surface and Subsurface Soils (within Northeastern corner of NPS property):

Metals:	*Pesticides/Dioxins/PCBs:*	*Other Organics:*
Antimony	Arochlor 1254	Acenaphthylene
Arsenic	Arochlor 1260	Acenaphthene
Barium	4,4' DDE	Anthracene
Beryllium	4,4' DDT	Benzo(a)anthracene
Cadmium	Dieldrin	Benzo(b)fluoranthene
Chromium	2,3,7,8-TCDD	Benzo(k)fluoranthene
Cobalt	2,3,7,8-TCDF	Benzo(g,h,i)perylene
Copper		Benzo(a)pyrene
Manganese		Chrysene
Mercury	*Volatiles Organics:*	Dibenzo(a,h)anthracene
Nickel		Dibenzofuran
Lead	*Acetone	Fluoranthene
Silver	Carbon disulfide	Naphthalene and derivatives
Vanadium	Carbazole	2-Methylnapthalene
Zinc	Benzene	2-Methylphenol
	Ethylbenzene	4-Methylphenol
	*Methylene chloride	Phenol
	*Methyl ethyl ketone	Pyrene
	Toluene	Phenanthrene
	Xylenes	Indeno(1,2,3-cd)pyrene
		*Bis(2-ethylhexyl) phthalate
		4-Nitroaniline
		*Di-n-butyl phthlate
		*Butyl benzyl phthlate
		*Diethyl phthlate
		Styrene

Sources:

Chester Environmental, Inc., 1993. Appendix E, Tabulation of Existing Analytical Data, National Park Service Property from November 1992 Expanded Site Inspection Report, General Engineering Laboratories.

Killam Associates, 1994. Site Investigation Report and Conceptual Containment Plan, South Carolina Aquarium Site, Charleston South Carolina. June 1994.

Professional Service Industries, Inc., 1993. Work Plan for Expanded Site Inspection, Charleston Harbor Site, Charleston, South Carolina. October 1993.

*Reported as laboratory artifacts

2.0 SCREENING CRITERIA

The criteria selected as screening criteria are health- or risk-based numerical criteria and guidelines which establish an acceptable concentration of a chemical in a specific media. The media of concern at the Aquarium site include soil, ground water, surface water, and sediment. Criteria and guidelines were selected which could be used to screen detected concentrations in a media for levels which may adversely effect human health or the health of ecological receptors.

Human health-based criteria and guidelines include federal and state drinking water standards, federal Draft Soil Screening Levels, federal guidance on the cleanup of sites with lead contamination, risk-based concentrations for industrial and residential exposures to soils, and ambient water quality criteria for the ingestion of fish. Ecological health criteria and guidelines are based on the protection of aquatic life. The focus on aquatic life is appropriate for this site because the Cooper River is the primary environmental receptor for site releases and the industrial nature of the area limits the presence of terrestrial life. Criteria and guidelines selected as protective of ecological health include ambient water quality criteria protective of aquatic life, Region IV saltwater quality screening values, sediment quality guidelines developed by the National Oceanic and Atmospheric Administration (NOAA) and draft sediment screening values presented by the United States Environmental Protection Agency (USEPA) Region IV Waste Management Division.

Because migration and transport of site constituents between media may occur, guidelines developed for one media may be applied to the screening of another media. For example, shallow ground water is assumed to discharge to the Cooper River and will be evaluated for impacts to human health and aquatic life by comparison to ambient water quality criteria.

2.1 DRINKING WATER STANDARDS

In accordance with the Safe Drinking Water Act, USEPA has established primary drinking water regulations which are designed to be protective of human health from the potential adverse effects of drinking water contaminants. Maximum Contaminant Levels (MCLs) are enforceable standards for public drinking water supplies which apply to a specific number of chemicals. The MCLs combine health effects data on specific chemicals with other concerns, such as analytical detection limits, treatment technology, and economic impact of compliance. The receptor population's total environmental exposure to a specific chemical is considered in developing the MCL, which attempts to set lifetime limits at the lowest practicable level to minimize the amount of toxicants contributed by drinking water. An intake of two liters of water per day is assumed in developing MCLs.

MCLs are relevant and appropriate as in situ standards where surface water or ground water is or may be used for drinking water. Shallow ground water at the site is not used for drinking water purposes and is believed to be separated hydraulically from the drinking water aquifer by the marl unit present at the site. However, groundwater at the site is classified as GB by SCDEC and, therefore, is considered a potential source of drinking water. Therefore, MCLs will be used as an indicator of ground water quality at the site. Because of the saline nature of the Cooper River, the river is not used as a source of drinking water. Therefore, MCLs are not considered applicable to surface water at this site.

