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DRAFT FINAL
FEASIBILITY STUDY

SITE 7: AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CONTRACT TASK ORDER 0247

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1.0 INTRODUCTION

This Report presents the results of a Feasibility Study (FS) at the Amphibious Base Landfill at the Naval Amphibious Base Little Creek (NAB Little Creek), in Virginia Beach, Virginia as part of the Installation Restoration (IR) Program. The landfill is also referred to as IR Site 7 and will hereafter be referred to as "Site." Figure 1-1 provides the location of NAB Little Creek. Figure 1-2 indicates the location of the Site. The following sections describe the site background and related information leading to the objectives for this FS.

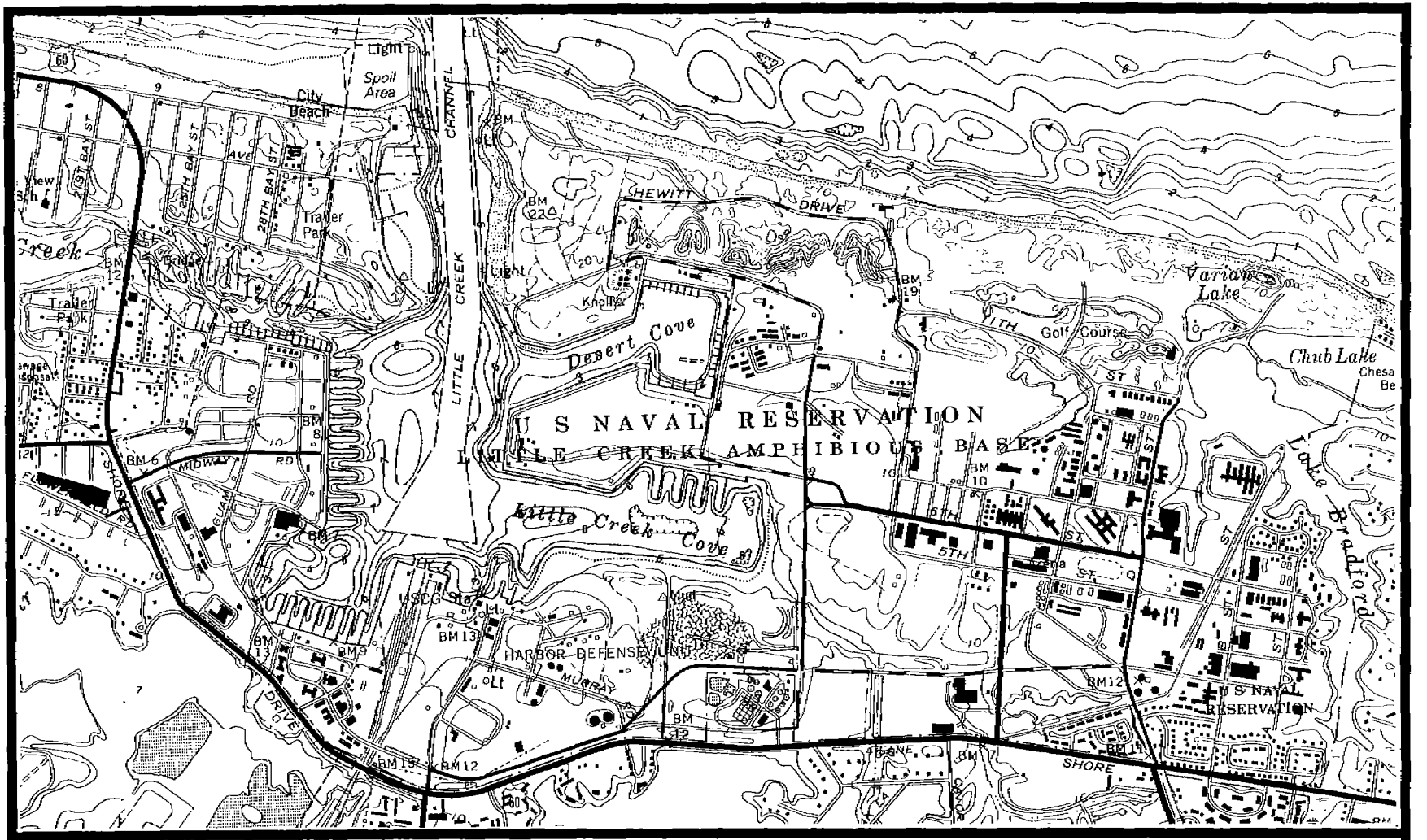
1.1 Site Background

NAB Little Creek, located in Virginia Beach, Virginia, provides logistic facilities and support services for local commands, organizations, homeported ships, etc., to meet the amphibious warfare training requirements of the Armed Forces of the United States. The facility is adjacent to the city line of Norfolk. The area surrounding this 2,147-acre facility is low lying and relatively flat with several fresh water lakes. Chubb Lake, Lake Bradford, Little Creek Reservoir/Lake Smith, and Lake Whitehurst are located on, or adjacent to, the facility.

NAB Little Creek was commissioned on July 30, 1945 by combining four contiguous activities. The Navy began purchasing land in the area from private estates and the Pennsylvania Railroad just prior to the outbreak of World War II. The first activity to be commissioned was the Amphibious Training Base in the southwestern corner of the present base near Little Creek Harbor. The base's mission was the training of landing craft personnel for operational assignments. Over the last fifty years, NAB Little Creek has expanded in both area and the complexity of its mission (PSI, 1991).

Environmental investigations at 17 sites were initially documented in the Initial Assessment Study (IAS). The IAS was completed in December 1984 by Rogers, Golden, and Halpern, of Philadelphia, Pennsylvania. In 1975, the Department of Defense initiated a program to investigate past disposal sites at military installations. This program, the Navy Assessment and Control of Installation Pollutants (NACIP), called for a three-phase operation. Phase One was the IAS to identify potentially contaminated areas. Phase Two was the Confirmation Study to verify and/or characterize the contamination. Phase Three includes the Remedial Action. The program was changed in 1986 to reflect the requirements of the Superfund Amendment and Reauthorization Act (SARA) and is now called the Installation Restoration Program (IRP).

NAB Little Creek is located in the Atlantic Coastal Plain physiographic province in southeastern Virginia. This portion of Virginia is also referred to as the Hampton Roads Area. The facility is bounded on the north by Chesapeake Bay, the east by Lake Bradford, and the south by Shore Drive. The facility's western boundary stretches over the Norfolk-Virginia Beach border. The central portion of the base is composed of Little Creek Cove, Desert Cove, and the Little Creek channel that connects with Chesapeake Bay. All of the installation lies within the jurisdictional boundary of Virginia Beach (Interim Remedial Investigation (IRI) 1991). Land use at the base is primarily industrial, while land development surrounding the site is suburban and industrial.



VIRGINIA

QUADRANGLE LOCATION

LITTLE CREEK AMPHIBIOUS BASE
VIRGINIA BEACH, VIRGINIA
SITE LOCATION MAP

Little Creek, VA Quadrangle
7.5 Minute Series (Topographic)

MN GN
8½° 151 MILS
0°43' 13 MILS

UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Prepared by:
Foster Wheeler Environmental Corporation

Figure 1-1
Scale: 1" = 2000'

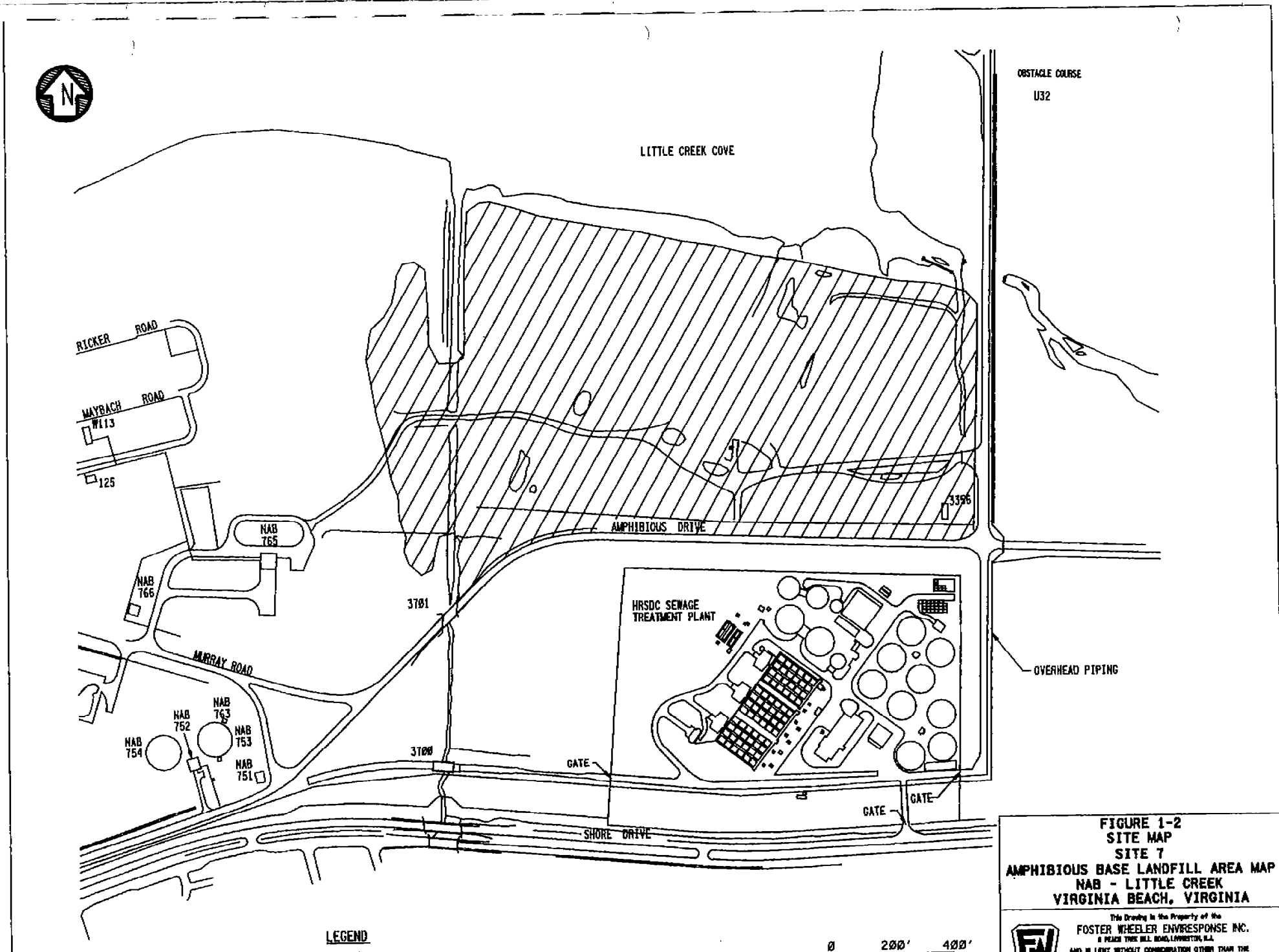


FIGURE 1-2
SITE MAP
SITE 7
AMPHIBIOUS BASE LANDFILL AREA MAP
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

NAB Little Creek has low subdued relief. Elevations at NAB Little Creek range from mean sea level along the Chesapeake Bay and Little Creek Cove to elevations as high as 40 feet above mean sea level at some of the larger dunes along the Bay. The average elevation of the facility is 10 feet above mean sea level. The primary surface features of the Hampton Roads Area are many rivers, lakes, and marshy areas (IRI, 1991).

1.2 Site Description

The site, shown on Figure 1-2, is located in the south-central portion of the installation. The area is bounded on the north by the southeast shoreline of Little Creek Cove, on the east by Helicopter Road, on the south by Amphibious Drive and the Hampton Roads Sanitation District (HRSD) treatment plant, and on the west by a relatively undeveloped area recently used for the construction of an ordnance storage area. The Amphibious Base Landfill was originally thought to cover 50 acres; however, as part of this Remedial Investigation/Feasibility Study (RI/FS) investigation, it has been determined through a review of historical aerial photographs and the HRSD treatment plant construction boring logs which show no indication of waste, debris, or contamination south of Amphibious Drive, that the areal extent of the landfill is approximately 38 acres. The area was originally an arm of Little Creek Cove which was filled with dredge spoils prior to its use as a landfill. A chain link fence borders the landfill to the south and east, and Little Creek Cove borders the northern side of the site. Locked gates control access to the site.

According to the IAS, the landfill operated from 1962 to 1979, spanning the period during which land disposal changed from an acceptable to an unacceptable technology for many chemicals and other materials. Before its use as a landfill, the site was used for the disposal of spoils from the dredging of Little Creek Cove. Some of the original dikes built to contain the dredging spoils are still visible in the northeast corner of the landfill area.

The Amphibious Base Landfill was initially operated as a trench-type landfill with open burning of refuse in the trenches. The trenches were excavated to the depth at which groundwater filled the trench as fast as it could be excavated. Standing water in the trenches was common. Cover was applied as necessary to maintain traction for the vehicles involved in the operations. For a landfill operated in this manner, it is difficult to establish the degree of combustion or the fate of any particular item disposed. Remaining evidence of the trenches is easily seen along the southern edge of the area. The fence line along Amphibious Drive has settled along with the ground surface as the wastes in the trenches have become more compacted than the adjacent soils. The landfill was later operated as an area landfill, with refuse spread over the ground surface and covered on a regular basis. This aspect of the operation has brought the surface elevation up to its present level.

The IAS estimated that the landfill contains approximately 500,000 cubic yards of waste. Of this total, a significant majority is probably comprised of non-hazardous solid waste from base housing and other residential activities at the installation. Specific records concerning the types and quantities of waste placed in the Amphibious Base Landfill are not available. Because the landfill was the recipient of all the wastes produced at NAB Little Creek, it most likely received potentially hazardous materials.

Waste oils and metals segregated from the wastes were placed in the landfill starting in 1970. However, a hazardous waste management plan was not implemented until 1979, the year in which the landfill was

closed. After closure, the landfill area continued to be used as a metal collection and transfer site, temporary storage for wastes, and burn area for scrap wood and trees. Currently, there is no metal collection, transfer activity or temporary storage of construction debris and miscellaneous rubble occurring on site. The waste storage activities were moved in the early 1980s and open burning was halted in 1984. The Navy does not currently intend to build on the landfill, thereby eliminating potential exposure to the subsurface soils by intrusive activities. If construction at the site is desired in the future, further evaluation of the subsurface conditions, including delineation of extent and detailed characterization of the landfill, would be required.

The landfill was constructed so that the central portion is comprised of a broad flat area bounded by gentle slopes on all sides. Most of the waste has been covered with soil and very little remains visible on the surface. The area bordering Little Creek Cove is well vegetated, with numerous trees and tall grasses. Most recently, the appearance of the landfill ranged from well-vegetated on the western portion to exposed, unvegetated soil in the central and eastern portions. In October 1994, a two to three inch topsoil cover was spread on all open areas of the landfill and the area was seeded to promote vegetative growth.

1.3 Previous Investigations

The IAS recognized that almost every type of waste generated at the base was received at the Amphibious Base Landfill. It was recommended that nine groundwater monitoring wells, fully penetrating the uppermost water-bearing zone, be installed around the perimeter of the landfill. Two groundwater level monitoring points were recommended for installation into the landfill itself. Two surface water samples also were recommended, along with a detailed reconnaissance of the landfill to identify any visible signs of contamination and establish the boundaries of the disposal area. Concerns of the IAS included the delineation of the landfill, especially the southern boundary, and its closest approach to Lake Smith Reservoir. These recommendations, with slight changes, became the scope of work for the Round 1 Verification Step (RVS).

The RVS at the site, the first step in the Confirmation Study process, was completed in October 1986. The purpose of the study was to verify the presence and/or absence of contamination at the site recommended in the IAS for a Confirmation Study. Samples collected during this phase included nine groundwater samples from monitoring wells, five surface water samples, and five sediment samples.

Volatile organic compounds (VOCs) were not detected in any of the groundwater samples. Base neutral compounds were detected at low levels in three monitoring wells. Acid extractable compounds and pesticides/PCBs were also not detected in the groundwater samples. Low levels of several metals, including cadmium, total chromium, selenium, silver, thallium, and zinc, were detected in all of the groundwater samples. Oil and grease also were detected in all nine groundwater samples at levels ranging from 3,000 parts per billion (ppb) to 47,000 ppb.

VOCs were not detected in any of the surface water samples, but low levels were detected in all of the sediment samples. Base neutral compounds were only detected in two sediment samples, while acid extractable compounds were only detected in two surface water samples. Pesticides/PCBs were detected in two sediment samples. Low levels of metals were detected in all of the surface water and sediment

samples except one. Oil and grease also were detected in all ten surface water and sediment samples at levels ranging from 297 ppb to 20,000 ppb.

The RVS report suggested that little or no contamination was leaving the landfill at that time, although the source of low level concentrations of some contaminants in the cove was not determined. The RVS recommended a second round of samples be collected from the nine monitoring wells and five surface water locations. Also, three additional surface water samples should be collected further from the landfill shoreline and one surface water sample from the drainage east of the landfill to assist in determining the source of the surface water contamination.

The IRI was conducted to determine whether or not further characterization activities or remedial action was warranted at Site 7 in December 1990 and January 1991. Additional and expanded sampling was performed in order to confirm the results obtained in the RVS. Samples collected during this phase included eight groundwater samples from monitoring wells, and nine surface water samples.

VOCs were not detected in any of the groundwater samples. Base neutral and acid extractable compounds were only detected in one sample, with a level of 3 micrograms per liter (μg/l) for naphthalene. Pesticides/PCBs and total petroleum hydrocarbons (TPH) were not detected in any of the groundwater samples. Total organic carbon (TOC) and total organic halogens (TOX) were detected in seven of the groundwater samples. Anions, including chloride, sulfate, and alkalinity, were detected in eight of the groundwater samples. Unfiltered samples for metals analysis were collected from all eight monitoring wells, and filtered samples were collected from three of the wells in March 1991. Metals were detected in all of the unfiltered and filtered groundwater samples at low concentrations.

VOCs, base neutral and acid extractable compounds, pesticides/PCBs, and TPH were not detected in any of the surface water samples. TOC and TOX were detected in five of the surface water samples. Anions, including chloride, sulfate, and alkalinity, were detected in all nine of the surface water samples. Unfiltered samples for metals analysis were collected from all of the surface water locations, and filtered samples were collected from two of the surface water locations. Metals were detected in all of the unfiltered and filtered surface water samples.

Based on the results of the RVS and IRI, the IRI report concluded that the landfill was not releasing contaminants to the groundwater and additional characterization or remediation was not warranted. The IRI recommended that the status of the landfill, with regard to Virginia regulations, be determined. Also, in order to complete a risk assessment, a limited program of soil sampling should be performed in the bare areas formerly used for staging.

A Remedial Investigation (RI) and sampling activities were conducted at the site by Foster Wheeler Environmental Services from May to July 1993. Samples collected during this phase included eight surface soils, five subsurface soils, nine groundwater, six surface water, and six sediment samples. The samples were analyzed by Ceimic Laboratories of Pittsburgh, Pennsylvania and the results were validated by Heartland Environmental Services of St. Peters, Missouri.

The results of the analysis were checked against the applicable criteria. The subsurface soil, surface soil, and sediment sample results have been compared to the soil concentrations listed in the United States Environmental Protection Agency (EPA) Region III Risk-Based Concentration (RBC) Table for residential

soils, January 1994. These RBCs were used as Data Screening Concentrations (DSCs) for this RI/FS. The EPA Region III RBC Table is contained in Appendix K of the 1994 RI/FS report. The groundwater sample results have been compared to both the Federal Maximum Contaminant Levels (MCLs), promulgated under the Safe Drinking Water Act (SDWA) in May 1993, and the Virginia State Water Control Board (VSWCB) Water Quality Standards (WQSs), May 1992. The MCLs include both the primary and secondary standards. The Federal MCLs and VSWCB WQSs have been applied to surface water sample results for comparison purposes only, since the Little Creek site is tidally influenced and brackish. The Federal and Virginia State Water Quality Standards are contained in Appendix L of the 1994 RI/FS report. In addition, groundwater results have been compared with background concentrations prior to chemicals of concern (COC) determination. The chemicals which were detected above the applicable criteria are presented in Tables 1-1 through 1-13 and are summarized below.

Surface Soils

Elevated PCBs (Aroclor-1260) were identified in two surface soil samples at concentrations of 920 and 3,500 micrograms per kilogram (μg/kg), respectively. These concentrations exceed the EPA DSC of 83 μg/kg for PCBs in soil. The occurrence of PCBs in the surface soil is random and displays no clear pattern of deposition. Benzo (a) pyrene exceeded its DSC of 88 μg/kg in one sample.

Elevated levels of aluminum, iron, lead, manganese, and zinc have been observed at various locations. In addition, low levels of arsenic, cadmium, chromium, cobalt, copper, and nickel have also been observed.

Subsurface Soils

A number of Target Analyte List (TAL) metals were detected in the subsurface soils. Of these, only beryllium and lead exceed their EPA DSCs. Iron and aluminum were detected at somewhat elevated concentrations. It should be noted that no subsurface samples were taken from the center of the landfill; only peripheral areas were investigated to evaluate the potential impact. Therefore, the investigative results do not represent the chemicals which might have historically been disposed in the landfill.

Groundwater

Total and dissolved TAL metals were the only analytes above their respective standards detected in groundwater. Elevated aluminum, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, and nickel exceed the primary or secondary MCLs. Barium exceeds the drinking water health advisory reference dose (RfD). Dissolved TAL metals, above their respective primary or secondary MCLs, include iron, manganese, and zinc.

Surface Water

Total TAL metals were the only analytes above their respective standards in the surface water. TAL metals above their respective primary or secondary MCLs include lead and manganese. Aluminum, arsenic, barium, and copper have been consistently detected at elevated levels. Iron has exceeded its WQSs of 300 μg/L in all surface water samples; but this is considered to be the background concentration for the site. Zinc exceeds its WQS of 50 μg/L in two samples at concentrations of 55.30 and 70.50 μg/L, respectively.

TABLE 1-1

SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN SURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
MAY 13, 1993

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-SS-101 Soil ug/kg	07-SS-102 Soil ug/kg	07-SS-109 (Duplicate 07-SS-102) Soil ug/kg	07-SS-103 Soil ug/kg	07-SS-104(1) Soil ug/kg	07-SS-105 Soil ug/kg
VOLATILE ORGANIC COMPOUNDS (VOCs):						
Methylene Chloride	ND	6 J	ND	ND	ND	ND
Acetone	ND	ND	11	ND	ND	12
TOTAL VOCs:	ND	6 J	11	ND	ND	12
TOTAL TICs:	ND	ND	ND	ND	ND	35 J

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-SS-106 Soil ug/kg	07-SS-107 Soil ug/kg	07-SS-108 Soil ug/kg	Trip Blank-3 Water ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):				
Methylene Chloride	ND	ND	ND	ND
Acetone	ND	ND	ND	ND
TOTAL VOCs:	ND	ND	ND	ND
TOTAL TICs:	ND	ND	ND	ND

NOTES:
ND indicates compound was not detected
ug/kg indicates micrograms per kilogram
ug/L indicates micrograms per liter
J indicates an estimated value.
TICs indicates tentatively identified compounds
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.

TABLE 1-2

SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS
DETECTED IN SURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
MAY 13, 1993

SAMPLE LOCATION/NUMBER	07-SS-101	07-SS-102	07-SS-109 (Duplicate 07-SS-102)	07-SS-103	07-SS-104(1)
SAMPLE MATRIX	Soil	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs):					
2-Methylnaphthalene	ND	ND	ND	ND	ND
Fluorene	60 J	ND	ND	ND	ND
Phenanthrene	830	ND	ND	ND	ND
Anthracene	220 J	ND	ND	ND	ND
Fluoranthene	1,300	ND	ND	ND	ND
Pyrene	1,600	ND	ND	62 J	52 J
Butylbenzylphthalate	58 J	ND	ND	ND	ND
Benzo (a) anthracene	710	ND	ND	ND	ND
Chrysene	390	ND	ND	ND	ND
bis (2-Ethylhexyl) phthalate	150 J	ND	58 J	120 J	140 J
Benzo (b) fluoranthene	510	ND	ND	ND	ND
Benzo (k) fluoranthene	380	ND	ND	ND	ND
Benzo (a) pyrene	450	ND	ND	ND	ND
Indeno (1,2,3-cd) pyrene	230 J	ND	ND	ND	ND
Benzo (g,h,i) perylene	210 J	ND	ND	ND	ND
TOTAL SVOCs:	7,098 J	ND	58 J	182 J	192 J
TOTAL TICs:	1,444 J	962 J	640 J	1,718 J	1,508 J

SAMPLE LOCATION/NUMBER	07-SS-105	07-SS-106	07-SS-107	07-SS-108
SAMPLE MATRIX	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs):				
2-Methylnaphthalene	ND	ND	62 J	ND
Fluorene	ND	ND	ND	ND
Phenanthrene	190 J	39 J	52 J	ND
Anthracene	51 J	ND	ND	ND
Fluoranthene	240 J	76 J	46 J	ND
Pyrene	250 J	88 J	120 J	ND
Butylbenzylphthalate	ND	ND	ND	ND
Benzo (a) anthracene	110 J	ND	ND	ND
Chrysene	82 J	ND	ND	ND
bis (2-Ethylhexyl) phthalate	56 J	190 J	180 J	47 J
Benzo (b) fluoranthene	100 J	ND	ND	ND
Benzo (k) fluoranthene	ND	ND	ND	ND
Benzo (a) pyrene	57 J	ND	ND	ND
Indeno (1,2,3-cd) pyrene	ND	ND	ND	ND
Benzo (g,h,i) perylene	ND	ND	ND	ND
TOTAL SVOCs:	1,136 J	393 J	460 J	47 J
TOTAL TICs:	430 J	431 J	6,568 J	1,990 J

NOTES:

ND indicates compound was not detected.
ug/kg indicates micrograms per kilogram.
J indicates an estimated value.
TICs indicates tentatively identified compounds.
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
Equipment rinsate and field blank in common with Site 11.

TABLE 1-3

SUMMARY OF PESTICIDES AND PCBs
DETECTED IN SURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
MAY 13, 1993

SAMPLE LOCATION/NUMBER	07-SS-101	07-SS-102	07-SS-109 (Duplicate 07-SS-102)	07-SS-103	07-SS-104(1)	07-SS-105
SAMPLE MATRIX	Soil	Soil	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PESTICIDES						
4,4'-DDT	ND	ND	ND	3.8 J	ND	ND
alpha-Chlordane	ND	ND	ND	5.1 J	ND	ND
PCBs:						
Aroclor-1260	ND	ND	ND	ND	920	ND
TOTAL PCBs:	ND	ND	ND	ND	920	ND

SAMPLE LOCATION/NUMBER	07-SS-106	07-SS-107	07-SS-108
SAMPLE MATRIX	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg
PESTICIDES			
4,4'-DDT	ND	ND	ND
alpha-Chlordane	ND	ND	ND
PCBs:			
Aroclor-1260	130 J	3,500 J	ND
TOTAL PCBs:	130 J	3,500 J	ND

NOTES:
ND indicates compound was not detected.
ug/kg indicates micrograms per kilogram.
J indicates an estimated value.
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
Equipment rinsate and field blank in common with Site 11.

TABLE 1-4

SUMMARY OF TAL METALS AND CYANIDE
DETECTED IN SURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
MAY 13, 1993

SAMPLE LOCATION/NUMBER	07-SS-101		07-SS-102		07-SS-109 (Duplicate 07-SS-102)		07-SS-103		07-SS-104(1)		07-SS-105	
SAMPLE MATRIX	Soil		Soil		Soil		Soil		Soil		Soil	
UNITS	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	
TAL METALS AND CYANIDE:												
Aluminum	3,410		3,650		3,320		4,970		6,240		3,850	
Arsenic	2.2		0.86	B	1.9		2.0		2.3		1.2	B
Barium	12.1	B	20.0	B	15.0	B	44.4		93.9		11.3	B
Beryllium	ND		ND		ND		0.65	B	0.43	B	ND	
Cadmium	ND		ND		ND		ND		1.4		ND	
Calcium	843	J	541	J	585	J	2,450		2,120		162	B
Chromium	8.3		6.8		6.5		11.3		26.5		4.6	
Cobalt	1.4	B	0.75	B	0.80	B	6.1	B	5.9	B	ND	
Copper	32.8	J	4.5	J	5.0	J	68.0	J	78.2	J	5.2	J
Iron	6,290	J	4,360	J	5,420	J	10,200	J	14,800	J	3,040	J
Lead	24.1	J	47.8	J	38.6	J	58.0	J	638	J	5.5	J
Magnesium	799	J	502	J	567	J	2,320		3,210		251	B
Manganese	50.8	J	33.8	J	55.0	J	184	J	470	J	18.1	J
Mercury	ND		ND		ND		ND		ND		ND	
Nickel	6.8	B	4.3	B	ND		16.1		18.0		ND	
Potassium	563	J	362	J	383	J	2,080		2,970		236	B
Sodium	ND		ND		ND		227	B	ND		ND	
Vanadium	202		9.3		10.1		39.5		36.7		7.8	B
Zinc	64.2		23.3		25.0		405		320		12.6	
Cyanide	ND		ND		ND		ND		ND		ND	

NOTES:

ND indicates compound was not detected.
mg/kg indicates milligrams per kilogram.
B indicates compound detected in lab blank.
J indicates an estimated value.
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
Equipment rinsate and field blank in common with Site 11.

TABLE 1-4 (CONTINUED)

SUMMARY OF TAL METALS AND CYANIDE
DETECTED IN SURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
MAY 13, 1993

SAMPLE LOCATION/NUMBER	07-SS-106		07-SS-107		07-SS-108	
SAMPLE MATRIX UNITS	Soil mg/kg		Soil mg/kg		Soil mg/kg	
TAL METALS AND CYANIDE:						
Aluminum	2,510		2,200		2,880	
Arsenic	1.6	B	2.1		3.5	
Barium	8.8	B	25.1	B	11.4	B
Beryllium	0.23	B	0.47	B	ND	
Cadmium	ND		ND		0.65	B
Calcium	483	J	2,100		206	J
Chromium	4.8		9.2		9.5	
Cobalt	0.91	B	1.5	B	1.1	B
Copper	8.8	J	20.9	J	7.7	J
Iron	3,550	J	3,460	J	7,330	J
Lead	7.6	J	98.9	J	18.8	J
Magnesium	419	J	362	J	630	J
Manganese	29.4	J	26.4	J	26.1	J
Mercury	ND		ND		0.07	B
Nickel	7.3		10.4		3.4	B
Potassium	400	J	277	B	762	J
Sodium	ND		ND		262	B
Vanadium	7.4	B	10.5		13.4	
Zinc	41.3		95.2		17.6	
Cyanide	ND		ND		ND	

NOTES:

ND indicates compound was not detected.
mg/kg indicates milligrams per kilogram.
B indicates compound detected in lab blank.
J indicates an estimated value.
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
Equipment rinsate and field blank in common with Site 11.

TABLE 1-5

SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN SUBSURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 14-16, 1993

SAMPLE LOCATION/NUMBER	07-SB-101D	07-SB-103D	07-SB-110 (Duplicate 07-SB-103D)	07-SB-105D(1)	07SB6D	07SB9D
SAMPLE MATRIX	Soil	Soil	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
VOLATILE ORGANIC COMPOUNDS (VOCs):						
Methylene Chloride	3 J	ND	ND	ND	ND	ND
Acetone	56 J	79	80	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND
2-Butanone	9 J	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	7 J	ND	ND
TOTAL VOCs:	68 J	79	80	7 J	ND	ND
TOTAL TICs:	ND	ND	ND	ND	ND	ND

SAMPLE LOCATION/NUMBER	07-ERB-05	07-ERB-06	07-ERB-07	07-FB-05	07-TB-06 7/14/93	07-TB-07 7/16/93
SAMPLE MATRIX	Water	Water	Water	Water	Water	Water
UNITS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):						
Methylene Chloride	6 J	ND	ND	6 J	5 J	ND
Acetone	14 B	21 B	ND	15 B	ND	ND
Chloroform	ND	4 J	4 J	ND	ND	ND
2-Butanone	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND
TOTAL VOCs:	20 JB	25 JB	4 J	21 JB	5 J	ND
TOTAL TICs:	ND	30 J	ND	ND	ND	22 J

NOTES:
ND indicates compound was not detected.
ug/kg indicates micrograms per kilogram.
ug/L indicates micrograms per liter.
B indicates compound detected in lab blank.
J indicates an estimated value.
D indicates sample taken in deep boring. All samples taken above water table.
TICs indicates tentatively identified compounds.
(1) indicates a matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
ERB indicates equipment rinsate blank
FB indicates field blank
TB indicates trip blank

TABLE 1-6

SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS
DETECTED IN SUBSURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 14-16, 1993

SAMPLE LOCATION/NUMBER	07-SB-101D	07-SB-103D	07-SB-110 (Duplicate 07-SB-103D)	07-SB-105D(1)	07SB6D
SAMPLE MATRIX	Soil	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs):					
1,4-Dichlorobenzene	ND	38 J	ND	ND	ND
bis (2-Ethylhexyl) phthalate	ND	ND	ND	ND	100 J
TOTAL SVOCs:	ND	38 J	ND	ND	100 J
TOTAL TICs:	1,830 J	228 J	154 J	260 J	73 J

SAMPLE LOCATION/NUMBER	07SB9D	07-ERB-05	07-ERB-06	07-ERB-07	07-FB-05
SAMPLE MATRIX	Soil	Water	Water	Water	Water
UNITS	ug/kg	ug/L	ug/L	ug/L	ug/L
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs):					
1,4-Dichlorobenzene	ND	ND	ND	ND	ND
bis (2-Ethylhexyl) phthalate	ND	ND	1 J	ND	ND
TOTAL SVOCs:	ND	ND	ND	ND	ND
TOTAL TICs:	198 J	10 J	9 J	18 J	12 J

NOTES:

ND indicates compound was not detected.
ug/kg indicates micrograms per kilogram.
ug/L indicates micrograms per liter.
J indicates an estimated value.
TICs indicates tentatively identified compounds.
D indicates sample taken in deep boring. All samples taken above water table.
(1) indicates a matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
ERB indicates equipment rinsate blank
FB indicates field blank

TABLE 1-7

SUMMARY OF TAL METALS AND CYANIDE
DETECTED IN SUBSURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 14-16, 1993

SAMPLE LOCATION/NUMBER	07-SB-101D		07-SB-103D		07-SB-110 (Duplicate 07-SB-103D)		07-SB-105D		07SB6D	
SAMPLE MATRIX	Soil		Soil		Soil		Soil		Soil	
UNITS	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	
TAL METALS AND CYANIDE:										
Aluminum	6,130		18,900		18,700		13,500		2,830	
Antimony	R		R		R		R		R	
Arsenic	3.4	J	1.3	J	1.3	J	5.1	J	2.4	J
Barium	15.0	B	46.1		43.3		28.6	B	7.6	B
Beryllium	0.27	B	0.31	B	0.28	B	0.33	B	0.44	B
Cadmium	1.9	J	1.0	J	2.2		1.5	J	1.1	J
Calcium	418	B	257	B	279	B	402	B	425	B
Chromium	9.7		15.8		18.7		18.8		5.5	
Cobalt	2.3	B	3.1	B	3.4	B	3.0	B	2.6	B
Copper	4.0	B	4.8	B	5.6		6.9		2.6	B
Iron	8,530		11,200		12,000		13,000		4,860	
Lead	6.4	J	8.4	J	7.5	J	5.6	J	3.5	J
Magnesium	1,440		834	J	805	J	952	J	752	J
Manganese	48.9		42.1		43.9		24.8		44.5	
Mercury	ND		0.07	B	ND		ND		ND	
Nickel	5.3	B	8.1	B	6.9	B	5.2	B	5.4	B
Potassium	922		556	B	592	B	639	B	496	B
Sodium	287	B	140	B	139	B	210	B	ND	
Vanadium	10.8		21.7		24.0		21.8		5.3	B
Zinc	17.6		16.6		16.9		15.5		27.8	
Cyanide	ND		ND		ND		ND		ND	

NOTES:
ND indicates compound was not detected
mg/kg indicates milligrams per kilogram
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value.
R indicates data rejected and unusable.
D indicates sample taken from deep boring. All samples taken above water table.
ERB indicates equipment rinsate blank
FB indicates field blank

TABLE 1-7 (CONTINUED)

SUMMARY OF TAL METALS AND CYANIDE
DETECTED IN SUBSURFACE SOIL SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 14-16, 1993

SAMPLE LOCATION/NUMBER	07SB9D		07-ERB-05		07-ERB-06		07-ERB-07	07-FB-05
SAMPLE MATRIX	Soil		Water		Water		Water	Water
UNITS	mg/kg		ug/L		ug/L		ug/L	ug/L
TAL METALS AND CYANIDE:								
Aluminum	4,320		ND		ND		ND	ND
Antimony	R		R		R		R	R
Arsenic	1.9	J	ND		R		R	ND
Barium	5.4	B	3.0	B	R		R	ND
Beryllium	0.42	B	ND		R		R	ND
Cadmium	1.1	J	ND		R		R	ND
Calcium	218	B	ND		R		R	ND
Chromium	4.7		ND		R		R	ND
Cobalt	5.1	B	ND		R		R	ND
Copper	2.9	B	ND		R		R	ND
Iron	3,730		ND		R		R	ND
Lead	3.9	J	3.2		R		R	ND
Magnesium	636	B	ND		R		R	ND
Manganese	17.4		2.0	B	1.0	B	ND	ND
Mercury	ND		ND		ND		ND	ND
Nickel	8.9		ND		ND		ND	ND
Potassium	477	B	ND		ND		ND	ND
Sodium	1,450		ND		ND		ND	ND
Vanadium	6.1	B	ND		ND		ND	ND
Zinc	58.0		ND		ND		ND	ND
Cyanide	ND		ND		ND		ND	ND

NOTES:
ND indicates compound was not detected
mg/kg indicates milligrams per kilogram
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value.
R indicates data rejected and unusable.
D indicates sample taken from deep boring. All samples taken above water table.
ERB indicates equipment rinsate blank
FB indicates field blank

TABLE 1-8

SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN GROUNDWATER SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1 & 2, 1993

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-GW-101 Water ug/L	07-GW-102 Water ug/L	07-GW-103 Water ug/L	07-GW-104 Water ug/L	07-GW-105 * Water ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):					
Acetone	NA	ND	NA	8 J	ND
TOTAL VOCs:	NA	ND	NA	8 J	ND
TOTAL TICs:	NA	ND	NA	ND	ND

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-GW-106 Water ug/L	07-GW-107 Water ug/L	07-GW-108 Water ug/L	07-GW-109 Water ug/L	07-TB-P2-104 Water ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):					
Acetone	ND	ND	ND	ND	18
TOTAL VOCs:	ND	ND	ND	ND	18
TOTAL TICs:	ND	ND	ND	ND	ND

NOTES:
ND indicates compound was not detected
ug/L indicates micrograms per liter
TB indicates trip blank
NA indicates sample was not analyzed by the laboratory.
J indicates an estimated value.
TICs indicates tentatively identified compounds.
* indicates sample collected on July 29, 1993.
Equipment rinsate and field blank shared with Background Well samples.
Trip Blank, matrix spike/matrix spike duplicate (MS/MSD), and blind duplicate sample for sample 07-GW-105 shared with Site 13.
MS/MSD and blind duplicate sample shared with Site 7 Surface Water samples.