Newly devised and revised MCLs are issued in the Federal Register. The USEPA Office of Water issues a listing of current MCLs, Maximum Contaminant Level Goals, and Health Advisories. The most current version of the Drinking Water Regulations and Health Advisories document will be used as a source document (USEPA, 1994a). The South Carolina Drinking Water Regulations which are designed to protect human health from ground-water exposures are, in general, based on the federal MCLs (SCDHEC, 1990). Both federal and state drinking water values will be considered in the qualitative assessment of detected concentrations in ground water samples. Table 2-1 lists federal and state drinking water standards for the constituents detected in Aquarium site media.

TABLE 2-1

DRINKING WATER STANDARDS AND
WATER QUALITY CRITERIA FOR TRACE METALS
AND ORGANIC COMPOUNDS, ug/L

Chemical Parameter	GROUND WATER BACKGROUND RANGE	SURFACE WATER BACKGROUND RANGE	MCLs	STATE MCLs	AMBIENT WATER QUALITY CRITERIA: PROTECTION OF AQUATIC LIFE: MARINE ACUTE	AMBIENT WATER QUALITY CRITERIA: PROTECTION OF AQUATIC LIFE: MARINE CHRONIC	AMBIENT WATER QUALITY CRITERIA: PROTECTION OF HUMAN HEALTH: FISH CONSUMPTION ONLY	REGION IV SALTWATER SCREENING VALUES: ACUTE	REGION IV SALTWATER SCREENING VALUES: CHRONIC
Volatile Organic Compounds:									
Benzene	ND	ND	5	5	5,100	700	40	1,090	109
Ethylbenzene	ND	ND	700	NA	430	NA	3,280	43	4.3
Toluene	ND	ND	1,000	NA	6,300	5,000	424,000	370	37
Xylene	ND	2 JB	10,000	NA	NA	NA	NA	NA	NA
Semi-Volatile Organic Compounds:									
Acenaphthene	ND	ND	NA	NA	970	710	NA	97	10
Acenaphthylene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
Anthracene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
Benzo(a)anthracene	ND	ND	0.1	NA	300	NA	0.0311	NA	NA
Benzo(b)fluoranthene	ND	ND	0.2	NA	300	NA	0.0311	NA	NA
Benzo(ghi)perylene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
Benzo(a)pyrene	ND	ND	0.2	NA	300	NA	0.0311	NA	NA
Benzo(k)fluoranthene	ND	ND	0.2	NA	300	NA	0.0311	NA	NA
Bis(2-Ethylhexyl)phthalate	ND	1 JB - 2 JB	6	NA	NA	NA	50,000	NA	NA
Carbozole	ND	ND	NA	NA	NA	NA	NA	NA	NA
Carbon disulfide	ND	ND	NA	NA	NA	NA	NA	NA	NA
Chrysene	ND	ND	0.2	NA	300	NA	0.0311	NA	NA
4,4'-DDE	ND	ND	NA	NA	14	NA	NA	1.4	0.14
4,4'-DDT	ND	ND	NA	NA	0.13	0.001	0.000024	0.13	0.001
Dibenz(ah)anthracene	ND	ND	0.3	NA	300	NA	0.0311	NA	NA
Dibenzofuran	ND	ND	NA	NA	NA	NA	NA	NA	NA
Dieldrin	ND	ND	NA	NA	0.71	0.0019	0.000076	0.71	0.0019
Fluoranthene	ND	ND	NA	NA	40	16	54	4	2
Fluorene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
Indeno(1,2,3-c,d)pyrene	ND	ND	0.4	NA	300	NA	0.0311	NA	NA
Methylene chloride	ND	8 J - 11	5	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
Naphthalene	ND	ND	NA	NA	2,350	NA	NA	235	23.5
Phenanthrene	2 J	ND	NA	NA	300	NA	0.0311	NA	NA
Polychlorinated Biphenyls	ND	ND	0.5	NA	10	0.03	0.000079	1.05	0.03
PCB-1248	ND	ND	0.5	NA	10	0.03	0.000079	1.05	0.03
Total PCBs	ND	ND	NA	NA	NA	NA	NA	NA	NA
Arochlor 1254	ND	ND	0.5	NA	10	0.03	0.000079	1.05	0.03
Arochlor 1260	ND	ND	0.5	NA	10	0.03	0.000079	1.05	0.03
Pyrene	ND	ND	NA	NA	300	NA	0.0311	NA	NA
2,3,7,8-TCDD (Dioxin)	ND (a)	ND (b)	3E-05	NA	NA	NA	0.000000014	NA	0.00001

TABLE 2-1

DRINKING WATER STANDARDS AND
WATER QUALITY CRITERIA FOR TRACE METALS
AND ORGANIC COMPOUNDS, µg/L

Chemical Parameter	GROUND WATER BACKGROUND RANGE	SURFACE WATER BACKGROUND RANGE	MCLs	STATE MCLs	AMBIENT WATER QUALITY CRITERIA: PROTECTION OF AQUATIC LIFE		AMBIENT WATER QUALITY CRITERIA: PROTECTION OF HUMAN HEALTH	REGION IV SALTWATER SCREENING VALUES	
					MARINE ACUTE	MARINE CHRONIC	FISH CONSUMPTION ONLY	ACUTE	CHRONIC
Metals:									
Antimony	ND	ND	6	NA	NA	NA	45,000	NA	NA
Arsenic	*24.9*	*5.3 B*	50	50	69	36	0.0175	69 (c)	36 (c)
Barium	15.1 B – 91.1 B	10.9 B – 19.5 B	2,000	1,000	NA	NA	NA	NA	NA
Beryllium	ND	ND	4	NA	NA	NA	0.117	NA	NA
Cadmium (e)	ND	ND	5	10	43	9.3	NA	43	9.3
Chromium III (e)	ND	ND	100 (d)	50	1,030	NA	3,433	1,030	103
Chromium VI (e)	ND	ND	100 (d)	50	1,100	50	NA	1,100	50
Cobalt	7 B	ND	NA	NA	NA	NA	NA	NA	NA
Copper (e)	***7.8 B – 9.1 B***	ND	1,300 TT	NA	2.9	2.9	NA	2.9	2.9
Lead (e)	***1.3 J – 150 J***	ND	15 TT	50	140	5.6	NA	140	5.6
Manganese	***83.9 – 800***	14.8 B – 18.9	50 S	NA	NA	NA	100	NA	NA
Mercury	***0.7***	ND	2	2	2.1	0.025	0.146	2.1	0.025
Nickel (e)	ND	ND	100	NA	75	8.3	100	75	8.3
Silver (e)	ND	ND	100 S	50	2.3	NA	NA	2.3	0.23
Sodium	58,600 – 195,000	432,000 – 5,990,000	NA	NA	NA	NA	NA	NA	NA
Vanadium	9.2 B – 11.9 B	11.2 B	NA	NA	NA	NA	NA	NA	NA
Zinc (e)	80.5	20.2 – 29	5,000 S	NA	95	86	NA	95	86

Units in µg/L.

(a) – Total dioxin/furans equaled 6.5E–07 µg/L in TEF units.
(b) – Total dioxin/furans equaled 6.0E–08 µg/L in TEF units.
B – The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.
J – Indicates an estimated value
NA – Not Available
ND – Not Detected
S – Secondary MCL
TT – Treatment Technique
(c) Trivalent arsenic
(d) Total Chromium
(e) Levels are hardenss dependent; 50 mg/L $CaCO_3$ was the default value.

Boxing indicates value exceeds criteria.
Bold indicates value exceeds Region IV criteria.
Italics indicates value exceeds Ambient Water Quality Criteria.
Shading indicates value exceeds MCLs.

SOURCES:

Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902–05, April 1994.
Professional Services Industry, Inc. 1994. Draft Report Site Inspection Charleston Harbor Site. project No. 513–44008, June 1994.
South Carolina Safe Drinking Water Regulations, Chapter 61 – Department of Health and Environmental Control, Regulation 61–58.5. December 28, 1990.
USEPA, 1993a. Drinking Water Regulations and Health Advisories. USEPA, Office of Water, May 1994.
USEPA, 1986. Quality Criteria for Water. EPA 440/5–86–001, May 1, 1987, USEPA, Office of Water Regulations and Standards.
USEPA, 1993. Ground Water Information Exchange and Technology Support, Volume II, Issue I. USEPA Region IV, Ground Water Technology Support Unit, January 1993.

2.2 AMBIENT WATER QUALITY CRITERIA

Section 303 of the Clean Water Act requires states to adopt or to promulgate surface water criteria at least as stringent as the federal Ambient Water Quality Criteria (AWQC). AWQC are established to prevent the discharge of toxic pollutants which could reasonably be expected to interfere with the designated uses of surface water resources as adopted by the states. The Aquarium site lies adjacent to the Cooper River near the point where the Cooper and Ashley Rivers converge. This section of the Cooper River is classified by the State of South Carolina as Class SB. Class SB water bodies are "tidal saltwaters suitable for primary and secondary contact recreation, crabbing, and fishing, except harvesting of clams, mussels, or oysters for market purposes or human consumption." Class SB water bodies are also considered suitable for the "survival and propagation of a balanced indigenous aquatic community of marine fauna and flora" (SCDHEC, 1993).