TABLE 1-9

SUMMARY OF TAL TOTAL AND DISSOLVED METALS AND CYANIDE
DETECTED IN GROUNDWATER SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1 & 2, 1993

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-GW-101 Water ug/L		07-GW-102 Water ug/L		07-GW-103 Water ug/L		07-GW-104 Water ug/L		07-GW-105 * Water ug/L		07-GW-106 Water ug/L	
TAL TOTAL METALS AND CYANIDE:												
Aluminum	18,000	J	23,300	J	330,000	J	117	J	4,590	J	7,740	J
Arsenic	8.0	J	50.6		20.5		ND		7.8	J	30.2	
Barium	52.7	B	80.1	B	754		41.9	B	36.2	B	33.7	B
Beryllium	ND		2.7	B	11.0		ND		1.9	B	ND	
Cadmium	ND		8.3		37.6		ND		ND		ND	
Calcium	7,960		42,400		50,300		109,000		125,000		120,000	
Chromium	13.8	J	29.7	J	360		ND		5.9	J	ND	
Cobalt	4.8	B	20.2	B	121		ND		ND		28.3	B
Copper	7.3	B	32.7		226		ND		38.3		4.7	B
Iron	17,600	J	98,300	J	224,000	J	4,800	J	63,000	J	22,300	J
Lead	9.9	J	15.6	J	177	J	ND		20.7	J	4.3	J
Magnesiuim	16,500		8,340		39,400		16,200		108,000		108,000	
Manganese	132		225		1,930		697		1,300		1,170	
Mercury	ND		0.18	B	0.27		ND		ND		ND	
Nickel	ND		ND		176		ND		ND		35.7	B
Potassium	13,300		7,810	J	29,500	J	15,100	J	10,700		20,000	J
Sodium	142,000		50,000		56,900		86,600		208,000		428,000	
Thallium	ND		R		R		R		R		R	
Vanadium	30.5	B	43.2	B	634		ND		ND		ND	
Zinc	42.9		77.4		1,620		ND		ND		37.7	
Cyanide	NA		NA		NA		NA		ND		NA	
TAL DISSOLVED METALS:												
Aluminum	ND		ND		272		ND		19.2	J	ND	
Arsenic	3.2	B	ND		3.4	B	ND		2.5	B	16.1	
Barium	8.1	B	16.8	B	101	B	32.0	B	17.2	B	24.0	B
Beryllium	ND		ND		ND		ND		1.1	B	ND	
Calcium	6,250		44,300		36,200		106,000		124,000		110,000	
Cobalt	3.5	B	6.6	B	24.6	B	ND		ND		ND	
Copper	2.1	B	3.1	B	3.1	B	ND		ND		ND	
Iron	1,070	J	605		8,380		ND		38,300	J	13,400	
Magnesiuim	11,300		7,110		15,000		18,800		111,000		98,900	
Manganese	46.2		129		955		621		1,270		1,070	
Mercury	0.15	B	ND		ND		ND		ND		0.15	B
Nickel	ND		ND		ND		ND		ND		ND	
Potassium	9,730		6,770		11,800		16,400		10,200		18,000	
Selenium	ND		ND		ND		ND		ND		ND	
Sodium	123,000		60,000		54,700		115,000		237,000		403,000	
Vanadium	ND		ND		ND		ND		R		ND	
Zinc	ND		ND		307		ND		ND		ND	

NOTES:

ND indicates compound was not detected
NA indicates compound was not analyzed
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value
R indicates data rejected and unusable
* indicates sample collected on July 29, 1993
ERB indicates equipment rinsate blank
FB indicates field blank
Equipment rinsate and field blank shared with the Background Well samples
Matrix spike/matrix spike duplicate (MS/MSD) and blind duplicate sample for sample 07GW05 shared with Site 13
MS/MSD and blind duplicate sample shared with Site 7 Surface Water samples

TABLE 1-9 (CONTINUED)

SUMMARY OF TAL TOTAL AND DISSOLVED METALS AND CYANIDE
DETECTED IN GROUNDWATER SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1 & 2, 1993

SAMPLE LOCATION/NUMBER SAMPLE MATRIX UNITS	07-GW-107 Water ug/L	07-GW-108 Water ug/L	07-GW-109 Water ug/L	07GWERB Water ug/L	07GWFB Water ug/L
TAL TOTAL METALS AND CYANIDE:					
Aluminum	225 J	929 J	1,060 J	ND	ND
Arsenic	ND	ND	ND	ND	ND
Barium	47.6 B	42.2 B	75.9 B	ND	ND
Beryllium	ND	ND	ND	ND	ND
Cadmium	ND	ND	4.4 B	ND	ND
Calcium	257,000	272,000	283,000	ND	ND
Chromium	ND	ND	ND	ND	ND
Cobalt	ND	ND	3.8 B	ND	ND
Copper	ND	5.9 B	17.7 B	ND	ND
Iron	ND	1,720 J	24400 J	18.9 J	27.6 J
Lead	ND	103 J	ND	ND	ND
Magnesium	380,000	393,000	596,000	ND	ND
Manganese	268	114	754	ND	1.7 B
Mercury	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND
Potassium	153,000 J	143,000 J	220,000 J	ND	ND
Sodium	3,570,000	3,520,000	5,430,000	ND	ND
Thallium	R	R	R	R	R
Vanadium	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND
Cyanide	NA	NA	NA	NA	NA
TAL DISSOLVED METALS:					
Aluminum	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND
Barium	46.2 B	45.0 B	47.6 B	ND	ND
Beryllium	ND	ND	ND	ND	ND
Calcium	255,000	288,000	236,000	ND	ND
Cobalt	ND	ND	ND	ND	ND
Copper	2.8	ND	8.3 B	ND	ND
Iron	ND	ND	9,350	ND	ND
Magnesium	375,000	397,000	520,000	ND	ND
Manganese	258	117	620	ND	ND
Mercury	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND
Potassium	152,000	149,000	192,000	ND	ND
Selenium	ND	2.4 J	ND	ND	ND
Sodium	3,550,000	3,580,000	4,680,000	ND	ND
Vanadium	ND	ND	ND	ND	ND
Zinc	ND	ND	34.9	ND	ND

NOTES:

ND indicates compound was not detected
NA indicates compound was not analyzed
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value
R indicates data rejected and unusable
* indicates sample collected on July 29, 1993
ERB indicates equipment rinsate blank
FB indicates field blank
Equipment rinsate and field blank shared with the Background Well samples
Matrix spike/matrix spike duplicate (MS/MSD) and blind duplicate sample for sample 07GW05 shared with Site 13
MS/MSD and blind duplicate sample shared with Site 7 Surface Water samples

TABLE 1-10

SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN SURFACE WATER SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1, 1993

SAMPLE LOCATION/NUMBER	07-SW-101	07-SW-102	07-SW-103	07-SW-107(1) (Duplicate 07-SW-103)	07-SW-104	07-SW-105	07-SW-106	07-TB-P2-104
SAMPLE MATRIX	Water	Water	Water	Water	Water	Water	Water	Water
UNITS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):								
Acetone	ND	17	15	17	ND	31	ND	18
TOTAL VOCs:	ND	17	15	17	ND	31	ND	18
TOTAL TICs:	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

ND indicates compound was not detected
ug/L indicates micrograms per liter
TICs indicates tentatively identified compounds
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
TB indicates trip blank

TABLE 1-11

SUMMARY OF TAL TOTAL METALS
DETECTED IN SURFACE WATER SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLE
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1, 1993

SAMPLE LOCATION/NUMBER	07-SW-101		07-SW-102		07-SW-103		07-SW-107(1) (Duplicate 07-SW-03)		07-SW-104		07-SW-105		07-SW-106	
SAMPLE MATRIX	Water		Water		Water		Water		Water		Water		Water	
UNITS	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
TAL TOTAL METALS:														
Aluminum	417	J	1,690	J	388	J	1,080	J	735	J	1,210	J	ND	
Arsenic	2.4	B	10.3		ND		ND		9	B	7	B	9.9	B
Barium	17.5	B	36.8	B	28.3	B	34.5	B	24.1	B	34.9	B	20.2	B
Calcium	125,000		86,500		159,000		182,000		51,100		80,500		22,300	
Cobalt	ND		4.7	B	3.4	B	3.4	B	5.6	B	5.1	B	ND	
Copper	ND		14.1	B	5.3	B	6.3	B	8.5	B	6.8	B	ND	
Iron	1,620	J	6,890	J	1,010	J	1,600	J	5,210	J	5,510	J	3,020	J
Lead	ND		5.1	J	ND		ND		50	J	3.2	J	ND	
Magnesium	298,000		190,000		403,000		457,000		37,400		146,000		28,000	
Manganese	156		306		83.9		91.6		322		193		334	
Potassium	109,000	J	72,800	J	155,000	J	181,000	J	15,900	J	54,100	J	8,800	J
Sodium	2,530,000		1,630,000		3,710,000		4,250,000		235,000		1,210,000		184,000	
Thallium	R		R		R		R		R		R		R	
Zinc	ND		55.3		ND		ND		30.8		70.5		ND	

NOTES:

ND indicates compound was not detected
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value.
R indicates data rejected and unusable.
(1) indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.

TABLE 1-12

SUMMARY OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN SEDIMENT SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1, 1993

SAMPLE LOCATION/NUMBER	07-SED-101(1)	07-SED-102	07-SED-103	07-SED-107 (Duplicate 06-SED-103)	07-SED-104
SAMPLE MATRIX	Soil	Soil	Soil	Soil	Soil
UNITS	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
VOLATILE ORGANIC COMPOUNDS (VOCs):					
Methylene Chloride	ND	7 J	ND	ND	ND
Acetone	ND	370 J	ND	ND	ND
Carbon Disulfide	ND	4 J	ND	ND	ND
2-Butanone	ND	65	ND	19	12 J
Toluene	ND	5 J	ND	ND	1 J
TOTAL VOCs:	ND	451 J	ND	19	13 J
TOTAL TICs:	ND	33 J	ND	ND	ND

SAMPLE LOCATION/NUMBER	07-SED-105	07-SED-106	07-SED-RB101	07-TB-P2-104
SAMPLE MATRIX	Soil	Soil	Water	Water
UNITS	ug/kg	ug/kg	ug/L	ug/L
VOLATILE ORGANIC COMPOUNDS (VOCs):				
Methylene Chloride	ND	ND	ND	ND
Acetone	ND	ND	ND	18
Carbon Disulfide	ND	ND	ND	ND
2-Butanone	ND	ND	ND	ND
Toluene	ND	ND	ND	ND
TOTAL VOCs:	ND	ND	ND	18
TOTAL TICs:	ND	ND	ND	ND

NOTES:

ND indicates compound was not detected
ug/kg indicates micrograms per kilogram
ug/L indicates micrograms per liter
J indicates an estimated value.
TICs indicates tentatively identified compounds.
(1) indicates a matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
RB indicates equipment rinsate blank
TB indicates trip blank.

TABLE 1-13

SUMMARY OF TAL METALS AND CYANIDE
DETECTED IN SEDIMENT SAMPLES
AND ASSOCIATED QUALITY CONTROL SAMPLES
SITE 7 - AMPHIBIOUS BASE LANDFILL
NAVAL AMPHIBIOUS BASE - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA
JULY 1, 1993

SAMPLE LOCATION/NUMBER	07-SED-101(1)		07-SED-102		07-SED-103		07-SED-107 (Duplicate 07-SED-103)		07-SED-104		07-SED-105		07-SED-106		07-SED-RB101	
SAMPLE MATRIX	Soil		Soil		Soil		Soil		Soil		Soil		Soil		Water	
UNITS	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		ug/L	
TAL METALS AND CYANIDE:																
Aluminum	3,290		6,520		2,670		2,080		938		1,380		221		ND	
Arsenic	3.9		8.6		2.7		1.8	B	2.9		1.8	B	1.2	B	ND	
Barium	10.0	B	23.8	B	8.4	B	7.0	B	4.3	B	6.3	B	1.6	B	ND	
Beryllium	0.28	B	ND		ND		ND		0.42	B	ND		ND		ND	
Cadmium	2.4		3.1		ND		ND		2.3		ND		ND		ND	
Calcium	479	B	1,120	B	1,500		385	B	214	B	394	B	ND		ND	
Chromium	8.4	J	10.1	J	5.7	J	7.4	J	5.6	J	3.9	J	1.5	J	5.4	B
Cobalt	2.5	J	3.4	J	ND		0.94	J	ND		0.95	J	ND		ND	
Copper	12.3		42.9		11.7		10.1		7.3		17.5		0.89	B	4.9	B
Iron	7,860		14,200		4,850		3,760		10,100		4,030		1,060		ND	
Lead	9.1	J	31.1		9.3	J	7.8	J	4.7	J	12.6	J	1.7	J	ND	
Magnesium	1,240	B	2,680		866	B	867	B	261	B	504	B	78.7	B	ND	
Manganese	30.6		67.2		21.4		17.1		8.9		16.8		2.7	B	2.0	B
Nickel	4.7	B	7.6	B	3.6	B	4.6	B	3.3	B	4.0	B	ND		ND	
Potassium	674	B	1,350	B	487	B	465	B	140	B	274	B	45.3	B	ND	
Silver	0.75	J	ND		ND		ND		ND		ND		ND		ND	
Sodium	2,340		5,160		1,340		2,700		399	B	628	B	299	B	ND	
Vanadium	9.0	B	23.2		5.8	B	5.4	B	10.2		9.1	B	ND		ND	
Zinc	36.8		213		41.2		35.5		29.5		37.2		ND		ND	
Cyanide	ND		ND		ND		ND		ND		ND		ND		ND	

NOTES:

ND indicates compound was not detected
mg/kg indicates milligrams per kilogram
ug/L indicates micrograms per liter
B indicates compound detected in lab blank
J indicates an estimated value.
(1) Indicates matrix spike/matrix spike duplicate (MS/MSD) sample was collected with this sample.
RB indicates equipment rinsate blank

Sediments

Various TAL metals, specifically aluminum, copper, iron, lead, manganese, and zinc, were detected at elevated levels in the site sediments. None of them exceeded EPA DSCs.

Chemicals of Concern

Affected media at the site are surface soils, subsurface soils, groundwater, and surface water. SVOCs and PCBs have been detected in surface soils; TAL metals are the contaminants of concern in surface soils, groundwater, and surface water. TAL metals detected in sediments do not pose any human health risks.

1.4 Nature and Extent of Contamination

The primary landfill materials are the wastes produced at NAB Little Creek including potentially hazardous materials. Waste oils and metals segregated from the wastes were placed in the landfill from 1970 to 1979. The landfill was closed in 1979, and after closure, the landfill area continued to be used as a metal collection and transfer site, temporary storage for wastes, and burn area for scrap wood and trees.

During the RI, mostly metals were detected in the samples collected at the site. Surface and subsurface soil samples were contaminated with elevated levels of metals. Aside from metals, only Aroclor-1260 and benzo(a)pyrene exceeded the DSC in two samples and one sample, respectively. No other contaminants were detected at concentrations exceeding their respective DSCs.

Groundwater and surface water samples were found to contain heavy metals at levels above their respective standards. No other contaminants were detected at concentrations exceeding the DSCs. During the RVS, oil and grease were detected in groundwater and surface water samples.

Various heavy metals were detected in sediment samples, but not at levels exceeding DSCs.

The RI did not identify the extent of contamination, which could provide a remediation target narrower than the entire 38 acres of the landfill. The preliminary FS, which was presented in Section 7.0 of the RI report, calculated a potential volume of 1.2 million cy, using an average fill height of 15 feet. The height was estimated based on the topography and the depth to clay layers observed in the borings at the edge of the landfill.

1.5 Baseline Risk Assessment

A baseline risk assessment (RA) was conducted using the analytical data obtained during the RI in 1993. Details of the RA can be found in the final RI/FS report dated October 1994. This RA evaluated risk for adults and children, as residents, workers, recreational users, or trespassers. The following exposure pathways were considered:

- ingestion and dermal contact with surface soils;
- ingestion, dermal contact, and inhalation of groundwater;
- ingestion and dermal contact with surface water & sediments; and
- ingestion of fish from the streams on or adjacent to the site.

Current Scenario

The only risk in the current scenario appears to be via surface water ingestion, where the hazard index (HI) was exceeded by the trespasser adult (3.45) and trespasser child (16.1). For these receptors, arsenic and manganese appear to dominate. The incremental cancer risk (ICR) was exceeded by both receptors: adult (2.12×10^{-4}) and child (1.98×10^{-4}), with arsenic being the controlling pollutant.

Future Scenario

A number of health risks exist in the future scenario. The HI for the resident child ingestion of both surface soil and subsurface soil exceeded the unity threshold. HI for surface soil ingestion is 2.56 and for subsurface soil ingestion is 1.15. The exceedances are mainly due to the presence of metals, primarily arsenic, iron, and manganese. In the groundwater ingestion pathway, the resident adult receptor exceeded both the HI (2.85) and the ICR (1.28×10^{-4}), where aluminum, arsenic, beryllium, cadmium, chromium, manganese, and vanadium dominate. In this same scenario, the HI for resident child was also exceeded (3.33). Risk indices for groundwater ingestion were calculated using total metals; the indices were not exceeded if dissolved metal concentrations are used. Finally, in the surface water ingestion pathway, the resident child exceeded the HI (16.1) and the ICR (1.98×10^{-4}), and the resident adult exceeded both the HI (3.45) and the ICR (2.12×10^{-4}). Arsenic, barium, and manganese significantly contribute to the index exceedances.

1.6 Purpose

The purpose of the feasibility study (FS) is to identify remedial alternatives to reduce the potential human health and environmental risks associated with the various contaminants of concern identified at the site and to investigate the feasibility of such alternatives using available information. The purpose of the FS report is to document the basis and procedures used in identifying, developing, screening, and evaluating a range of remedial alternatives in order to recommend the most feasible and cost-effective remedial alternative. The FS report is prepared in accordance with the USEPA document titled "Guidance for Conducting RI/FS under CERCLA," October 1988 (EPA/540/G-89/004).

This FS is based on the background summary presented in Sections 1.1-1.5. Details of the site background, field investigations, and analytical findings can be found in the final RI/FS report dated October 1994. The following assumptions and limitations should also be recognized at this juncture:

- Subsurface soils at the site have not been fully investigated. The presence of hazardous substances in the subsurface is assumed since the site was a former landfill.

- The intent of site remediation under the IR program is to mitigate human health risks rather than restore the site to natural conditions. The remedial objective is to mitigate

migration of these hazardous contaminants to the adjacent environment, i.e. groundwater, surface water, and the surface soils.

- Ecological assessments for Little Creek Cove and the adjoining surface water streams have not indicated to-date, any specific impact from the landfill, and the FS has been prepared accordingly. If future assessments indicate ecological risks, additional evaluations and/or actions will be taken as appropriate.

2.0 REMEDIAL ACTION OBJECTIVES

This section identifies site-specific cleanup objectives based on the nature and extent of contamination, the potential for human and ecological exposures, and the current and future uses of the site.

Media of concern at the site are soils, groundwater, and surface water. Surface and subsurface soils are contaminated with metals, Aroclor-1260, and benzo(a)pyrene. Groundwater and surface water are contaminated with metals. The only risk in the current scenario appears to be via surface water ingestion; while in the future scenario, dermal contact of surface soil, groundwater ingestion, and surface water ingestion pathways present potential human health risks. Within this setting, applicable or relevant and appropriate requirements (ARARs) are presented in this section and overall remedial action objectives (RAOs) are developed.

2.1 Applicable or Relevant and Appropriate Requirements

The primary concern during the development of RAOs for hazardous waste sites is the degree of protection afforded by a given remedy to human health and the environment. Section 121(d) of SARA and the NCP (40 CFR 300; March 8, 1990) require that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make response actions comply with all pertinent federal and state environmental requirements. State requirements must also be attained under Section 121(d)(2)(c) of SARA, if they are more stringent than the federal requirements, are legally enforceable, and consistently applied statewide.

Under SARA, an ARAR is defined as follows:

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

Applicable Requirements are those requirements or standards promulgated under federal or state law that would be legally applicable to the response action if that action were not taken pursuant to Sections 104 or 106 of CERCLA.

Relevant and Appropriate Requirements are those federal or state requirements or standards that, while not applicable, are designed to apply to problems sufficiently similar (relevant) to those encountered at the site rendering their application appropriate. Relevant and appropriate requirements are intended to have the same weight as applicable requirements. Requirement must be relevant and appropriate to be an ARAR.