According to the South Carolina Water Classifications and Standards, garbage, sludge, or other refuse is not allowed in the river (SCDHEC, 1993). In addition, treated wastes or potentially deleterious substances can not be present in concentrations which adversely effect the survival and propagation of marine fauna and flora, adversely affect the aesthetic quality of fish taken for human consumption, or make the water unsafe or unsuitable for secondary recreation.

In order to protect South Carolina waters from affects of toxic pollutant discharges, the State has adopted the federal AWQC. The State has adopted federal criteria which are protective of both aquatic life and human health. The Cooper River adjacent to the site is considered primarily saltwater. Marine criteria protective of aquatic life are considered more appropriate for comparison to the water concentrations detected at the Aquarium Site. The AWQC are compared to maximum constituent concentrations detected in ground-water samples and storm water samples as well as samples taken directly from the Cooper River because storm water and ground water is assumed to discharge to the river.

The AWQC for the protection of human health identify two routes of exposure: exposure from drinking water and the consumption of aquatic organisms, primarily fish, and from fish

consumption alone. The salinity of the Cooper River makes the river an undesirable source of drinking water. Therefore, AWQC for the protection of human health from the ingestion of fish alone will be used to judge water quality at the site. The AWQC criteria are based on the assumed daily ingestion rate of 6.5 grams of fish. Ambient concentrations corresponding to incremental lifetime risk levels have been estimated for those constituents which exhibit carcinogenic and /or mutagenic effects in laboratory tests. The AWQC levels representing a risk level of 10^{-6} will be used for comparison to site concentrations. The AWQC protective of human health are listed in Table 2-1.

The AWQC have also been based on organoleptic data. These criteria are adopted in order to prevent undesirable taste or odor in surface water features, but are not designed to be protective of human or aquatic life. Organoleptic criteria were not available or were less stringent than other guidelines and were not utilized in the comparison to site concentrations.

Marine AWQC protective of aquatic life have been developed for acute and chronic exposures. Acute criteria apply to exposures of less than 24-hour duration and are not-to-be-exceeded values. Chronic criteria are based on 24-hour average or 4-day average concentrations which produced observable impacts on the study population. It should be noted that AWQC do not take into account possible food chain effects such as biomagnification and do not address additivity of effects from multiple toxicants. Because of the chronic nature of potential releases or discharges occurring at the site, marine chronic values are considered the more appropriate values to be used for comparison to site concentrations. Table 2-1 lists chronic marine AWQC and Region IV saltwater quality screening levels (USEPA, 1986; 1993a).

The state allows the development of site-specific standards based on biological monitoring of the indigenous instream community. The state also does not consider a criterion violated if the criterion is below the analytical detection limit and the biological community is not adversely impacted (SCDHEC, 1993). However, population surveys and toxicity testing is not included in the current investigation by Killam, so this evaluation cannot be made.

The AWQC protective of aquatic life for the constituents previously detected in site media are listed in Table 2-1. AWQC criteria are compared to levels of constituents detected in site ground water and surface water. Potential adverse impacts are noted when site concentrations exceed both upstream levels and marine AWQC criteria. Additional investigation of site-specific impacts on aquatic life, i.e. population studies and toxicity testing, will be evaluated if exceedances are noted.

2.3 SEDIMENT CRITERIA

The NOAA has developed Effects Range concentrations which are non-enforceable guidance criteria for sediments (Long et al, 1993). These concentrations were derived from data on the potential of these chemicals to cause adverse biological effects in coastal marine and estuarine environments. Two guideline values, an Effects Range-Low and an Effects Range-Median, were determined for nine trace metals, total PCBs, two pesticides, thirteen polynuclear aromatic hydrocarbons (PAHS), and three classes of PAHs. These sediment guidelines are not human health-based numbers, but are designed to be protective of aquatic life and will be used to identify potential areas of concern in the vicinity of the site.

The USEPA Region IV Waste Management Division has developed a table of screening values which are to serve as tools in the preliminary review of analytical data from hazardous waste sites (USEPA, 1994b). Exceedences of the screening values are seen as an indication that further investigation may be needed. The Region IV sediment screening values are based on the works of Long and Morgan (1991), McDonald (1993), and Long et al. (1993). The Region IV and NOAA Sediment Quality Guidelines are presented in Table 2-2.

Site soils may potentially wash into the adjacent river during construction activities. Therefore, constituent levels detected in site soils will be compared to sediment criteria in order to evaluate potential adverse impacts on aquatic life from surface runoff.

TABLE 2-2

SURFACE SOIL AND SEDIMENT QUALITY GUIDELINES FOR TRACE METALS AND ORGANIC COMPOUNDS, mg/kg

Chemical Parameter	Surface Soil Background Range	Sediment Background Range	Effects Range–Low	Effects Range–Median	EPA Region IV Screening Value
Volatile Organic Compounds:					
Benzene	ND	ND	NA	NA	NA
Ethylbenzene	0.046 J	ND	NA	NA	NA
Toluene	ND	ND	NA	NA	NA
Xylenes	0.007 J – 0.058	ND	NA	NA	NA
Semi–Volatile Organic Compounds:					
Acenaphthene	ND	ND	0.016	0.5	0.33
Acenaphthylene	0.032 J	ND	0.044	0.64	0.33
Anthracene	0.032 J	ND	0.0853	1.1	0.33
Arochlor–1254	ND	ND	0.0227 (a)	0.18 (a)	0.033 (a)
Arochlor–1260	ND	ND	0.0227 (a)	0.18 (a)	0.033 (a)
Benzo(a)anthracene	0.12 J – 0.24 J	ND	0.261	1.6	0.33
Benzo(a)pyrene	0.03 J – 0.25 J	ND	0.43	1.6	0.33
Benzo(g,h,i)perylene	0.24 J	ND	NA	NA	NA
bis(2–Ethylhexyl)phthalate	0.079 J – 0.22	0.076 J – 0.16 J	NA	NA	NA
Butylbenzyl phthalate	ND	ND	NA	NA	NA
Carbazole	ND	ND	NA	NA	NA
Chlordane	0.0047 P	ND	NA	NA	0.0017
Chrysene	0.16 J – 0.31 J	ND	0.384	2.8	0.33
4,4'–DDE	*0.00085 J – 0.0046 P*	ND	0.0022	0.027	NA
4,4'–DDT (Total)	0.0011 JP – 0.0019 JP	0.00065 JP	0.00158	0.0461	0.0033
Dibenzo(a,h)anthracene	0.035 J – 0.053 J	ND	0.0634	0.26	0.33
Dibenzofuran	ND	ND	NA	NA	NA
Dieldrin	ND	ND	NA	NA	0.0033
Endrin	ND	ND	NA	NA	0.0033
Fluoranthene	0.26 J – 0.56	0.072 J – 0.12 J	0.6	5.1	0.38
Fluorene	ND	ND	0.019	0.54	0.33
Indeno(1,2,3–cd)pyrene	0.12 J – 0.23 J	ND	NA	NA	NA
2–Methyl napthalene	ND	ND	0.07	0.67	0.33
Naphthalene	ND	*0.22 J*	0.16	2.1	0.33
Nitrobenzene	ND	ND	NA	NA	NA
N–nitrosophenylamine	ND	ND	NA	NA	NA
Phenanthrene	0.10 J – 0.21 J	0.1 J	0.24	1.5	0.33
Pyrene	0.25 J – 0.41	0.076 J – 0.083 J	0.665	2.6	0.33
Low Mol. Wt. PAHs	NA	ND	0.552	3.16	0.33
High Mol. Wt. PAH	NA	ND	1.7	9.6	0.33
2,3,7,8–TCDD	ND	ND	NA	NA	NA
2,3,7,8–TCDF	1.8E–06	ND	NA	NA	NA
Total Dioxins	3.0E–06	4.6 – 7.6	NA	NA	NA
Total PAHs	0.11 – 3.1	ND	4.022	44.7	2.9
Total PCBs	ND	ND	0.0227	0.18	0.033