The EPA has also indicated that "other" federal and state criteria, advisories, and guidelines may have To Be Considered (TBCs) during the development of remedial alternatives. TBCs are not promulgated, not enforceable, and do not have the same status as ARARs. However, they may be useful in establishing a cleanup level or in designing the remedial action, especially when no specific ARARs exist or not

sufficiently protective. Examples of such other criteria include: EPA Drinking Water Health Advisories, Carcinogenic Potency Factors, and Reference Doses.

Section 121 of SARA requires that the remedy for a CERCLA site must attain all ARARs unless one of six conditions for a waiver is satisfied. These are:

- The selected remedial action is an interim remedy or a portion of a total remedy which will attain the standard upon completion.

- Compliance with such requirements will result in greater risk to human health and the environment than alternate options.

- Compliance with such requirements is technically impracticable from an engineering perspective.

- The selected remedial action will attain the equivalent of an ARAR.

- The requirement is a state requirement that has not been consistently applied in similar circumstances.

- Compliance with the ARAR will not provide a balance between protecting public health and the environment at this site with the availability of funds for response at other sites.

ARARs and TBCs are both used during the FS process to:

- Develop remedial action objectives and determine the appropriate extent of cleanup;
- Scope, formulate, and evaluate the remedial action alternatives; and,
- Govern implementation and operation of the selected remedial alternative.

ARARs and TBCs fall into three broad categories, based on the manner in which they are applied at a site. These categories are as follows:

- Chemical specific - These ARARs and TBCs define acceptable exposure levels for a specific chemical in an environmental medium and are used in establishing preliminary remediation goals. They may be actual concentration based cleanup levels, or they may provide the basis for calculating such levels. Examples of chemical-specific ARARs are MCLs for drinking water or ambient air quality standards.

- Location-specific - These ARARs and TBCs set restrictions on remedial activities at a site due to its proximity to specific natural or man-made features. Examples of natural site features include floodplains or wetlands. Examples of man-made features are local historic buildings and structures.

- Action-specific - These ARARs and TBCs set controls or restrictions for particular treatment and disposal activities related to the management of site media containing

constituents of concern. Examples of action-specific ARARs are effluent discharge limits and hazardous waste manifesting requirements.

In general, chemical-specific ARARs and TBCs are considered during the assessment of risks to human health and the environment. These ARARs and TBCs are also considered in the development of the remedial action objectives. The action-specific ARARs and TBCs, which affect the implementation and/or operation of the remedial alternatives, are primarily used to assess the feasibility of remedial technologies and alternatives. Tables 2-1 A, B, and C present potential Federal action-specific, chemical-specific, and location-specific ARARs, while Tables 2-2 A, B, and C present potential Virginia action-specific, chemical-specific, and location-specific ARARs which may be applicable to the landfill.

2.1.1 Chemical-Specific ARARs and TBCs

A partial listing of potential federal and state chemical-specific ARARs and TBCs that apply to NAB Little Creek sites is presented below. All of the ARARs and TBCs listed provide some specific guidance on "acceptable" or "permissible" concentrations of chemicals of concern in air, drinking water, treatment residues, etc., at the site. It should be noted that such a list is not totally inclusive and must be reviewed for completeness periodically to evaluate if additions to, or deletions from the list are required. At a minimum, this review should take place every five years. A brief discussion of the chemical-specific ARARs and TBCs is presented below.

The Safe Drinking Water Act (SDWA) promulgated National Primary Drinking Water Standard MCLs (40 CFR 141). MCLs are enforceable standards for chemicals of concern in public drinking water supply systems. They are based on health risks, as well as the economic and technical feasibility of removing a contaminant from a water supply system. EPA has recently also proposed Maximum Contaminant Level Goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs are nonenforceable guidelines that do not consider the technical feasibility of contaminant removal. Secondary MCLs (40 CFR 143) are not enforceable, but are intended as guidelines to protect the public welfare. Chemicals of concern covered are those that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and may deter public acceptance of drinking water provided by public water systems. SDWA requirements are applicable to groundwater treatment alternatives.

EPA Health Advisories are nonenforceable guidelines, developed by the EPA Office of Drinking Water, for chemicals that may be intermittently encountered in public water supply systems. Health advisories are available for short-term, long-term, and lifetime exposures for a 10 kg child and/or a 70 kg adult. Health advisories may be applicable for remedial actions involving groundwater treatment, especially for contaminants of concern that are not regulated under the SDWA.

EPA Ambient Water Quality Criteria (AWQC) were developed for 64 pollutants in 1980, pursuant to Section 304(a)(1) of the Clean Water Act. In 1984, EPA revised nine criteria previously published in 1976 (Quality Criteria for Water) and in the 1980 documents. AWQC are not legally enforceable, but have been used by many states to develop enforceable water quality standards. AWQC are available for the protection of human health from exposure to contaminants of concern in drinking water and from the ingestion of aquatic biota and for the protection of freshwater and saltwater aquatic life. AWQC may be

TABLE 2-1 A

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Excavation	Movement of excavated materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed	Material containing RCRA hazardous wastes subject to land disposal restrictions are placed in another unit	40 CFR 268.40	
	Areas from which materials are excavated may require cleanup to levels established by closure requirements	RCRA hazardous waste placed at site after the effective date of the requirements.	40 CFR 264.228(a),(b) 40 CFR 264.258(a) and (b)	
Waste Pile	Use a single liner and leachate collection system. Waste put into waste pile subject to land ban regulations.	RCRA hazardous waste, non-containerized accumulation of solids, non-flammable hazardous waste that is used for treatment or storage	40 CFR 264.251 (except 251(j), 251(e)(11)	Requirements may be ARAR for soils stockpiled onsite prior to treatment or disposal
Closure of Waste Pile	At closure owner shall remove or decontaminate all waste residue and equipment	Waste pile used to store hazardous waste	40 CFR 264.25(a) and (b) except references to procedural requirements.	
Thermal Treatment	Establishes requirements for owners and operators of interim status facilities that thermally treat hazardous waste in devices other than incinerators	RCRA hazardous waste treatment	40 CFR 265.370-265.383	Would not be an ARAR if treatment unit is determined to be an incinerator.
Land Treatment	Treatment unit design requirements and specifications	Facilities that treat or dispose of hazardous waste in land treatment units	Title 40 CFR 264.271(a)(2) and (3)	
	Design, construction, operation and maintenance of land treatment units.	Facilities that treat or dispose of hazardous waste in land treatment units.	Title 40 CFR 264.273(a) to (g)	
	Vadose zone monitoring and response requirements.	Facilities that treat or dispose of hazardous waste in land treatment units.	Title 40 CFR 264.278	

TABLE 2-1 A (continued)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Closure of Land Treatment Unit	Closure and post closure care requirements for hazardous waste land treatment units.	Land treatment unit used to treat or dispose hazardous waste.	40 CFR 264.280	
Treatment when waste will be land disposed	Treatment of waste subject to ban on land disposal must attain levels achievable by best demonstrated available treatment technologies (BDAT) for each hazardous constituent in each listed waste, if residual is to be land disposed.	Placement of RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, or underground mine or cave	40 CFR 268.40 and 42	
	BDAT standards for spent solvent wastes and dioxin-containing wastes are based on one of four technologies or combinations: steam stripping, biological treatment, carbon adsorption; and incineration. Any technology may be used if it will achieve the concentration levels specified		40 CFR 268.30,31 42 US 6924(d)(3)(e)(3)	
Placement of waste in land disposal unit	Attain land disposal treatment standards before putting waste into landfill in order to comply with land ban restrictions.	Placement of RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, or underground mine or cave.	40 CFR 268.40	Applicable only for hazardous wastes that are regulated under land disposal restrictions.
Surface water control	Prevent run-on and control and collect run-off from a 24-hour 25-year storm. Prevent over-topping of surface impoundments	RCRA hazardous waste treated, stored, or disposed after the effective date of the requirements.	40 CFR 264.251(c,d,f,g,h,k)	

TABLE 2-1 A (continued)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Discharge to groundwater from regulated unit	Groundwater Protection Standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that are designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance.	Uppermost aquifer underlying a waste management unit beyond the point of compliance; RCRA hazardous waste, treatment, storage, or disposal.	40 CFR 264.94(a)(1),(a)(3),(c),(d)and (e)	Standards require consideration of cleanup to background.
	Owners/operators of RCRA surface impoundment, waste pile, land treatment unit, or landfill shall conduct a monitoring and response program for each regulated unit	Surface impoundment, waste pile, land treatment unit, or landfill for which constituents in or derived from waste in the unit may pose a threat to human health or the environment.	40 CFR 264.91(a) and (c), except as it cross-references permit requirements	
Underground injection of wastes and treated groundwater	The underground injection control (UIC) program prohibits injection activities that allow movement of contaminants into underground sources of drinking water which may result in violations of MCLs or adversely affect health.	An approved UIC program is required in states listed under Safe Drinking Water Act (SDWA) Section 1422. Class I wells and class IV wells are the relevant classifications for CERCLA sites. Class I wells are used to inject hazardous waste beneath the lowermost formation within 1/4 mile that contains an underground source of drinking water (USDW). Class IV wells are used to inject hazardous or radioactive waste into or above a formation that contains an USDW within 1/4 mile of the well.	40 CFR 144.12, excluding the reporting requirements in 144.12(b) and 144.12(c)(I)	The following UIC requirements may be ARARs for alternatives that include reinjection of treated groundwater.

TABLE 2-1 .. (continued)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Underground injection of wastes and treated groundwater	The UIC program regulated construction of new Class IV wells and operation and maintenance of existing wells.		40 CFR 144.13	
	Class IV wells are banned except for reinjection of treated groundwater into the same formation from which it was withdrawn, as part of a CERCLA cleanup or RCRA corrective action.		40 CFR 144.13(c)	
Disposal of pesticides	Unacceptable disposal methods include: - Those inconsistent with the label - Open dumping - Open burning - Disposal into any body of water Chemically deactivate pesticide and recover heavy metals. If chemical deactivation facilities are not available, encapsulate the pesticide and bury it. Store pesticide if neither deactivation or burial are available.	Treatment recommended for organic mercury, lead, cadmium, arsenic, and all inorganic pesticides.	40 CFR 165.7 and 165.8	Not an enforceable requirement. May be a TBC.
Discharge to air	Provisions of State Implementation Plan (SIP) approved by EPA under Section 110 of CAA.	Major sources of air pollutants	40 USC Section 7410; portions of 40 CFR Section 52 applicable to state in which site is located	Specific pertinent rules are listed below.
	National Primary and Secondary Ambient Air Quality standards (NAAQS) - standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare	40 CFR Sections 50.4 - 50.12	Not an ARAR; Federal NAAQS are nonenforceable standards. May be a TBC.
New Source of discharge to air	Meet standards of performance for new sources and emission standards for hazardous air pollutants.	Stationary source constructed or modified after effective date of requirement. Specified stationary sources of specific hazardous air pollutant(s).	40 CFR 60	
New Source of discharge to air	National Emission Standards for Hazardous Air Pollutants (NESHAPS)	Any stationary source for which a standard is prescribed under this regulation.	40 CFR 61	

TABLE 2-1 A (continued)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Hazardous Materials Transportation	No person shall represent that a container or package is safe unless it meets the requirements of 49 USC 1802, et seq. Or represent that a hazardous material is present in a package or motor vehicle if it is not.	Interstate carriers transporting hazardous waste and substances by motor vehicle. Transportation of hazardous material under contract with any department of the executive branch of the Federal government.	49 CFR 171.2(f)	Substantive portions of these requirements would be ARARs for transport of hazardous materials onsite. Offsite transport must comply with both substantive and administrative requirements.
Solid Waste Disposal	A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary or a court-or State-established alternative.	Solid waste disposal facility and practices except agricultural wastes, overburden resulting from mining operations, land application of domestic sewage, location and operations of septic tanks, solid or dissolved materials in irrigation return flows, industrial discharges that are point sources subject to permits under CWA, source special nuclear or by-product material as defined by the Atomic Energy Act, hazardous waste disposal facilities that are subject to regulation under RCRA Subtitle C, disposal of solid waste by underground well injection, and municipal solid waste landfill units.	40 CFR 257.3-4 and Appendix I.	
	A facility shall not cause a discharge of pollutants into waters of the U.S. that is in violation of the substantive requirements of the NPDES under CWA Section 402, as amended.		40 CFR 257.3-3(a)	

TABLE 2-1 A (continued)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Solid Waste Disposal	A facility shall not cause a discharge of dredged material or fill material to waters of the U.S. that is in violation of the substantive requirements of CWA Section 404.		40 CFR 257.3-3	
	A facility or practice shall not cause nonpoint source pollution of waters of the U.S. that violates applicable legal substantive requirements implementing an area wide or Statewide water quality management plan approved by the Administrator under CWA Section 208, as amended.		40 CFR 257.3-3(a)	
	The facility or practice shall not engage in open burning of residential, commercial, institutional, or industrial solid waste.	Not applicable to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, landclearing debris from emergency cleanup operations, and ordnance.	40 CFR 257.3-7(a)	
	The facility shall not violate applicable requirements developed under State implementation plan approved or promulgated by the Administrator pursuant to CAA Section 110, as amended.		40 CFR 257.3-7(b)	

TABLE 2-1 B

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

REQUIREMENT	PREREQUISITES	CITATION	ARAR DETERMINATION	COMMENTS
Water quality criteria	Discharges to water of the United States and groundwater	33 USC 1314(a) and 42 USC 9621(d)(2)		Water quality criteria are not generally relevant and appropriate in selecting cleanup levels in groundwater, because consumption of contaminated fish is not a concern. However, a water quality criteria adjusted to reflect only exposure from drinking the water may be useful in the absence of a promulgated MCL or MCLG. Also, water quality criteria may be relevant and appropriate for any groundwater discharge to surface water.
Toxicity characteristic leaching procedure (TCLP) regulatory levels; Persistent and bioaccumulative toxic substances total threshold limit concentrations (TTLCs) and soluble threshold limit concentrations (STLCs).	Hazardous waste treatment, storage, or disposal.	Title 22 CCR, 66261.24(a).		Applicable for determining whether waste is hazardous.
Groundwater protection standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that are designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance.	Uppermost aquifer underlying a waste management unit beyond the point of compliance; RCRA hazardous waste, treatment, storage, or disposal.	40 CFR 264.94, except 6624.94(a)(2), and 94(b)		Applicable for hazardous waste TSD facilities; potentially relevant and appropriate in site-specific circumstances, such as when the source of the waste is unknown but the waste is similar in composition to listed waste or when waste constituents have released or have the potential to release to groundwater. See NCP criteria at 40 CFR 300.400(g)(2).
Water quality standards	Discharges to water of the United States	33 USC 1313 and 57 Federal Register 60920-60921		Federal water quality standards would be applicable for any discharges to surface waters. Discharges to surface water (from contaminated groundwater or surface runoff) should be evaluated here. Discharges that would occur as part of the response action should be evaluated under action-specific requirements.

TABLE 2-1 B (Continued)

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

REQUIREMENT	PREREQUISITES	CITATION	ARAR DETERMINATION	COMMENTS
Water quality criteria	Discharges to waters of the United States and groundwater.	33 USC 1314(a) and 42 USC 9621(d)(2)		Federal water quality standards may be relevant and appropriate for any discharges to surface water. Discharges to surface water (from contaminated groundwater or surface runoff) should be evaluated here. Discharges that would occur as part of the response action should be evaluated under action-specific requirements.
Definition of RCRA hazardous waste	Waste soil	40 CFR Sections 261.21 261.22(a)(1), ; 261.23 261.24(a)(1), and 261.100		Applicable for determining whether waste is hazardous.
Provisions of State Implementation Plan (SIP) approved by EPA under Section 110 of CAA.	Major sources or air pollutants.	40 USC 7410; portions of 40 CFR 52.220 applicable to state in which site is located.		Need to evaluate whether emission of air pollutants regulated by SIP is currently occurring. Emissions that would be part of the response action should be evaluated under the action-specific requirements.

TABLE 2-1 C

POTENTIAL FEDERAL LOCATION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

LOCATION	REQUIREMENT	PREREQUISITES	CITATION	ARAR DETERMINATION	COMMENTS
Within floodplain	Actions taken should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302		Check FEMA maps for the area. Information reference should be included in the comment.
Critical habitat upon which endangered species or threatened species depend	Action to conserve endangered species or threatened species, including consultation with the Department of the Interior.	Determination of effect upon endangered or threatened species or its habitat.	16 USC 1536(a)		EIS completed for MILCON projects at the facility will have information on endangered species that have been observed in the site vicinity. If endangered species are present, the ecological assessment should evaluate potential effects of the contamination present and the planned response action.
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 6, appendix A; excluding Sections 6(a)(2). 6(a)(4), 6(a)(6); 40 CFR 6.302		Using wetlands maps and other site-specific information, determine if there are any wetlands in the immediate vicinity of the site. If wetlands are present, the site investigation should determine if they are currently being degraded by the contamination at the site or if they could be impacted by the response action for the site.
	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8		This requirement would be an ARAR if discharge of dredged or fill material to a wetland is planned as part of the response action.
Within coastal zone	Conduct activities in a manner consistent with approved State management programs.	Activities affecting the coastal zone including lands thereunder and adjacent shoreland.	Section 307(c) of 16 USC 1256(c); also see 15 CFR 930 and 923.45		If site is near a coastal area, check with appropriate state agency to determine the applicability of this requirement. EIS for MILCON projects at the facility may have this information.

TABLE 2-2

POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Excavation	Movement of excavated materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed	Material containing RCRA hazardous wastes subject to land disposal restrictions are placed in another unit	40 CFR 268.40	Land Disposal Restrictions not regulated by State.
	Areas from which materials are excavated may require cleanup to levels established by closure requirements	RCRA hazardous waste placed at site after the effective date of the requirements.	VR 672-10-01, Part X, Sections 10.10.I.1, 2 and 10.11.I.1,2, except as it cross-references procedural requirements	
Waste Pile	Use a single liner and leachate collection system. Waste put into waste pile subject to land ban regulations.	RCRA hazardous waste, non-containerized accumulation of solids, non-flammable hazardous waste that is used for treatment or storage	VR 672-10-01, Part X, Section 10.11.B	Requirements may be ARAR for soils stockpiled onsite prior to treatment or disposal
Closure of Waste Pile	At closure owner shall remove or decontaminate all waste residue and equipment	Waste pile used to store hazardous waste	VR 672-10-01, Part X, Section 10.11.I.1, 2 except reference to procedural requirements	
Thermal Treatment	Establishes requirements for owners and operators of interim status facilities that thermally treat hazardous waste in devices other than incinerators	RCRA hazardous waste treatment	VR 672-10-01, Part X, Section 9.15	Would not be an ARAR if treatment unit is determined to be an incinerator.
Land Treatment	Treatment unit design requirements and specifications	Facilities that treat or dispose of hazardous waste in land treatment units	VR 672-10-01 Part X, Section 10.12.B.1(b)and(c)	
	Design, construction, operation and maintenance of land treatment units.	Facilities that treat or dispose of hazardous waste in land treatment units.	VR 672-10-01, Part X, Section 10.12.D	

TABLE 2-2 A (Continued)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Land Treatment	Vadose zone monitoring and response requirements.	Facilities that treat or dispose of hazardous waste in land treatment units.	VR 671-10-01, Part X, Section 10.12.I	
Closure of Land Treatment Unit	Closure and postclosure care requirements for hazardous waste land treatment units.	Land treatment unit used to treat or dispose hazardous waste.	VR 672-10-01, Par X, Section 10.12K	
Treatment when waste will be land disposed	Treatment of waste subject to ban on land disposal must attain levels achievable by best demonstrated available treatment technologies (BDAT) for each hazardous constituent in each listed waste, if residual is to be land disposed.	Placement of RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, or underground mine or cave	40 CFR 268	Not regulated by State. See Federal Action-Specific ARARs.
Placement of waste in land disposal unit	Attain land disposal treatment standards before putting waste into landfill in order to comply with land ban restrictions.	Placement of RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, or underground mine or cave.	40 CFR 268.4	See Federal Action-Specific ARARs Table.
Surface water control	Prevent run-on and control and collect run-off from a 24-hour 25-year storm. Prevent over-topping of surface impoundments	RCRA hazardous waste treated, stored, or disposed after the effective date of the requirements.	VR 672-10-01, Part X, Sections 10.11.B; 10.12D and 10.13B	
Discharge to groundwater from regulated unit	Groundwater Protection Standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that are designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance.	Uppermost aquifer underlying a waste management unit beyond the point of compliance; RCRA hazardous waste, treatment, storage, or disposal.	VR 672-10-01, Part X, Section 10.5D	Standards require consideration of cleanup to background.
Discharge to groundwater from regulated unit	Owners/operators of RCRA surface impoundment, waste pile, land treatment unit, or landfill shall conduct a monitoring and response program for each regulated unit	Surface impoundment, waste pile, land treatment unit, or landfill for which constituents in or derived from waste in the unit may pose a threat to human health or the environment.	VR 672-10-01, Part X, Section 10.5.B, except as it cross-references permit requirements	

TABLE 2-2 A (Continued)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Underground injection of wastes and treated groundwater	The underground injection control (UIC) program prohibits injection activities that allow movement of contaminants into underground sources of drinking water which may result in violation of MCLs or adversely affect health	An approved UIC program is required in states listed under Safe Drinking Water Act (SDWA) Section 1422.	40 CFR 144, 146, and 147 VR 680-14-01, Part I, Section 1.6(H)	Not regulated by State. See Federal Action-Specific ARARs Table.
Discharge to air	Provisions of State Implementation Plan (SIP) approved by EPA under Section 110 of CAA.	Major source of air pollutants	VR 120-10,02	Specific pertinent rules are listed below.
	Virginia Ambient Air Quality Standards-standards for ambient air quality to protect public health and welfare.	Contamination of air affecting public health and welfare	VR 120-03	
Discharge of visible emissions and fugitive dust	Fugitive dust/emissions may not be discharged to the atmosphere at amounts in excess of standards	Any source of fugitive dust/emissions	VR 120-04, Rule 4-1	
Discharge of toxic pollutants	Toxic pollutants may not be discharged to the atmosphere at amounts in excess of standards.	Any emission from the disturbance of soil, or treatment of soil or water, that do not qualify for the exemptions under Rule 4-3.	VR 120-04, Rule 4-3	
Hazardous Materials Transportation	Hazardous materials must be packaged, marked, labelled, placarded, and transported in the manner required	Interstate carriers transporting hazardous waste and substances by motor vehicle. Transportation of hazardous material under contract with any department of the executive branch of the Federal government	49 CFR 171 and 172	See Federal Action-Specific ARARs Table.
Solid Waste Disposal	A facility shall not cause a discharge of dredged material or fill material to waters of the U.S. that is in violation of the substantive requirements of CWA Section 404.		VR 672-20-10, Part V, Section 5.1.C(12)	
	A facility or practice shall not cause nonpoint source pollution of waters of the U.S. that violates applicable legal substantive requirements implementing an areawide or Statewide water quality management plan approval by the Administrator under CWA Section 208, as amended.		VR 672-20-10, Part V, Section 5.1.C(12)	

TABLE 2-2 A (Continued)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Solid Waste Disposal	The facility or practice shall not engage in open burning of residential, commercial, institutional or industrial solid waste.	Not applicable to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, landclearing debris from emergency cleanup operations, and ordnance.	VR 672-20-10, Part V, Section 5.1.C(8)	
	The facility shall not violate applicable requirements developed under a State implementation plan approved or promulgated by the Administrator pursuant to CAA Section 110, as amended.		VR 672-20-10, Part V, Section 5.1.C(8)	
Discharge of treated water to surface waters.	Regulated point-source discharges through the VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records	Applicable to discharge of treated water to surface water.	VR 680-14001	Substantive requirements of VPDES permit will be used to determine the discharge limits for the discharge of the treated water to surface water on site.

TABLE 2-2 B

POTENTIAL VIRGINIA CHEMICAL-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Water quality standards based on water use and class of surface water	Discharges to surface waters.	VR 680-21-01.14	Water quality standards may be relevant and appropriate for any groundwater discharge to surface water.
Groundwater standards established for State anti-degradation Policy	Public water system	VR 680-21-04	May be relevant and appropriate for development of cleanup levels if no MCL is available.
Toxicity characteristic leaching procedure (TCLP) regulatory levels.	Hazardous waste treatment, storage, or disposal.	VR 672-10-01, Part III, Section 3.9A	Applicable for determining whether waste is hazardous.
Groundwater protection standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that are designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Section 264.94 in the uppermost aquifer underlying the waste management area beyond the point of compliance.	Uppermost aquifer underlying a waste management unit beyond the point of compliance;RCRA hazardous waste, treatment , storage, or disposal.	VR 672-10-01 Part X, Section 10.5.E, except 10.5.E(1)(b) and E(2)	Applicable for hazardous waste TSD facilities; potentially relevant and appropriate in site-specific circumstances, such as when the source of the waste is unknown but the waste is similar in composition to listed waste or when waste constituents have released or have the potential to release to groundwater.
Water quality standards based on water use and class of surface water	Discharge to surface waters.	VR 680-21-01.14	Water quality standards would be applicable for any discharges to surface waters. Discharges to surface water from contaminated groundwater or surface runoff should be evaluated. Discharges that would occur as part of the response action should be evaluated under action-specific requirements.

TABLE 2-2 C

POTENTIAL VIRGINIA LOCATION-SPECIFIC ARARs
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

LOCATION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	VR 672-10-01, Part X, Section 10.1.I(2)	Check FEMA maps for the area. Information reference should be included in comment.
Critical habitat upon which endangered species or threatened species depend	Action to conserve endangered species or threatened species, including consultation with the Virginia Board of Game and Inland Fisheries.	Determination of effect upon endangered or threatened species or its habitat.	Code of Virginia Section 29.1-563 et seq. and 29-100 et seq.	Biological assessment should be conducted and submitted to VDEQ for review by the Virginia Board of Game and Inland Fisheries to determine whether endangered species or their habitats are threatened by the site. Certain species of fish and wildlife are identified as being threatened and are entitled to special preservation and protection measures under these statutes.
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetlands as defined by Executive Order 11990 Section 7.	Code of Virginia Section 62.1-13.1 et seq. and VR 450-01-0051	Using wetlands maps and other site-specific information, determine if there are any wetlands in the immediate vicinity of the site. If wetlands are present, the site investigation should determine if they are currently being degraded by the contamination at the site or if they could be impacted by the response action for the site.
Adjacent to Coastal Zone	Conduct activities in a manner consistent with approved State management program	Activities affecting the coastal zone including lands thereunder and adjacent shoreland.	Section 307(c) of 16 USC 1456(c); 15 CFR 930 and 923.45	If activities impact a coastal zone, determine if the activity is consistent with and applicable to this requirement.

applicable to those remedial actions which involve groundwater treatment and/or discharges to surface water.

Federal Ambient Water Quality Criteria (Clean Water Act) - The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Analytical results from groundwater at the site will be compared to Federal Ambient Water Quality Criteria or standard analytical detection limits to ensure that these criteria are being met.

The Clean Air Act (CAA) of 1976 (42 USC 7401) and CAA amendments of 1990 govern air emissions resulting from remedial actions. National Ambient Air Quality Standards (NAAQS) were promulgated under the Clean Air Act. NAAQS are available for six chemicals or groups of chemicals and for airborne particulates. The sources of the contaminant and the route of exposure were considered in the formulation of the standards, but the costs of achievement and the feasibility of implementing them were not considered. The NAAQS allow for a margin of safety to account for unidentified hazards and effects. During site remediation, it is necessary to keep particulate emissions to a minimum.

Section 112 of the Clean Air Act defines the National Emissions Standards for Hazardous Air Pollutants (NESHAPs). NESHAPs are available for several compounds such as benzene, vinyl chloride, and trichloroethylene. A number of other pollutants are recognized as hazardous, but no emission standards have been developed for them. In these cases, other guidelines such as reference doses or carcinogenic potency factors may be useful.

Reference Doses (RfDs) refer to the amount of a toxicant (in mg/day for a 70 kg adult) that is not expected to result in adverse health effects after chronic exposure of the general population. They are used to evaluate the potential for noncarcinogenic effects associated with exposure to site-related constituents of concern.

Carcinogenic potency factors (CPFs) represent the upper 95 percent confidence limit of the carcinogenic potency of a compound. The CPF is expressed as the lifetime cancer risk per a reference dose unit, or the inverse of mg/kg/day. An upper bound estimate of cancer risk can be determined by converting the estimated dose of a compound to an incremental lifetime cancer risk. CPFs for the site constituents of concern were presented in the RA report in Section 6.0.

Virginia Air Pollution Control Regulations govern air emissions from remedial actions. The regulations provide for the control and prevention of air pollution. These air quality standards may be applicable to remedial actions involving direct or indirect emissions to the atmosphere.

Virginia Surface Water Standards - The Virginia Surface Water Standards are those standards set by the Commonwealth of Virginia similar to those standards given by the Clean Water Act. Analytical results from groundwater samples taken prior to discharge will be compared to the Virginia standards or standard analytical detection limits to ensure that acceptable criteria are being met for the surface water. Refer to Table 2-2 for additional ARARs from the State of Virginia.

2.1.2 Location-Specific ARARs and TBCs

A partial listing of potential federal and state location-specific ARARs and TBCs is presented below. It should be noted that such a list is not totally inclusive and must be reviewed for completeness periodically, to evaluate if additions to, or deletions from, the list are required. At a minimum, this review should take place every five years.

Wetlands Protection (Executive Order 11990) - Executive Order 11990 requires federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction and loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. It requires that action be taken to minimize the destruction, loss or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

Wetlands Construction and Management (40 CFR 6, Appendix A) - Requires federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.

Fish and Wildlife Coordination Act (16 USC 661, et. seq.) - The Fish and Wildlife Coordination Act requires action to protect fish and wildlife from actions modifying streams or areas affecting streams. The appropriate federal and state agencies and the U. S. Fish and Wildlife Service will be contacted in order to determine if this Act affects the NAB Little Creek sites.

Endangered Species Act of 1973 (16 USC 1531) (40 CFR Part 502) - The Endangered Species Act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modifications to their habitat.

In order to evaluate the requirements of the Endangered Species Act, the Fish and Wildlife Improvement Act of 1978, the Fish and Wildlife Conservation Act of 1980, and the Fish and Wildlife Coordination Act, the National Heritage Database has to be consulted. The report that is generated from this search provides information on managed areas, rare plants and animals, and their status.

Coastal Zone Management Act - The Coastal Zone Management Act requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management. It has been determined that the site lies within the Virginia coastal zone.

Clean Water Act, Section 404 (Wetlands) - Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into certain waters (including wetlands). Dredge or fill material should not be discharged into an aquatic ecosystem unless it can be demonstrated that the discharge will not have an adverse impact on the ecosystem.

National Historic Preservation Act (1966) - This Act requires federal agencies to identify all affected properties on or eligible for the National Register of Historic Places in the vicinity of the site when considering remedial actions. The Virginia Office of Historic Places can be contacted to obtain a list of Historic Places to determine and identify any historic landmarks/places in the general area of the site.

Executive Order 11988 (Floodplain Management) requires federal agencies to evaluate potential effects of the planned actions in a floodplain environment to reduce the risk of flood losses and to restore and preserve the natural and beneficial values of the floodplain. The Flood Disaster Protection Act and the National Flood Insurance Act and their implementation regulations (24 CFR 1909) require the purchase of flood insurance before federal funds are spent for projects in a special flood hazard area in a community participating in the National Flood Insurance Program. Coverage must continue throughout the useful life of the project.

Virginia Wetlands Act, Title 62.1 - This act states that it is public policy of the Commonwealth of Virginia to preserve the wetlands and prevent their despoliation and destruction and to accommodate necessary economic development in a manner consistent with wetlands preservation. This act sets standards that apply to the use and development of wetlands. Refer to Table 2-2 for additional ARARs from the State of Virginia.

2.1.3 Action-Specific ARARs and TBCs

A partial listing of potential federal and state action-specific ARARs and TBCs is presented below. These ARARs govern activities undertaken as part of site remediation. It should be noted that such a list is not totally inclusive and must be reviewed for completeness periodically, to evaluate if additions to, or deletions from, the list are required. At a minimum, this review should take place every five years.

The Resource Conservation and Recovery Act (RCRA), as amended, governs the generation, transportation, storage, and disposal of hazardous wastes. RCRA (40 CFR 264) standards apply to remedial actions that include on-site storage, off-site hauling and disposal of hazardous wastes, which may be considered for this site. 40 CFR 264 and 265, Subparts Z, AA and BB address new regulations being developed to provide standards for controlling hazardous volatile organic compound emissions. These would be considered during groundwater treatment.

Identification and Listing of Hazardous Waste - The criteria for identifying the characteristics of hazardous waste and for listed hazardous wastes are provided in RCRA, 40 CFR Part 261 and Virginia Waste Management Regulations VR 672-10-1. Any wastes found to be RCRA hazardous wastes will be stored, treated and/or disposed according to the applicable regulations in these sections.

RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264) - 40 CFR Part 264 regulates the treatment, storage and disposal of hazardous waste. It will be determined which constituents of concern found on site are RCRA listed or characteristic hazardous wastes. If RCRA hazardous wastes are found to be present on site, all applicable rules and regulations as stated in 40 CFR Part 264 will be followed and the appropriate coordination will be obtained.

RCRA Excavation and Fugitive Dust Requirements (40 CFR 264.251 and 264.254) - All excavation activities will be designed and operated to comply with all applicable regulations in these sections, and to minimize the threat to public health and the environment from the release of constituents of concern. During the remedial activities, the site will be inspected and/or monitored for uniformity, damages and imperfections, deterioration, improper operation of run-on and run-off control systems, proper functioning

of wind dispersal control systems, the presence of leachate in (and the proper functioning of) leachate collection and removal systems, and all other applicable requirements.

RCRA Land Disposal Restrictions (40 CFR 268) - 40 CFR Part 268 identifies those RCRA hazardous wastes that are restricted from land disposal. Waste that is land disposal restricted would be shipped off site for disposal with the proper labels, manifests, and notification forms indicating that the waste is land disposal restricted.

OSHA (29 CFR 1910, 1926, 1940) - These regulations provide occupational safety and health requirements applicable to workers engaged in on-site field activities. Threshold Limit Values (TLVs) refer to airborne concentrations of substances and represent conditions under which repeated exposures are not expected to result in adverse effects. These ARARs are within the jurisdiction of the on-site health and safety officer. Except for the No Action alternative, OSHA requirements apply to all other remedial alternatives. Therefore, all workers will be trained in accordance with the regulations, and these regulations will be enforced by the Site Health and Safety Officer during all remedial activities.

DOT Rules for Hazardous Materials Transport (49 CFR 107, 171.1 - 171.500) - DOT regulations govern the off-site transport of hazardous materials for disposal and/or treatment. Waste handlers involved in site remediation activities must have all proper permits and certifications. These regulations will be applicable to all remedial alternatives involving treatment or disposal of contaminated media or residues. The wastes from the remedial activities will be classified for transportation based on the chemicals present in the material. Shipping papers (including hazardous waste manifests) will be prepared that describe the hazardous material to be transported and will include contents, shipper's name, proper shipping address, hazard class, identification number, total quantity, and certification that the material is presented according to DOT regulations. All wastes will be packaged according to DOT regulations with the proper markings on each container.

SARA requires that federal agencies pursue permanent solutions. Implementations of alternatives that provide permanent solutions has been evaluated in this report.

Land Disturbing Activities are regulated under the Virginia Stormwater Management Act, Sec. 10.1-603.1 et seq.; Virginia Stormwater Management Regulations (VR 215-02-00), the Virginia Erosion and Sediment Control Law, Code of Virginia 10.1-560 et seq., the Virginia Erosion and Sediment Control Regulations (VR 625-02-00), as well as local stormwater management and sediment and erosion control programs administered by the County Design. The Virginia Department of Environmental Quality has delegated its authority to LANTDIV to review any land-disturbing activities, and erosion and sedimentation control activities.

Virginia Solid Waste Regulations (VR-672-20-10) - The purpose of these regulations is to establish standards and procedures pertaining to the construction, operation, maintenance, closure and post-closure of solid waste management facilities in the Commonwealth of Virginia in order to protect the public health, public safety, the environment, and natural resources. All Virginia Solid Waste Regulations will be strictly adhered to during all remedial activities at NAB Little Creek, and all applicable permits will be obtained.

Virginia Hazardous Waste Management Regulations (VR-672-10-01) - The purpose of these regulations is to provide control of all hazardous wastes that are generated within, or transported to, the Commonwealth of Virginia for storage, treatment, or disposal. These regulations establish a management control system which assures the safe and acceptable management of a hazardous waste from the moment of its generation through each step of management until the ultimate destruction or disposal. All Virginia Hazardous Waste Management Regulations will be strictly adhered to during all aspects of the remedial activities at NAB Little Creek.

Excavation/Offsite Disposal of Soils is regulated under Virginia Waste Management Act, Code of Virginia Sections 10.1-1400 et seq.; Virginia Hazardous Waste Management Regulations (VHWMR) (VR 672-10-1); Virginia Solid Waste Management Regulations (VSWMR) (VR 672-20-10), as well as the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901, and the applicable regulations contained in Title 40 of the Code of Federal Regulations; and the U. S. Department of Transportation Rules for Transportation of Hazardous Materials, 49 CFR Parts 107, 171.1-172.558.

If the remedial response contemplated involves storage, treatment or disposal of a Virginia Hazardous Waste Management Regulations (VHWMR)/RCRA hazardous waste, various VHWMR/RCRA requirements may need to be complied with, as specified in VHWMR and/or the applicable 40 CFR Parts. Because Virginia administers an authorized state RCRA program, the VHWMR will serve as the governing ARAR in place of the RCRA regulations contained in the 40 CFR Parts, except for the Land Disposal Restrictions of 40 CFR Part 268.

The transportation of hazardous waste must be conducted in compliance with VHWMR (VR 672-10-1) Part V (Manifest Regulations for Hazardous Waste Management), and Part VII (Regulations Applicable to Transporters of Hazardous Waste), VHWMR (VR 672-30-1) Regulations Governing the Transportation of Hazardous Materials, and 49 CFR Parts 107, 171.1-172.558.

The deposits of any soil, debris, sludge or any other solid waste from a site must be done in compliance with VSWMR (VR 672-20-10). Contaminated material from the site that is not classified as hazardous may be classified as a special waste under Part VIII of VSWMR. Specific authorization from VDWM is required before a landfill operator in Virginia can accept special wastes. Refer to Table 2-2 for additional ARARs from the State of Virginia.

2.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are statements that specify site remediation goals and identify which constituents of concern, media, and exposure pathways will be addressed by remedial actions. Remedial or cleanup goals establish exposure levels that are protective of human health and the environment. They are developed by considering ARARs, TBCs, the toxic or carcinogenic potential of constituents of concern, aggregate risks posed by multiple constituents of concern or exposure pathways, and environmental threats. The RAOs are subsequently used in screening of remedial technologies and in the development and detailed evaluation of remedial alternatives.

Based on results of the previous investigations, nature and extent of contamination, and the risk assessment presented in the preceding sections, the following RAOs are established for the site:

- Reduce the human health risks associated with the ingestion of site soils and groundwater;

- Mitigate the migration of constituents of concern from the site groundwater to the nearby surface water streams, and to the interconnected aquifers, if any. The water table aquifer at the site is not used or likely to be used for drinking water purposes as the City of Virginia Beach Public Utilities Department has indicated that it is standard practice to prohibit the use of the shallow water aquifer as a potable source, and therefore, restoration of the aquifer to drinking water levels is not considered a part of the objective; and

- Mitigate the human health risks attributable to Site 7 associated with ingestion of surface water in Little Creek Cove and local canals near the site.