TABLE 2-2

SURFACE SOIL AND SEDIMENT QUALITY GUIDELINES FOR TRACE METALS AND ORGANIC COMPOUNDS, mg/kg

Chemical Parameter	Surface Soil Background Range	Sediment Background Range	Effects Range – Low	Effects Range – Median	EPA Region IV Screening Value
Metals:					
Antimony	ND	ND	NA	NA	12
Arsenic	2.1 B – 5.8	3 – 13.6	8.2	70	8
Barium	12.8 B – 76.3	4.9 B – 31.3 B	NA	NA	NA
Beryllium	0.26 B – 0.37 B	0.94 B – 1.2 B	NA	NA	NA
Cadmium	ND	ND	1.2	9.6	1
Chromium	6.2 – 11.1	7.6 – 46	81	370	33
Copper	3.9 B – 33.7	11.2 B – 15.8 B	34	270	28
Lead	***36.1 – 304***	*2.9 – 69.9*	46.7	218	21
Manganese	11.9 – 53.6	75.6 – 540	NA	NA	NA
Mercury	*0.12 – 0.34*	ND	0.15	0.71	0.1
Nickel	12.8	16.6 – 19 B	20.9	51.6	20.9
Silver	ND	ND	1.0	3.7	2
Vanadium	4.3 B – 10.6	7.4 B – 60	NA	NA	NA
Zinc	26.3 – 130	10.8 – 61.2	150	410	68

Units in mg/kg, dry weight.

B – For unvalidated organic analyses, this qualifier indicates that the constituent was also detected in a laboratory method blank. For inorganic analyses, this laboratory qualifier indicates the result was detected below the specified Contract Required Detection Limit.
J – Indicates an estimated value.
P – Used for a pesticide/Arochlor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported.
NA – Not Applicable
ND – Not Detected

(a) Value for PCBs

Boxing indicates value exceeds criteria.
Italics indicates value exceeds low range
Bold indicates value exceeds median range.
Shading indicates value exceeds Region IV Criteria.

Sources:
Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902–05, April 1994 (see text).
Long et al., 1993. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Draft, Environmental Mgt. (10/93)

2.4 SOIL CRITERIA

The criteria which will be used to evaluate human health risks associated with soil exposures are listed in Table 2-3. The USEPA Office of Solid Waste and Emergency Response (OSWER) has developed Draft Soil Screening Levels (SSLs) for 30 chemicals which may be used to determine if detected soil levels may potentially present a human health concern and warrant further study (USEPA, 1993b). Concentrations above the SSL should not trigger a response action, but indicate a need for further evaluation of potential risks which may be posed by soil constituents. The SSLS are based on residential exposure scenarios which assume long-term exposures (up to 30 years) and exposure to young children as well as adults. Because SSLs are based on residential exposure scenarios, these risk-based levels are conservatively protective of human health. When site soil concentrations are below SSLs, no further study should be warranted. The SSL guidance is currently in draft but is scheduled for finalization along with SSLs for 60 additional chemicals during the summer of 1994 (USEPA, 1993c).

Criteria for lead levels in soil are not included in the Draft SSL Guidance. The OSWER has issued guidance on establishing soil lead cleanup levels at CERCLA sites which use a lower limit of 500 parts lead per million (ppm) soil in residential soils. The lower limit of 500 ppm is expected to prevent blood levels in exposed children from exceeding the recommended limit for children, 10 micrograms lead per decaliter of blood. If site concentrations exceed the 500 ppm level, the need for further evaluation of potential health risks is indicated (USEPA, 1989; 1992). A lead level of 500 ppm is used to screen soil and sediments for potential impacts to human health.

Because the number of SSLs is currently limited and only presents values for 7 of the 28 preliminary constituents of concern in soil, another source of human health risk-based criteria for soil exposures is warranted. Region IV and the State of South Carolina do not currently have numeric screening criteria by which to evaluate the risk to human health associated with soil exposures. As an alternative, the USEPA Region III Risk-Based Concentrations will be used as a risk-based screen (USEPA, 1994c). Risk-based concentrations provides benchmark values for industrial and residential exposure scenarios to surface soils. The values were