3.0 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

General response actions are presented in this section to achieve the RAOs developed in Section 2.2. Then, specific remedial technologies associated with the general response actions are described. The discussion of these remedial technologies associated with a typical cleanup of contaminated soil and water media were developed from: the Interim Final Guidance for Conducting RI/FS under CERCLA (October 1988); the Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (December 1988); the revised Handbook for Remedial Action at Waste Disposal Sites (1985); experience on other hazardous waste projects; knowledge of new technologies; and the best professional judgement of Foster Wheeler Environmental Corporation engineers and scientists performing feasibility studies.

3.1 General Response Actions

Remediation technologies are categorized in terms of general response actions. General response actions (GRAs) are broad categories of remedial actions capable of addressing the contamination problem at the site. Some response actions may be sufficiently broad to be able to satisfy all the remedial action objectives and cleanup goals for the site by themselves. Other response actions must be combined in order to achieve the site remedial goals and cleanup objectives.

Based on the existing knowledge of the site, general response actions identified for remediation include: no further action, limited action or institutional controls, containment, removal, collection, on-site and off-site treatment, and on-site and off-site disposal. These response actions are applicable to all affected media, soil, groundwater, surface water, and sediments, and are summarized below.

No Further Action: The NCP and SARA require the evaluation of a No Further Action alternative as a basis for comparison with other remedial alternatives. CERCLA mandates a five-year review be conducted to determine whether or not the contamination has spread. If necessary, appropriate action would be considered at that time.

Institutional Controls Action: For this category of response action, no active remedial measures would be conducted. However, existing and new monitoring wells at the site would typically be used to conduct a long-term groundwater monitoring program. Periodic monitoring of soil can also be carried out. At NAB Little Creek sites, monitoring of surface water and sediments is also considered appropriate due to the potential for release of contaminants of concern into these media. Monitoring is implemented to provide data to evaluate changes in site conditions and to assess potential risks over time.

The limited actions usually include institutional controls which can reduce potential hazards by reducing, controlling or eliminating exposure to hazardous chemicals. These control measures typically include site access restrictions, public awareness and educational programs, restriction on groundwater usage in a specified area, and warnings against excavation and use of soil in the area.

Containment Actions: These actions include technologies that involve little or no treatment, but provide protection of human health and the environment by reducing the mobility of contaminants of concern and risks of exposure. Containment technologies may require periodic monitoring to determine their effectiveness. Containment actions consist of controlling groundwater movement through the use of

technologies like capping, and horizontal and vertical barriers. Capping is an effective containment measure at landfills to control volatile emissions from soils, eliminate direct exposure, and reduce infiltration of contaminants with precipitation.

Removal technologies for solids refer to methods used to excavate and handle soils, sediments, wastes, or other solid materials. Removal technologies for groundwater refer to methods used to collect or extract groundwater such as extraction wells and interceptor trenches. These actions reduce the mobility of the contaminants of concern through physical removal. Removal technologies provide no reduction in toxicity or volume of wastes, but are usually used in conjunction with treatment or disposal technologies. Removal technologies may also be used to reduce migration, as in the case of groundwater gradient control.

Disposal: This category of response action can occur on-site or off-site. Disposal actions like collection reduce the mobility of the contaminants of concern through physical deposition and may be used separately or in conjunction with treatment technologies. However, by themselves, disposal actions do not reduce the toxicity or the volume of the media that contain contaminants of concern. For solid materials, disposal is usually accomplished in a properly permitted facility operating in full compliance with all applicable regulations. If the waste is treated, on-site disposal is an option. In the case of groundwater, disposal technologies typically include reinjection, discharge to surface waters, discharge to the public water supply system, and discharge to a publicly owned treatment works (POTW).

Treatment: This category of response action is preferred under SARA and can occur either on-site or off-site. Treatment technologies include physical, chemical, thermal and biological processes. Treatment technologies are preferred because they generally reduce the toxicity, mobility or volume of hazardous substances present at the site. Treatment technologies generally afford a higher degree of protection to public health and the environment, since the reduction in toxicity, mobility or volume is permanent in nature.

General response actions applicable to soils at the site are the following:

- No Further Action,
- Institutional Control Action,
- Containment, and
- Removal followed by Treatment and/or Disposal.

The general response actions for groundwater are the following:

- No Further Action
- Institutional Control Action,
- Containment Options, and
- Collection and Treatment.

The remediation efforts for surface water are driven by the fact that Little Creek Cove and the East and West canals are heavily tidally influenced. In this scenario, collection and treatment of surface water is not practical. The remediation efforts should focus on No Further Action, Institutional Control Action

and Containment, in conjunction with the response actions for groundwater. Therefore the applicable general response actions are:

- No Further Action
- Institutional Control Action, and
- Containment.

3.2 Remedial Technology Screening

The remedial technologies and associated process options are presented and screened in the following sections. The factors used in this screening process were based on the USEPA document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," October 1988 and included effectiveness, implementability, and relative cost. Brief definitions of effectiveness, implementability, and relative cost, as they apply to the screening process, are as follows:

Effectiveness - This evaluation focuses on the potential effectiveness of process options in handling the estimated volume of contaminated media and meeting the remediation goals; the potential impacts to human health and the environment during construction and implementation; and how proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability - This evaluation encompasses both the technical and administrative feasibility of the technology or process option. It includes an evaluation of pretreatment requirements, residuals management, the relative ease or difficulty in obtaining the required permits, the availability of equipment and materials, and operating and maintenance requirements. Process options that are clearly ineffective or unworkable at the site are eliminated.

Relative Cost - Cost plays a limited role in the screening process. Both capital as well as operating and maintenance costs are considered. The cost analysis is based on engineering judgement, and each process is evaluated as to whether costs are high, low or moderate relative to the other options within the same technology type.

3.3 Identification and Screening of Soil Remedial Technologies

Table 3-1 presents a summary of initial screening of soil remedial technologies.

3.3.1 No Further Action

The no further action alternative is evaluated to establish a baseline for comparison with other remedial alternatives for the site. CERCLA mandates a five-year review to be conducted to determine whether or not the contamination has spread. If necessary, appropriate action would be considered at that time.

TABLE 3-1

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Further Action	None	Not Applicable	No Action	Required for consideration by NCP
Institutional Controls	Access	Fencing	Fence to reduce site access. Restrictions	Applicable
	Legal Restrictions	Land Use Restrictions	Land use restrictions to restrict future site uses.	Potentially Applicable
	Public Education Programs	Restoration Advisory Board Meetings	Restoration Advisory Board meetings to restrict current and future land use on base.	Applicable
Soil Control Technologies	Soil Monitoring	Soil Sampling	Sampling and analysis of surface and subsurface soils.	Not applicable alone. Could be used in conjunction with other RAOs.
	Containment Technologies	Composite Clay Cap	Clay cap to prevent contact with soil and restrict infiltration of precipitation.	Potentially Applicable
		Soil Cover and Vegetative Layer	Soil layer to prevent contact with contaminated soil.	Not applicable because landfill already covered and vegetated.
Soil Removal Technologies	Excavation	Conventional Excavation Equipment	Removal of contaminated soil using conventional excavation equipment.	Potentially Applicable
	Off-Site Disposal	RCRA Hazardous Waste Landfill	Excavated soils are transported to a RCRA permitted facility for disposal.	Potentially Applicable
		Solid Waste Landfill	Excavated soils are transported to a permitted solid waste landfill for disposal.	Potentially applicable to nonhazardous contaminated soil.

TABLE 3-1 (continued)

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Soil Removal Technologies	Excavation	Conventional Excavation Equipment	Removal of contaminated soil using conventional excavation equipment.	Potentially Applicable
	Physical Treatment	Stabilization	The process involves mixing the soil with siliceous material and various setting agents.	Potentially Applicable
		Solids Processing	Involves modifying the size of solid material by physical means.	Potentially Applicable
		Solvent Extraction	Extraction of contaminants by organic solvents.	Not applicable to all contaminants of concern.
		In-Situ Vacuum Extraction	Subsurface organic contaminants are vacuumed up via well.	Not Applicable
		Soil Washing	The extraction of contaminants from soil by mixing with water solvent, surfactants, or chelating agents.	Potentially Applicable
		Soil Flushing	Similar to soil washing except for performed in-situ.	Potentially Applicable
	Chemical Treatment	Neutralization	Changing the pH from either acidic or basic to neutral.	Not Applicable
		Electro-Acoustic Soil Decontamination	Application of a DC electric field and an acoustic field to a decontaminate soils.	Not Applicable

TABLE 3-1 (continued)

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Soil Removal Technologies (continued)	Biological Treatment	Aerobic	System of injection and extraction wells to introduce bacteria and nutrients under aerobic conditions in order to degrade contaminants.	Potentially Applicable
		Anaerobic	Natural degradation of organic contaminants via microorganisms in an anaerobic environment.	Potentially Applicable
		Composting	Contaminated material is mixed with a bulking agent such as manure or leaves.	Potentially Applicable
		Land Farming/ Land Treatment	Aerobic digestion of biodegradable material by microorganisms.	Potentially Applicable
	Thermal Treatment	Rotary Kiln Incineration	Volatilization and oxidation of organics via contact with high temperatures and oxygen.	Potentially Applicable
		Vitrification	Involves combining the contaminated soil with molten glass at a temperature of 1,500 degrees C or greater.	Potentially Applicable
		Low Temperature Thermal Desorption	Use of moderate temperature (400 to 800 degrees F) to volatilize organics.	Potentially Applicable

3.3.2 Institutional Controls

Institutional control options include access restrictions, land-use restrictions, and public education programs.

Access Restrictions: Fencing is one of the options to restrict direct access to the site. There is a chain link fence bordering the site to the south and east. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Little Creek Cove borders the northern side of the site. Locked gates control access to the site. Another form of access restriction is posting warning signs. This can eliminate the risk pathways associated with ingestion or dermal contact by a child or an adult casually wandering in. Fencing would not reduce toxicity, mobility, or volume; and it would not be effective in reducing exposure to groundwater contamination.

Land-use restrictions: Probable land-use restrictions include prohibiting excavation or any other intrusive activities at the site. In order to reduce exposure to groundwater, installing new wells screened in the water table aquifer can be prohibited. A more severe measure would be prohibiting the use of existing wells within a certain distance from the site. Also, no new well development in the deeper Yorktown aquifer is anticipated in the vicinity of the site.

Public Education Programs: As part of the community involvement effort, area residents would be appraised of the potential risks and their magnitude by preparation and distribution of informational press releases and circulars, and conducting public meetings. NAB Little Creek has been conducting Restoration Advisory Board (RAB) meetings, open to the public, at regular intervals.

3.3.3 Soil Control Technologies

Soil Monitoring: Soil monitoring would include periodic sampling and analysis of surface and subsurface soils. Soil monitoring technology is not effective in achieving response objectives or in meeting ARARs. However, soil monitoring is required to monitor soil contamination and to evaluate the progress and effectiveness of any soil remediation that is implemented at the site. Even if no soil remediation is implemented, monitoring at hazardous waste sites is usually conducted to determine whether contaminant concentrations have decreased to safe levels through natural flushing and/or attenuation. Soil monitoring is easily implemented, but would require long-term management efforts. At the site, soil monitoring will have to be conducted if No Action or Institutional Control alternatives are chosen.

Containment Technologies: The technology for in-situ containment of contaminated soils is capping the contaminated areas with a low permeability cover to reduce infiltration and subsequent leaching of contaminants from the soil into the groundwater, and to reduce potential direct contact hazards.

Capping: Two capping options will be considered: 1) a RCRA cap, 2) a multi-media (soil and HDPE liner) cap.

A RCRA cap is a multi-layer cap satisfying the requirements of the EPA's RCRA Guidance Document, (Surface Impoundments, Liner Systems and Freeboard Control, July 1982). The RCRA cap consists of a two-foot thick compacted clay layer overlain by a high density polyethylene (HDPE) synthetic membrane

liner, HDPE synthetic drainage net, and 2 to 3 feet of clean fill and topsoil. The topsoil layer would be vegetated with grass to resist erosion.

A multi-media cap is a simplified version of the RCRA cap, and would consist of a 6-inch sand layer, overlain by an HDPE liner and synthetic drainage net, overlain by 2 to 3 feet of cover soil, and vegetation to resist erosion.

The placement of a cap over the contaminated soil areas of the site would provide containment and reduce potential surface contact hazards posed by contaminated soils. A cap is also effective in minimizing infiltration and subsequent leaching of contaminants in underlying soil.

A RCRA cap and a multi-media cap are both considered extremely effective in limiting infiltration, and subsequent leaching of contaminants from the underlying soil. Both caps would require periodic maintenance to prevent excessive erosion and to ensure the continued integrity of the liners.

Both types of caps are equally effective in reducing the potential for direct contact with contaminated soil, and could be implemented to prevent direct contact with surface soils and limit infiltration through the subsurface contaminated soils. The RCRA cap would be the most difficult to implement because the overall thickness of a typical RCRA cap is 5 to 7 feet. If surface soil contamination surrounds existing buildings or other structures, constructing a RCRA cap can be very difficult around those buildings. There is no such concern at the site. A multi-media cap would be easier to construct since it can be only 3 to 4 feet thick. With the RCRA and multi-media caps, the capped area must be protected from future land use in order to protect the integrity of the cap.

3.3.4 Soil Removal Technologies

The potentially applicable technology for removal of contaminated soil is excavation. Excavated soil would be treated or disposed, and the excavation would then be backfilled with clean fill.

Excavation: The horizontal and vertical extent of contamination in surface and subsurface soils has not been delineated precisely. Therefore, the extent of excavation required to achieve the target cleanup levels is difficult to estimate. However, the excavation option at the site, for example, may involve a million cubic yards of soils. Excavation of such an amount of soil is a relatively large operation and may be difficult to implement without disturbing the adjoining site operations. Structural supports are usually required during excavation of contaminated soil near existing structures; however, this may not be a concern at the site. Excavation would require staging areas for equipment, a stockpile area, and equipment operating areas.

Excavation uses standard earthmoving equipment which is readily available, but the excavation would have to be carefully staged and managed in order to reduce the possibility of spreading contamination via fugitive dust emissions, storm-water runoff, and infiltration of precipitation through contaminated soil stockpiles. There are risks of exposure to dust containing metals and SVOCs during excavation of the contaminated materials. Ambient air monitoring and appropriate health and safety measures would be required in order to protect worker health and safety.

Excavation is not intended to reduce the toxicity or volume of contaminated soil; however, it is required for subsequent treatment or off-site disposal.

3.3.5 Soil Disposal Technologies

Soil disposal can be accomplished either at on-site or off-site landfills. Given the site background and current usage at NAB Little Creek, the on-site landfill option is ruled out. Disposal at off-site landfills would involve transportation by a licensed hazardous waste hauler, preparing appropriate manifests, following all DOT regulations, and finally disposing the soils at an approved, permitted commercial facility. Facilities located in Virginia, Pennsylvania, the Carolinas, and Maryland would probably be used. Additional analysis such as Toxicity Characteristic Leaching Procedure (TCLP) may be required to characterize the contaminated soil. For those areas where TCLP results are above the regulatory levels, the waste will have to go to a permitted facility as a RCRA hazardous waste. However, such a scenario is not anticipated.

3.3.6 Soil Treatment Technologies

A large number of treatment technologies are applicable to the contaminants of concern in the soil. Some of these technologies can be applied in-situ (without excavating the soil) while others require excavation prior to treatment (ex-situ). On-site treatment can be accomplished by mobile treatment units that can be set up at the site on a temporary basis, or by a semi-permanent treatment system which may be constructed at the site. On-site treatment is usually more cost-effective than off-site treatment because of the elimination of transportation costs, which typically comprise a large portion of overall costs for off-site options. Potentially applicable treatment technologies for soil include:

Physical Treatment: Physical treatment involves technologies which separate chemicals from the soil, whereupon the soil may then be backfilled or treated further by other methods. Physical treatment processes that may be applicable at the site include stabilization (both in-situ and ex-situ), solids processing (including crushing, grinding, or sieving to size-segregate material for subsequent treatment), solvent extraction, soil vapor extraction, soil washing, and in-situ soil flushing.

Stabilization: Stabilization, also referred to as solidification or fixation, applies to processes involving mixing of a setting agent with excavated or in-situ contaminated soils to form a durable product in which contaminants are chemically bound and/or entrapped by the solidified mass. Typical additives include Portland cement, flyash, kiln dust, lime, soluble silicates, gypsum, and various combinations of these materials.

The purpose or goal of stabilization is to improve the handling and physical characteristics of sludges, and/or to reduce the mobility of the contained pollutants. Stabilization may be required for residual sludges or ash from other types of treatment processes prior to disposal.

Organic wastes are not effectively immobilized by some stabilization processes. For example, organics interfere with the setting reaction of Portland cement, affecting the durability and the characteristics of the final product. Generally, this precludes the use of cement stabilization as a treatment for organic wastes. Recently, however, it has been reported that PCB-contaminated soils and sediments have been successfully treated with the addition of organophilic clays to reduce PCB mobility.

Silicate-based processes involve the addition of a source of silicates along with a setting agent. Silicates are often added in the form of fly ash, blast furnace slag, cement kiln dust, or soluble silicates (e.g., potassium or sodium silicate). The setting agent is typically Portland cement or lime, although other suitable materials are available.

In-situ stabilization (soil mixing) of the surface and subsurface contaminated soils can be performed using equipment and technology available from service vendors. Stabilization of excavated soil or residual treatment sludges can be performed in mixing pits. Ex-situ stabilization can also be performed in batches, but the preparation of materials involves the additional expense of excavation and additional risk of exposure of site workers.

A stabilization option can be applicable to soils at the site if treatment is the preferred method.

Solids Processing: Solids processing utilizes sorting, crushing, grinding, shredding and screening to either sort out undesirable materials or modify the size of solid materials. Screening of site wastes may be useful to help dewater and size-segregate debris prior to treatment. Screening may be applied to a wide range of soils and mixed debris. Separation of soils according to size helps improve production from crushing and grinding operations. Crushing and grinding may be used to reduce the size of solid wastes and mixed debris prior to treatment or disposal. Reducing the size of the waste particles can enhance subsequent waste treatment: 1) by liberating the hazardous waste from inert material; 2) by increasing specific surface area; and 3) by breaking down oversized particles resulting in uniformly sized particles for subsequent physical separation.

Solids processing is a well established technology which utilizes readily available equipment. Physical hazards as well as the potential for dust emissions would have to be addressed.

Based on the evaluations presented so far, only stabilization will be the applicable treatment technology carried forward to the remedial alternative development stage. Institutional controls, capping, excavation, and disposal are also screened for further consideration as elements of remedial alternatives.

Solvent Extraction/ Chemical Extraction: Organic solvents, amines, or other polar solvents are used to extract organic hazardous compounds from the soil/sludge matrix. With proper mixing and temperature, high removal efficiencies are achieved in this process. This technology is suitable for sludges contaminated with oils and semivolatile organics. The extracting solvent must be immiscible with the aqueous phase and the density differential enables eventual separation. Use of this technology requires excavation and possibly transport of site soils. Further, the treatment does not destroy the contaminants. Solvent extraction is not effective in removing heavy metals, and therefore will not be considered further.

Soil Vapor Extraction: In-situ vacuum extraction removes VOCs from soil in the vadose or unsaturated zone. Subsurface organic contaminants are "vacuumed up" via a well; vapor and liquids are separated; and vapor is released to the atmosphere after activated carbon treatment. This is a simple technology and does not require highly trained operators or sophisticated equipment. Recovery rate is a function of the volatility of the contaminants, porosity of the vadose zone soils, and depth to groundwater. Use in saturated, tarry or clayey soils is greatly restricted. This technology is primarily applied to VOCs, which are not a concern at the site.

Soil Washing: Soil washing mixtures employ water, surfactants, and oxidizing or reducing agents to extract contaminants in the soil matrix. Many vendors have developed proprietary reagents to enhance soil washing. Soil washing is effective for removal of heavy metals and other inorganics from coarse soils. Washing fluids with good extraction coefficients and proper mixing are the keys to the success of this process. This technology has recently been selected at many remedial sites. Soil washing is limited in its effectiveness to remove organics from soil, and also needs excavation as an initial step. Therefore, this technology is not a candidate for consideration in the development of remedial alternatives.

Soil Flushing: Soil washing, conducted in-situ, is soil flushing. However, the injection/recirculation of washing fluids, soil characteristics, and uniformity become important parameters. Soil porosity and mobility of washing fluids and contaminants have to be well demonstrated before undertaking an in-situ remedy. Also, the washing fluids and solvents need to be less volatile and non-toxic, and safe and easy to handle. Soil flushing is not very effective in removing organics in soil. At Site 7, where subsurface characterization has not been fully undertaken, there are risks of spreading the flushing liquids, and with it, the site contaminants further into the subsurface. These risks outweigh any benefits offered by the technology.

Chemical Treatment: Chemical treatment processes involve chemical reactions with specific contaminants. These reactions modify the contaminant so it is no longer hazardous or so that it may be removed from the soil by some other process, often a physical removal. Neutralization and electro-acoustic soil decontamination (ESD) are two technologies potentially applicable to site soils.

Neutralization: Neutralization is the process of changing the pH of the solution from acidic (below 7) or alkaline (7-14) to a neutral value of 7. Waste acids and alkalis are neutralized to eliminate their reactivity and corrosivity. The process should be performed in a well-mixed system. Care should be taken to ensure completeness, compatibility, and prevent any formation of toxic products. This can be an inexpensive process if waste acids are used to neutralize waste alkalis (equalization). Neutralization is applicable only if liquid waste, either acidic or alkaline, is present. Neutralization or pH adjustment can also be used as a pretreatment for other processes. Since there is no liquid waste present, application of this technology in conjunction with other technologies at the site is limited.

Electro-Acoustic Soil Decontamination (ESD): This process is based on the synergistic application of a d.c. electric field and an acoustic field to contaminated soils to increase the transport of leachants through the soils. Applicability has been demonstrated for removal of heavy metals such as zinc and cadmium, and other ionic compounds. It can be applied in-situ. The technology is still on a laboratory scale and will not be considered any further.

Biological Treatment: Biological treatment uses microorganisms to biodegrade organic contaminants. Both aerobic (requires oxygen) and anaerobic (does not require oxygen) processes can be utilized, dependent upon the compound requiring treatment. Biodegradation can be conducted both in-situ and ex-situ at the site.

Aerobic Biological Treatment: Organic molecules, primarily hydrocarbons, are oxidized to carbon dioxide and water by microorganisms. These microorganisms require adequate levels of inorganic and organic nutrient growth factors, oxygen, and sufficient biologic space. Aerobic treatment is used to treat aqueous waste with low levels (BOD < 10,000 ppm) of non-halogenated organics and can easily handle

variable wastewater and pollutant loads. The treatment requires consistent, stable operating conditions. The process can be conducted in aerated lagoons, lined ponds, or in a trickling filter design. Large surface area and retention time are key factors to ensure proper mixing. Light/nutrient imbalances may result in algae blooms. Most of the organic contaminants can be destroyed in this manner if sufficient microbial population, nutrients, oxygen, and biological mobility are present.

Anaerobic Digestion: Reduction of organic matter is achieved in an oxygen-free environment. A number of proprietary engineered processes based on this principle are being marketed. An airtight reactor is usually required to control the process and to sustain the anaerobic mechanism. Anaerobic processes can handle organic loads higher than the aerobic process, and aqueous wastes with low to moderate levels of organics can be treated. Certain halogenated organics are treated more efficiently in anaerobic methods.

In-Situ Biological Treatment: Organic contaminants in subsurface soils and groundwater are treated by special strains of cultured bacteria and naturally occurring microorganisms. Usually the process is aerobic, and proper pH, temperature, and oxygen concentration should be maintained. Nutrients have to be pumped into the system. Interaction of microbes, oxygen, and nutrients is facilitated in a relatively coarse/permeable soil. Care must be taken not to drive the contaminants into deeper zones by minimizing their mobilization during the process. Moderate levels of risk reduction can easily be achieved by this process. This technology has not yet been fully demonstrated. A pilot-scale study is highly recommended prior to a full-scale setup.

Composting: Composting involves the storage of highly biodegradable and structurally stable material (e.g. wood chips) with a small percentage (less than ten percent) of biodegradable waste. Adequate aeration and optimum temperature and moisture conditions have to be maintained. Composting is relatively insensitive to toxicants. It has not yet been widely used in the hazardous waste field, but it is potentially applicable to soils and sludges with high levels of organic contaminants. It is imperative to collect composting leachate and treat it if required.

Land Farming/Land Treatment: This is a mechanism to conduct aerobic digestion on-site. The contaminated soil is excavated and staged in the designated area, in a layer of pre-determined thickness. Better control of the operating conditions is possible as compared with the in-situ option. The reaction times are higher, but costs are lower as compared to a bioreactor. The phenols, PAHs, and VOCs in soils can be destroyed in this manner.

Biological treatment is a preferred technology for organic contaminants, but is not effective for metals. Therefore, it will not be considered further in the compilation of remedial alternatives.

Thermal Treatment: Thermal treatment technologies utilize elevated temperatures to modify or destroy contaminants in the soil. Thermal treatment processes that may be potentially applicable at the site include low temperature thermal desorption, incineration, and in-situ vitrification.

Rotary Kiln Incineration: Wastes and auxiliary fuels are introduced to the high end of an inclined, rotating kiln. Ash residue and exhaust gases are collected at the low end of the kiln and may be further treated. This technology is intended primarily for solid organic waste. Explosive waste and wastes with

high inorganic salts/heavy metals require special evaluation. Lead emissions can pose a serious problem in this setup if lead is also present.

Vitrification: Hazardous wastes are converted into a glassy substance utilizing very high temperatures. This is usually done in-situ by inserting large electrodes into the soil, with graphite providing the starter path. Between 1000 to 2000 °C, many organics are destroyed by pyrolysis, and inorganics are immobilized when the soil melt cools down. The process is effective only on soils with significant levels of silicates. The process has been applied to radioactive waste. Environmental impacts from off-gas must be considered. The process is more appropriate to soils with high levels of heavy metals and silicates.

Low Temperature Thermal Desorption (LTTD): Volatile and semi-volatile organics can be removed at moderate temperatures (up to 600 °C) from the contaminated soil. An inert carrier gas is typically used to transport volatilized organics and water. Organics are condensed and treated separately. Several different desorber/dryer designs are available. The process is designed to separate organics without any decomposition. Levels below 1 ppm are usually accomplished. Some of the less volatile chemicals may not be volatilized at low temperatures, especially if they are bound in a tarry sludge matrix.

Thermal treatment technologies are usually at the high end of the cost spectrum and therefore do not offer a cost-effective solution to the low levels of contamination observed at the site. Therefore, these technologies will not be considered further.

3.4 Identification and Screening of Groundwater Remedial Technologies

Table 3-2 presents a summary of initial screening of groundwater remedial technologies.

3.4.1 No Further Action

The No Further Action alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives for the site. CERCLA mandates a five-year review to be conducted to determine whether or not the contamination has spread. If necessary, appropriate action would be considered at that time.

3.4.2 Institutional Controls

Institutional control options include access restrictions, land-use restrictions, and public education programs.

Access Restrictions: Fencing is one option to restrict direct access to the site. A chain link fence borders the site to the south and east. Locked gates control access to the site. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Another form of access restriction is posting warning signs. This can eliminate the risk pathways associated with ingestion or dermal contact by a child or an adult casually wandering in. Fencing would not reduce any toxicity, mobility, or volume; as well as not being effective in reducing exposure to groundwater contamination.

TABLE 3-2

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Further Action	None	Not Applicable	No Action	Required for consideration by NCP
	Monitoring	Groundwater Monitoring	On-going monitoring well sampling.	Potentially Applicable
Institutional Controls	Land Use Restrictions	Base Master Plan	Use of Base Master Plan to restrict current and future use of groundwater on the Base.	Potentially Applicable
		Land Use Restrictions	Land use restrictions to restrict future use of groundwater, denial of well permits, and acquisition of groundwater rights.	Potentially Applicable
	Public Education Programs	Meetings, Written Notices, etc.	Public education activities such as meetings and written notices to inform the public of potential health risks associated with groundwater usage.	Potentially Applicable
Groundwater Containment Technologies	Barriers	Horizontal	Slurry walls, sheet-piling cut-off walls.	Potentially Applicable
	Gradient Control	Extraction Wells	Use of extraction wells to control groundwater flow.	Potentially Applicable
Groundwater Collection Technologies	Collection	Barrier Drain Systems	System of perforated pipe laid in trenches and backfilled with permeable media to intercept and collect contaminated groundwater.	Potentially Applicable
		Extraction Wells	Series of wells to extract contaminated groundwater.	Potentially Applicable

TABLE 3-2 (Continued)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Groundwater Treatment Technologies	Physical Treatment	Sedimentation/ Clarification	Removal of solids from dilute suspensions through gravity settling.	Potentially applicable for metals pretreatment of groundwater.
		Filtration	Process by which suspended solids are removed from solution by forcing the fluid through a porous membrane.	Potentially applicable for metals pretreatment of groundwater.
		Air and Steam Stripping	Mixing large volume of air or steam with water in a packed column or diffused aeration chamber to promote transfer of VOCs to air.	Potentially Applicable
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through a carbon vessel.	Potentially Applicable
		Reverse Osmosis	Use of high pressure to force water through a membrane leaving contaminants behind.	Potentially Applicable
	Chemical Treatment	Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water.	Potentially Applicable
		Chemical Precipitation	Adjustment of pH of a solution to a value where the constituents to be removed have their lowest solubilities.	Potentially applicable for metals pretreatment of groundwater.
		Chemical Oxidation Enhanced by UV Photolysis	Oxidation of waste stream with UV light to destroy contaminants.	Potentially Applicable

Land-Use Restrictions: Probable land-use restrictions to reduce exposure to groundwater include prohibiting installation of new wells screened in the water table aquifer. A more severe measure would be prohibiting the use of existing wells within a certain distance from the site. Also, no new well development in the deeper Yorktown aquifer is anticipated in the vicinity of the site.

Public Education Programs: As part of the community involvement effort, area residents would be apprised of the potential risks and their magnitude by preparation and distribution of informational press releases and circulars and conducting public meetings. NAB Little Creek has been conducting Restoration Advisory Board (RAB) meetings, open to the public, at regular intervals.

3.4.3 Groundwater Containment Technologies

Slurry Walls: Subsurface barriers such as sheet piling cut-off walls or slurry walls constructed of low permeability material have been used on many sites to control groundwater movement. Vertical barriers control groundwater by restricting movement across the barrier. The slurry wall is constructed by backfilling an excavated trench with bentonite slurry. Sheet piling cut-off walls consist of interlocking metal sheets, which may be plastic-coated to prevent galvanic corrosion, that are driven into the ground using a pile driver or similar device. Construction of slurry walls is technically feasible unless the depth becomes excessive. The cost of this option depends on the area which needs to be covered and the depth.

Slurry walls do not reduce the toxicity or volume of contaminated groundwater. They are effective in controlling contaminated groundwater mobility if the bottom of the slurry wall intersects a natural zone of low permeability, i.e. a confining clay layer. At the site, almost the entire area has a clay layer underneath the fill material and sand layer. This clay layer is generally encountered at 20 to 25 feet bgs and no more than 40 feet bgs. Therefore, slurry walls can be a potential containment measure, keyed onto the clay layer.

Slurry walls are also used at some sites to reduce groundwater flow through the source and subsequent leaching of contaminants into the groundwater. At the site, these considerations do not apply.

Other measures: Extraction wells are used as a containment measure, a discussion of which is presented under the collection technologies. Caps of various type present another groundwater containment option by preventing infiltration. Cap technologies are discussed under soil control technologies in Section 3.3.3.

3.4.4 Groundwater Collection Technologies

Groundwater collection technologies involve the active manipulation (pumping) and management of groundwater prior to subsequent treatment and/or disposal. Collection technologies are utilized to remove the contaminated groundwater from the aquifer and to physically prevent or reduce plume migration. The selection of an appropriate groundwater collection system depends upon the objectives of the remedial action, the depth of contamination, and the geologic and hydrogeologic characteristics of the aquifer.

Barrier Drain Systems: The barrier drain system uses trench drains, tile drains or dual media drains to collect and extract the groundwater downgradient of the contamination plume. This system is most useful in formations with low transmissivity and when the flow of contaminated groundwater must be controlled

over a large area. It creates a continuous zone of influence in which groundwater flow is directed toward the drain. The major activities associated with construction of subsurface drains are trench excavation, trench stabilization, and installation of a perforated drain pipe and associated filter materials. The barrier drain extraction system is well-demonstrated and highly reliable. Drains installed to depths in excess of 30 feet are difficult to construct and generally do not perform well. Barrier drains involve long-term operations and do not treat groundwater, but act only as a preliminary collection step. The cost to install barrier drains is relatively low to moderate. The hydrogeological characteristics at the site need to be properly modeled before this option can be considered.

Extraction Wells: Extraction well systems consist of a series of wells installed into a stratum to remove contaminated groundwater. These systems are most useful in formations with high transmissivity. They can be installed and screened at any desired depth and location. The zone of influence and amount of water that can be pumped from these wells depends primarily on the aquifer characteristics. The extraction wells do not directly reduce the volume or toxicity of the contaminated water, but are used rather as a support process prior to implementing a treatment technology. Additionally, the wells can be used for gradient control to reduce the rate of contaminant migration. A scheme of varying the flow rates can be used to optimize the removal from a specific zone of contamination. The extraction well system is well-developed and highly reliable at hazardous waste sites. The cost of extraction well systems depends on the number of wells, their depths, and the rate of pumping. The relative costs for this technology are moderate. This technology option will be considered for the site.

3.4.5 Groundwater Disposal Technologies

Groundwater disposal can be accomplished either by reinjection, surface water discharge, transportation to a local publicly owned treatment works (POTW) or a commercial treatment facility. Either reinjection or surface water discharge would require a National Pollutant Discharge Elimination System (NPDES) permit, and these options can be considered only if extracted groundwater is treated to MCLs. It is not yet determined whether a local POTW capacity is available. Disposal in a commercial treatment facility would require permitting similar to soil disposal. These options can be further evaluated only after the groundwater remediation strategy is further refined.

3.4.6 Groundwater Treatment Technologies

Treatment can be conducted on-site using mobile units or more permanent treatment plants contained within buildings, or conducted off-site at a treatment facility. Although the same remedial technologies are applicable for on-site or off-site treatment of contaminated groundwater, on-site treatment should be considered first to minimize transportation and handling costs. The applicability of complete or partial on-site treatment depends primarily on the availability of land for the treatment facilities. It is expected that the groundwater treatment system would require a relatively large capacity and, therefore, off-site treatment would not be technically practical and cost-effective. The available technologies for treating groundwater include biological, physical and chemical processes.

Biological Treatment: Biodegradation is a treatment process whereby hazardous chemical substances (primarily organic chemicals) may be transformed to non-toxic or less toxic metabolites through the enzymatic action of microorganisms. Under optimum conditions, and through the use of appropriate organisms, such degradation mechanisms may result in the complete mineralization of organic chemicals

to carbon dioxide, water or methane, and biomass. Biodegradation of selected organic chemicals can be conducted through the use of chemical-specific aerobic or anaerobic microorganisms. Such organisms may be indigenous species that have been isolated and developed through various enrichment techniques or exogenous bacteria which were isolated from other sites or waste streams and developed for commercial use, or they may be cultures that have been genetically engineered to degrade various persistent synthetic compounds.

Biological treatment systems are dependent upon the ability of the microorganisms to biodegrade various organic substrates. Studies have shown that the availability of oxygen (for aerobic systems) and micronutrients like phosphorus and nitrogen, the proper pH, and temperature are important parameters to be considered for biological treatment systems to function properly. Additional factors that may also be necessary to biodegrade various organics include trace inorganic elements, cosubstrates such as glucose or other readily degraded organics, or possible analog enrichment. Several factors may have a negative influence on biological systems such as the presence of toxins or the formation of toxic metabolites, preferred substrates, and contaminant concentrations that are high enough to be toxic or inhibitory. In addition, it is possible that in some cases the groundwater contaminant concentrations are below the threshold concentration where enzymes are produced and thus result in no degradation. Often more than one species of microflora may be required to accomplish the complete degradation of a given substrate. In general, mixed microbial cultures have a greater biodegradative capacity and provide a better probability to reduce organic compounds to carbon dioxide and water.

Biological treatment could be applied to groundwater in-situ, or in a bioreactor system after collection/extraction. The processes can be classified as aerobic or anaerobic, depending on whether the microorganisms used thrive in the presence or absence of oxygen, respectively. Aerobic biodegradation is achieved in the presence of oxygen and is the most widely used biological process. Aerobic process options include activated sludge, trickling filters, and rotating biological contactors. Anaerobic biodegradation is performed by microorganisms that do not require oxygen. The most common anaerobic process, anaerobic digestion, produces methane and carbon dioxide as byproducts of the degradation process. New biotechnologies are considered to be those which use genetically engineered and mutated microorganisms. Theoretically, these organisms can be developed to feed on only the major site contaminants. These organisms are then released into the groundwater. After all the organic contaminants are destroyed, the microorganisms die from lack of food. This treatment method is still in the experimental stages.

Physical Treatment: Physical treatment processes utilize the differences in physical properties of the contaminants to separate them from water. The water may then be discharged or treated further by other methods. Potentially applicable physical treatment technologies include sedimentation, filtration, air and steam stripping, carbon adsorption, and reverse osmosis.

Sedimentation/Clarification: Sedimentation or clarification is a process used to remove settleable suspended particles from water. The equipment used produces quiescent hydraulic conditions so that gravitational forces are able to settle out the unstable solids. The typical designs of sedimentation tanks involve a sloping bottom to collect the settled solids and an overflow weir for the supernatant (clear) liquid. Once the particles reach the bottom, they are generally removed as an underflow, and their movement is assisted by a series of slowly moving paddles, rakes or arms. This technology can be used alone or in conjunction with precipitation.

Filtration: Filtration is a process in which suspended and colloidal particles which are not readily settleable are removed from water by physical entrapment on a given media. Fluid flow through the filter medium may be accomplished by gravity or it may be pressure induced. Beds of granular material like sand and anthracite are commonly used filters in water treatment. Other types of filters include vacuum filters, plate and frame filters, and belt filters. These are often used to dewater sludges produced by processes like sedimentation and chemical precipitation. Packed beds of granular material are usually backwashed to remove the filter cake. The collected solids will require disposal and their costs will depend on whether the material is considered hazardous or non-hazardous.

Air and Steam Stripping: Air stripping is a mass transfer process in which volatile contaminants in water are transferred to the gaseous phase. This process works best on contaminants with high volatility and low solubility. Generally, organic compounds with a Henry's Law constant greater than or equal to 3.0 liter-atm/mole can be readily removed from groundwater by air-stripping. Several contacting systems can be used, such as mechanical surface aerators, diffused aeration, spray or tray towers, open channel cascades, spray fountains, and counter-current packed towers. Surface aeration and counter-current packed towers are considered to be the most energy efficient systems. Air-stripping might require consideration of techniques to mitigate an atmospheric discharge of contaminants in the exhaust gas. Packed tower systems are more amenable to air pollution controls. Generally, vapor phase carbon adsorption beds, flare burner systems, and catalytic incineration are used for capture and/or destruction of the volatilized contaminants. In the counter-current packed tower configuration, water is distributed over the top of the packing material, while air is forced upward from the bottom of the tower. Primary factors which govern the efficiency of the process include the air-to-water ratio, pressure drop, tower height, surface area of the packing material, contact time, and temperature of the influent. Pretreatment of suspended solids and inorganics like iron and manganese, may be necessary to avoid deposition on, and subsequent clogging of, the packing material.

Steam-stripping uses steam to remove organics from aqueous waste in much the same way that air-stripping works, but because of the heat involved in the process, is sometimes more effective on some contaminants than air stripping alone. It is generally used for removal of organic compounds which are relatively less volatile and more soluble, and can handle a wider concentration range of contaminants in the influent stream. The towers used for steam stripping are generally smaller than those used for air stripping because the higher temperatures used provide a greater driving force for removal. However, the energy costs are generally much higher. Steam stripping is generally not used unless the contaminants include compounds like methyl-ethyl ketone, xylenes, etc.