TABLE 2-3

SOIL QUALITY CRITERIA FOR TRACE METALS
AND ORGANIC COMPOUNDS, mg/kg

Chemical Parameter:	Surface Soil Background Range	Subsurface Soil Background Range	Surface Soil SSLs	Region III Risk-Based Concentrations Industrial	Region III Risk-Based Concentrations Residential
Volatile Organic Compounds:					
Benzene	ND	ND	2.5	99	22
Ethylbenzene	0.046 J	ND	58	100,000	7,800
Toluene	ND	ND	150	200,000	16,000
Xylenes	0.007 J - 0.058	ND	97	1,000,000	160,000
Semi-Volatile Organic Compounds:					
Acenaphthene	ND	ND	NA	61,000	4,700
Acenaphthylene	0.032 J	ND	NA	NA	NA
Acetone	10 J - 34 J	0.1	NA	100,000	7,800
Anthracene	0.032 J	0.028 J	NA	310,000	23,000
Benzo(a)anthracene	0.12 J - 0.24 J	0.18 J	NA	3.9	0.88
Benzo(b)fluoranthene	0.054 J - 0.39	0.25 J	NA	3.9	0.88
Benzo(k)fluoranthene	0.24 J - 0.17 J	0.099 J	NA	39	8.8
Benzo(g,h,i)perylene	0.24 J	0.14 J	NA	NA	NA
Benzo(a)pyrene	$\boxed{0.03\ J - 0.25\ J}$	$\boxed{0.2\ J}$	0.11	0.39	0.088
Bis(2-Ethylhexyl)phthalate	0.079 J - 0.22	0.73 B	NA	200	46
Butylbenzyl phthalate	ND	ND	NA	200,000	16,000
Carbazole	ND	ND	NA	140	32
Carbon disulfide	ND	ND	NA	100,000	7,800
Chrysene	0.16 J - 0.31 J	0.14 J	0.8	390	88
4,4'-DDE	0.00085 J - 0.0046 P	ND	NA	8.4	1.9
4,4'-DDT	0.0011 JP - 0.0019 JP	ND	1.9	8.4	1.9
Dibenz(a,h)anthracene	0.035 J - 0.053 J	0.051 J	NA	0.39	0.088
Dibenzofuran	ND	ND	NA	NA	NA
Di-n-butyl phthalate	ND	ND	NA	100,000	7,800
Dieldrin	ND	ND	0.04	0.18	0.04
Diethyl phthalate	ND	ND	NA	820,000	63,000
2,4-Dimethylphenol	ND	ND	NA	20,000	1,600
Fluoranthene	0.26 J - 0.56	0.14 J	NA	41,000	3,100
Fluorene	ND	ND	NA	41,000	3,100
Indeno(1,2,3-cd)pyrene	0.12 J - 0.23 J	0.16 J	NA	3.9	0.88
Methylene chloride	5 J	ND	44	380	85
Methyl ethyl ketone	ND	ND	NA	610,000	47,000
2-Methylnaphthalene	ND	ND	NA	NA	NA
2-Methylphenol	ND	ND	NA	51,000	3,900
4-Methylphenol	ND	ND	NA	5,100	390
Naphthalene	ND	ND	52	41,000	3,100
4-Nitroaniline	ND	ND	NA	3,100	230
Phenanthrene	0.10 J - 0.21 J	0.088 J	NA	NA	NA
Phenol	ND	ND	NA	610,000	47,000
Polychlorinated Biphenyls	ND	ND	NA	0.37	0.083
Arolchlor 1254	ND	ND	NA	0.37	0.083
Arochlor 1260	ND	ND	NA	0.37	0.083
Pyrene	0.25 J - 0.41	0.15 J	NA	31,000	2,300
Styrene	ND	ND	NA	200,000	16,000
2,3,7,8-TCDD	ND	ND	NA	0.000018	0.0000041
2,3,7,8-TCDF	1.8E-06	ND	NA	NA	NA

TABLE 2-3

SOIL QUALITY CRITERIA FOR TRACE METALS
AND ORGANIC COMPOUNDS, mg/kg

Chemical Parameter:	Surface Soil Background Range	Subsurface Soil Background Range	Surface Soil SSLs	Region III Risk-Based Concentrations Industrial	Residential
Metals:					
Antimony	ND	ND	NA	410	31
Arsenic (a)	**2.1 B**	**2.1 B**	0.37	1.6	0.37
Barium	12.8 B – 76.3	22.2 B	NA	72,000	5,500
Beryllium	0.26 B – 0.37 B	ND	NA	0.67	0.15
Cadmium	ND	ND	39	510	39
Chromium IV	6.2 – 11.1	6.2	390	5,100	390
Cobalt	1.1 B – 1.7 B	1.4 B	NA	180,000	NA
Copper	3.9 B – 33.7	12.5	NA	38,000	2,900
Lead	36.1 – 304	67	500 (b)	NA	NA
Manganese	11.9 – 53.6	35.2	NA	5,100	390
Mercury (inorganic)	0.12 – 0.34	ND	23	310	23
Nickel	12.8	ND	1,600	20,000 (c)	1,600
Silver	ND	ND	NA	5,100	390
Sodium	12.4 B – 97 B	132 B	NA	NA	NA
Vanadium	4.3 B – 10.6	7 B	NA	7,200	550
Zinc	26.3 – 130	16.7	NA	310,000	23,000

Units in mg/kg.

B – For unvalidated organic analyses, this qualifier indicates that the constituent was also detected in a laboratory method blank.
For inorganic analyses, this laboratory qualifier indicates the result was detected below the specified Contract Required Detection Limit.
J – Indicates an estimated value.
NA – Not Available
ND – Not Detected
(a) Arsenic as a carcinogen.
(b) OSWER Directive #9355.4-02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, USEPA Office of Solid Waste and Emergency Response, 1989.
(c) Nickel as soluble salts.

Boxing indicates value exceeds criteria.
Bold indicates value exceeds SSLs.
Shading indicates value exceeds Region III criteria.

SOURCES:

Chester Environmental, 1994. Preliminary Site Characterization Summary – Calhoun Park Area Site RI/FS. Project No. 371902-05, April 1994.

USEPA, 1993. Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response, September 1993.

EPA Region III Risk-Based Concentration Table, Third Quarter, 1994. July 11, 1994.

developed according to USEPA guidelines for the development of preliminary remediation goals (USEPA, 1991) and utilize USEPA default values for industrial and residential exposures to soils.

Several assumptions were used in the development of the Region III Risk-based Concentrations and draft SSLs which may differ from exposures occurring during construction. The industrial scenario used to develop the Region III industrial soil criteria assumes an exposure duration of 25 years for 250 working days per year. Both the Draft SSL and Region III residential exposure scenarios for exposure to carcinogens in soil assumes an exposure duration of 30 years for 350 days per year. The exposure scenario for residential exposure to noncarcinogens in soil are based on soil ingestion by child aged one to six years because, typically, young children ingest soil at a greater rate than residential adults. During excavation activities, construction workers may be potentially exposed to site soils for a short exposure duration (one year or less), but at a greater daily rate than the residential rate used to calculate the Region III or SSL criteria for soils.

The applicability of the Region III criteria and draft SSLs is limited by certain factors. Construction workers will have subchronic or short-term exposures, while the criteria assume long-term or chronic exposures. Region III values are based on soil ingestion and do not address dermal absorption or inhalation exposure pathways. SSLs address soil ingestion and inhalation exposures, but do not address dermal absorption exposures. Neither of the criteria address ecological health concerns, so sediment criteria protective of estuarine life will also be compared to soil concentrations.

Construction workers can utilize protective clothing and proper hygiene (i.e., hand washing) to limit exposure to soils and sediments. Limiting exposures by the use of protective clothing and proper hygiene are not addressed by the Region III or SSLs criteria.

2.5 BACKGROUND CONCENTRATIONS

Investigations at the Calhoun Park Area site and the NPS property included the collection of background samples for soil, surface water, sediment, and groundwater (Chester Engineering, 1994; PSI, 1994). Analytical data for these samples were included in the screening criteria tables after eliminating background samples with outlier points. Location maps are included in the Chester Engineering Report (1994) and in the PSI Report (1994).

Background surface soil data (zero to one foot) includes data from locations BM-01D-A, BS-01A, BS-02A, and BS-03A. The sample from location BM-02A-A appeared to have several data points beyond the range of background and was not included in the Law background data set.

Subsurface background values are taken from sample BM-02A-B. The other subsurface background sample, BM-01D-B, contained elevated PAH and metal levels and was discounted by Law as a background sample (Chester, 1994). Background results for surface and subsurface soils are presented in Table 2-3.

The range for the background groundwater data is based results from locations BG-01A (and its duplicate, BG-101A-dup), BG-01D, and BG-02A. These locations included two shallow and one sand aquifer monitoring well. Data were combined, although the sand aquifer values are generally lower (Chester, 1994). Background results for ground water are presented in Table 2-1.

Both PSI (1994) and Chester (1994) collected background surface water and sediment samples. Sample locations for surface water (SW) and sediments (SD) included SW/SD-18, SW/SD-19, NPS-SW/SD-07, NPS-SW/SD-08, and NPS-SW/SD-09. Background results for surface water are presented in Table 2-1. Background sediment results are presented in Table 2-2.

2.6 CONCLUSION

The chemical-specific risk-based criteria cited in this document are appropriate for the initial evaluation of site data when identifying potential constituents and media of concern. These criteria may serve to indicate if the site needs further evaluation for potential human or ecological risks. The criteria may also be used to indicate potential concerns for the property owner in leasing the tract to the City of Charleston without containment or remedial action.

In the case that exceedances of the criteria are detected, the criteria are not intended to serve as cleanup goals or as a substitute for a baseline risk assessment. Because the criteria are chemical-specific, cumulative effects for exposure to multiple chemicals and multiple media are not addressed by a direct comparison of site concentrations to the criteria presented in this document.

3.0 REFERENCES

Chester Environmental, Inc., 1993. Appendix E, Tabulation of Existing Analytical Data, National Park Service Property from: November 1992 Expanded Site Inspection Report, General Engineering Laboratories.

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