Carbon Adsorption: Carbon adsorption removes organics from aqueous wastes via surface attachment between the organic solutes and the large internal pore structure of the activated carbon. This attachment within the pores is due to a force of attraction known as the Van der Waals force. The major parameters which influence the effectiveness of the adsorption include the solubility of the organic compound, the pH and temperature of the influent, empty bed contact time, and the surface area/volume ratio of the adsorbent. Typical activated carbon adsorption treatment systems include gravity flow or pressure flow columns in series and/or parallel configurations with backwashing capability. Granular activated carbon is generally used with loading rates of 0.5 to 5.0 gpm/sq.ft. This technology can treat single-phase waste streams with high molecular weights, high boiling points, low solubility and polarity, and relatively non-polar chlorinated hydrocarbons and aromatics. Concentrations of up to 10,000 ppm can be effectively treated using carbon adsorption; however, the process works best for aqueous streams with a

suspended solids' concentration less than 100 ppm and a concentration of dissolved inorganics, oil, and grease of less than 10 ppm. For these reasons, some pretreatment of the aqueous waste stream may be necessary. The spent carbon must be either regenerated at an appropriate facility, or disposed as a hazardous material.

Reverse Osmosis: Osmosis is a process which occurs whenever two solutions of different solute concentration levels reach an equilibrium across a semi-permeable membrane. The solvent (water in this case) will naturally flow from the less concentrated solution into the more concentrated solution. To reverse this process, the solution with the high concentrations must be pressurized to a level higher than the osmotic pressure. At sufficiently high pressures, usually 200-800 pounds per square inch (psi), the water will flow out of the more concentrated solution, leaving the contaminants trapped on the other side of the semi-permeable membrane. The volume of the concentrated waste is generally 10 to 20 percent of the feed volume. This concentrated waste will require additional treatment which is usually expensive. Reverse osmosis has been demonstrated to be effective for treatment of brackish waters and aqueous metal wastes, and recent findings indicate it is useful in removing some specific organics from solution. The effectiveness of this process is highly dependent on the chemical composition of the waste solution to be treated and the characteristics of the membrane.

Chemical Treatment: Chemical treatment processes generally involve destruction of hazardous substances by reaction with other chemical species to convert them into nonhazardous gases, liquids or solids. Potentially applicable process options include ion exchange, chemical precipitation, oxidation/reduction, and ultra-violet (UV) radiation induced photolysis. Chemical oxidation with ozone or hydrogen peroxide enhanced by UV photolysis is often a very effective combination and is discussed below.

Ion Exchange: Ion exchange is a process in which toxic ions are removed from solution by being exchanged with relatively harmless ions held by the ion exchange material. Both organics and inorganics can be removed by this process. However, removal of inorganics is more common. Ion exchange resins are manufactured for removal of a wide variety of organic and inorganic ions. A practical upper concentration limit for ion exchange is about 2500 to 4000 ppm. Contaminant concentrations in the groundwater at NAB Little Creek sites are well below these levels. Due to the large variety of ions present in the water, removal to levels below ARARs may be difficult. Generally, a train of resin beds in series containing different resins for organics, cation and anion removal are typically used. The beds have to be monitored for breakthrough and must be regenerated using a wide variety of regeneration chemicals which may themselves be hazardous. Ion exchange can be used both as a pretreatment and as a polishing step.

Chemical Precipitation: Precipitation is a physical and chemical technique that can be used to remove metals from an aqueous stream. The metals can be precipitated out of solution by changing the chemical equilibrium of the solution. It is generally achieved by adding a chemical that reacts directly with the metal to form an insoluble product. When used prior to other treatment technologies, this process eliminates the probability of reduced efficiency due to dissolved metals precipitation. The pH of the waste stream can be adjusted to optimize the precipitation process. Usually, the pH varies between 8 and 12. Metals can be precipitated as hydroxides, carbonates, and sulfides. Typical precipitating agents include calcium oxide, caustic soda, sodium sulfide, ferrous sulfide, and hydrogen sulfide gas.

Chemical Oxidation Enhanced by UV Photolysis: Chemical oxidation enhanced by UV photolysis is an emerging technology for cleanup and destruction of organics in groundwater. Commercial applications using hydrogen peroxide and ozone as the oxidant have been developed. UV light reacts with hydrogen peroxide and/or ozone molecules to form hydroxyl radicals. These very powerful chemical oxidants then react with the organic contaminants in the water. In addition, many organic contaminants absorb UV light and become more reactive to chemical oxidants. If carried to completion, the end products of the oxidation process are carbon dioxide and water. Both hydrogen peroxide and ozone form hydroxyl radicals under UV light catalysis.

The UV/oxidation treatment technology may be used to oxidize a variety of chlorinated hydrocarbons, including PCE and TCE. UV/oxidation will not eliminate inorganic contaminants; however, they could be removed by precipitation prior to allowing the feed stream to enter the UV/oxidation unit. The system has no filtering or adsorption media to dispose of or regenerate, and treats groundwater contaminated with VOCs without air emissions or generation of hazardous wastes. There is no secondary waste management necessary.

Design of a UV/oxidation treatment system is dependent upon many variables including the type and concentration of organic contamination, the light transmittance of the water, and the type and concentration of dissolved solids. Pretreatment of the contaminated groundwater may be necessary to reduce the suspended solids content, since excessive suspended solids can occlude the UV light, thus decreasing the effectiveness of the system. Additionally, precipitation of metals may be necessary to reduce scaling and fouling of the unit.

Groundwater treatment is a significant issue only for sites where aquifer restoration is the remedial action objective. Since this is not the case at IR Site 7, no groundwater treatment technologies will be retained for alternative development.

3.5 Identification and Screening of Surface Water Remedial Technologies

Table 3-3 presents a summary of initial screening of surface water remedial technologies.

3.5.1 No Further Action

The no further action alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives for the site. CERCLA mandates a five-year review to be conducted to determine whether or not the contamination has spread. If necessary, appropriate action would be considered at that time.

3.5.2 Institutional Controls

Institutional control options include access restrictions, land-use restrictions, and public education programs.

TABLE 3-3

INITIAL SCREENING OF SURFACE WATER REMEDIAL TECHNOLOGIES
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Further Action	None	Not Applicable	No Action	Required for consideration by NCP
	Monitoring	Five year review	Conduct a five year review to determine whether contamination has spread.	Potentially Applicable
Institutional Controls	Access Restrictions	Fencing and Warning Signs	Fencing to prevent access, warning signs against unauthorized access.	Potentially Applicable
		Land Use Restrictions	Land use restrictions prohibiting use of surface water for consumption, irrigation, fishing, or any other recreational purposes.	Potentially Applicable
	Public Education Programs	Meetings, Written Notices, etc.	Public education activities such as meetings and written notices to inform the public of potential health risks associated with surface water usage.	Presently being performed.
Surface Water Containment Technologies	Barriers	Vertical	Vertical barriers to restrict surface water flow in the canals and around the Base.	Potentially Applicable
	Run-on Prevention and run-off Interception	Run-on preventors and run-off interceptors	Use of run-on and run-off interceptors to limit contact of landfill leachate with surface water.	Potentially Applicable

Access Restrictions: Fencing is one option to restrict direct access to the site waters and nearby surface water bodies; but it is not practical. Another form of access restriction is posting warning signs. This can eliminate the risk pathways associated with ingestion or dermal contact by a child or an adult casually wandering in. Access restrictions would not reduce any toxicity, mobility, or volume; and they would not be effective in reducing exposure to groundwater contamination.

Land-use restrictions: Probable land-use restrictions include prohibiting any use of surface water for consumption, irrigation, or fishing from site shorelines.

Public Education Programs: As part of the community involvement effort, area residents would be apprised of the potential risks and their magnitude, which is currently being accomplished through RAB meetings.

3.5.3 Surface Water Containment Technologies

Vertical barriers can be constructed to restrict the surface water flow in the canals in and around the site. This will effectively eliminate migration of contaminants through surface waters. However, no such measure is conceivable for the Little Creek cove.

Another containment method is to institute run-on prevention and runoff interception measures around the landfill so that contaminants leached from the site soils would not be introduced into any surface water body.

3.6 Summary of Remedial Technology Screening

Based upon the discussions provided above, the most feasible remedial technologies identified for use at the site are summarized below.

Soils

Remedial alternatives for soils at the site were developed based on the GRAs and site-specific physical and chemical characteristics. Remedial alternatives for soils will address contaminants which equal or exceed the HI of 1 and/or the ICR of 1×10^{-4}. Remedial alternatives which may meet or exceed the RAOs for soils at the site are categorized as follows:

- Alternative 1A - No Further Action
- Alternative 2A - Institutional Control Action
- Alternative 3A - Installing a Multi-media Cap
- Alternative 4A - In-Situ Treatment by Chemical Fixation at Hot Spots
- Alternative 5A - Excavation and Off-site Disposal of Soils at Selected Hot Spots

Groundwater

Remedial alternatives for the site groundwater were developed based on the GRAs and site-specific physical and chemical characteristics. Remedial alternatives which may meet or exceed the RAOs for groundwater at the site are categorized as follows:

- Alternative 1B - No Further Action and Monitoring
- Alternative 2B - Institutional Controls
- Alternative 3B - Multi-Media Cap
- Alternative 4B - Multi-Media Cap with Vertical Barriers
- Alternative 5B - Multi-Media Cap with Vertical Barriers, Pumping & Treatment by Chemical Precipitation, Discharge to POTW

Surface Water

Remedial alternatives for the site surface water and sediments were developed based on the GRAs and site-specific physical and chemical characteristics. Treatment of surface water is not deemed necessary since TAL metals are the only contaminants of concern at this time; and the water is not used as a potable source. Remedial alternatives which may meet or exceed the RAOs for surface water at the site are categorized as follows:

- Alternative 1C - No Further Action and Monitoring
- Alternative 2C - Institutional Controls
- Alternative 3C - Surface Controls, Vertical Barriers, and Collection
- Alternative 4C - Run-on Prevention, Runoff Interception

3.7 Identification of Alternatives

Based on the requirements of the remedial action objectives and the evaluation of remedial technologies for the three media, the following five remedial alternatives have been identified for detailed analysis for the site:

- Alternative 1: No Further Action.
- Alternative 2: Institutional Control Action which will consist of land-use restrictions, development and implementation of a public awareness program, limitation of site access, and preparation of a top soil and vegetative cover on the open surfaces of the landfill and monitoring.
- Alternative 3: Capping the landfill using a Geosynthetic Clay Liner (GCL), monitoring groundwater and surface water quality, implementing institutional controls such as land

use restrictions and posting warning signs, and implementing a public awareness program.

- Alternative 4: All of Alternative 3, plus a groundwater containment measure such as a slurry wall around the entire landfill to prevent further migration of groundwater contaminants of concern.

- Alternative 5: All of Alternative 2, plus the selective removal and/or treatment of surface and subsurface soils.

4.0 DETAILED ANALYSIS OF ALTERNATIVES

The detailed evaluation of remedial alternatives at the site was prepared in accordance with the USEPA document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," October 1988. This evaluation was conducted using the following criteria:

Two Primary or Threshold Criteria:

- Overall protection of human health and the environment
- Compliance with ARARs

Five Balancing Criteria:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Two Modifying Criteria:

- State Acceptance
- Community Acceptance

This section defines these nine criteria. Each of the following five subsections present a detailed description of an alternative, and the alternative's detailed evaluation based on the first seven criteria. Evaluation according to the two modifying criteria, state and community acceptance, is not included in this document at this time, since the state and public have not been provided with a formal opportunity to review the detailed analysis of the remedial alternatives. Therefore, state and community response will be incorporated during finalization of this FS.

Overall Protection of Human Health and the Environment: This criterion assesses whether each alternative provides adequate protection of human health and the environment. Evaluation of the overall protectiveness of an alternative focuses on whether a specific alternative achieves adequate protection, and describes how site risks posed through each pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. The assessment of overall protection draws on the assessment of other evaluation criteria, especially compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness. This evaluation also allows consideration of whether an alternative poses any unacceptable short-term or cross-media effects.

Compliance with ARARs: This evaluation criteria determines whether each alternative will meet all of the federal and state ARARs that have been identified in Section 2.1. The following are addressed for each alternative during the detailed analysis of ARARs:

- Compliance with chemical-specific ARARs. This factor addresses whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with location-specific ARARs. This involves a consideration of whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with action-specific ARARs. This involves determination of whether the ARARs can be met or whether a waiver is appropriate.

Long-Term Effectiveness and Permanence: This evaluation addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals or untreated wastes. The following components of the criterion are addressed for each alternative:

- Magnitude of Residual Risk. This factor assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities.

- Adequacy and Reliability Controls. This factor assesses the adequacy and stability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site. It also addresses the long-term reliability of management controls for providing continued protection from residuals.

It also assess the potential need for replacement of the remedy and the continuing need for repairs to maintain the permanence of the remedy.

Reduction of Toxicity, Mobility or Volume: This evaluation criterion addresses the statutory preference for selecting remedial actions that use treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This evaluation focuses on the following specific factors for a particular remedial alternative:

- The treatment processes the remedy will employ, and the materials they will treat

- The amount of hazardous materials that will be destroyed, recycled, or treated

- The degree of expected reduction in toxicity, mobility, or volume, including how the principal threat is addressed through treatment

- The degree to which the treatment will be irreversible

- The type and quality of treatment residuals that will remain following treatment

- The degree to which treatment reduces the inherent site hazards

Short-Term Effectiveness: This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives are met. Under this criterion, alternatives are evaluated with regard to their effects on human health and the environment during implementation of the remedial action. The following factors are addressed as appropriate for each alternative:

- Protection of workers during remedial actions. This factor assesses threats that may be posed to workers and the effectiveness and reliability of protective measures that would be taken.

- Protection of the community during remedial actions. This aspect of short-term effectiveness addresses any risk that results from implementation of the proposed remedial action, such as dust from excavation, transportation of hazardous materials, etc.

- Environmental impacts. This factor addresses the potential adverse environmental effects that may result from the construction and implementation of an alternative, and evaluates the reliability of the available mitigation measures in preventing or reducing the potential impacts.

- Time until remedial response objectives are achieved. This factor includes an estimate of the time required to achieve protection for the entire site or for individual elements associated with specific site areas or threats.

Implementability: The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:

- Technical Feasibility: The relative ease of implementing or completing an action based on site specific constraints, including the use of established technologies, including:

    - Ability to construct the alternative as a whole (constructability)

    - Operational reliability, or the ability of a technology to meet specified process efficiencies or performance goals

    - Ability to undertake future remedial actions that may be required

    - Ability to monitor the effectiveness of the remedy

- Administrative Feasibility: The ability and time required to obtain any necessary approvals and permits from other agencies

- Availability of Services and Materials: The availability of the technologies, materials, or services required to implement an alternative, including:

  - Available capacity and location of needed treatment, storage, and disposal services

  - Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

  - Timing of the availability of prospective technologies under consideration

  - Availability of services and materials, plus the potential for obtaining bids which are competitive (which may be particularly important for innovative technologies)

Cost:

- Capital Costs: Capital costs consist of direct (construction) and indirect (non-construction and overhead) costs. Direct costs include costs for equipment, labor and materials incurred to develop, construct, and implement a remedial action. Indirect costs are expenditures for engineering, financial, and other services that are not actually part of construction, but are required to implement a remedial alternative.

- Operation and Maintenance (O&M) Costs: O&M costs refer to post-construction costs necessary to ensure the continued effectiveness of a remedial action. They typically refer to long-term power and material costs (such as the operational costs of a water treatment facility), equipment replacement costs, and long-term monitoring costs.

- Costs for Five-Year Review: CERCLA, as amended, Section 121(C) states that a five-year review of a remedial action is required if that remedial action results in hazardous contaminants remaining on-site.

- Present Worth Analysis: This assessment is used to evaluate the capital and O&M costs of a remedial alternative on a present worth basis. Present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year, usually the current year. This allows the comparison of remedial alternatives on the basis of a single cost representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. A discount rate (interest rate) of five percent has been used during this FS to calculate the present worth.

State Acceptance:

- The state's position and key concerns relative to the alternatives

- State comments on ARARs or the proposed use of waivers

Community Acceptance:

- The community's position and key concerns relative to the alternatives.

The evaluation of the state and community acceptance criteria will be incorporated after presenting the draft final FS to the State and RAB members; these criteria will not be discussed until that time.

4.1 Detailed Evaluation of Alternative 1: No Further Action

The No Further Action alternative is evaluated as a baseline for comparison with other alternatives, as required by the NCP.

4.1.1 Detailed Description of Alternative 1

The No Further Action alternative entails leaving the site as it currently exists with no additional remedial work to be performed within or outside the site boundaries.

Because this alternative results in contaminants remaining onsite, CERCLA §121(c) requires that the site be monitored and data be reviewed every 5 years for a period of 30 years to determine whether the contamination has spread. The no further action decision is then re-evaluated against the monitoring data, mobility of the contaminants is reassessed, and a determination is made as to whether or not additional remedial action(s) are necessary.

4.1.2 Overall Protection of Human Health and the Environment: Alternative 1

As no remedial actions are implemented under this alternative, human health and the environment are not protected. The human health risks, described in the risk assessment, from groundwater, surface water, and soil at the site would remain unmitigated. The possibility of groundwater being used as a potable water supply is highly unlikely because the aquifer underlying the site is not currently used for drinking water purposes. This alternative would not meet remedial action objectives and would not be protective of the environment as there would be no reduction in long- or short-term risks relative to existing (baseline) conditions. Other than the continued presence of contaminants onsite, there would be no direct impacts to wetlands under the No Further Action alternative.

4.1.3 Compliance with ARARs: Alternative 1

As this alternative does not remove contaminated soils or provide containment of contaminated materials, none of the applicable or relevant and appropriate RCRA standards (40 CFR Part 264 through 268) are met.

Federal and Virginia MCLs and health advisories are not achieved as the No Further Action alternative does not enable compliance with these criteria.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, are met under the No Further Action alternative since the wetlands and floodplains would not be disturbed. However, the No Further Action alternative does not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands.

4.1.4 Long-Term Effectiveness and Permanence: Alternative 1

This alternative does not effectively prevent or reduce the magnitude of risk to human health or the environment. The estimated risks identified in the risk assessment are not mitigated.

The No Further Action alternative does not result in a quantifiable long-term reduction in risk to ecological receptors since contaminated soils are left in place. Remedial action objectives are not met.

4.1.5 Reduction of Toxicity, Mobility, or Volume: Alternative 1

Because no treatment technologies are employed, the toxicity, mobility, or volume of contaminants are not reduced under this alternative.

4.1.6 Short-Term Effectiveness: Alternative 1

As no remedial activities are undertaken during this alternative, there are no potential impacts to workers responsible for implementing the alternative and no significant new risks to nearby residents are expected. This alternative does not result in a quantifiable short-term increase or reduction in risk to ecological receptors. Remedial action objectives are not met. Short-term habitat impacts due to remedial activities will not occur.

This alternative does not require any time to implement as it does not involve any remediation.

4.1.7 Implementability: Alternative 1

As no remedial measures are implemented under this alternative, implementability, constructability, and availability of materials and services are non-issues.

If additional remedial actions were required in the future, no component of this alternative would limit such options.

4.1.8 Cost: Alternative 1

The costs of this alternative are expected to be approximately $25,000 in Year Five for the five-year review and related monitoring.

4.2 Detailed Evaluation of Alternative 2: Institutional Control Action

The major components of Alternative 2 include:

- Fortification of the existing perimeter fence
- Land-use restrictions to restrict site access
- Implementation of a public awareness program including warning signs
- Reinforcement of existing soil/topsoil and vegetative cover
- Performance of semi-annual long-term environmental monitoring
- Performance of a five-year review of site conditions

4.2.1 Detailed Description of Alternative 2

This is a partial containment alternative with no treatment. As part of the Best Management Practice, NAB Little Creek has already undertaken various activities at the site to reduce any adverse human exposure to the contaminants of concern. The site access has been limited, and the loose materials at the site have been removed. A six inch soil cover has already been installed and vegetation planted which will reduce the risks from soil contact and ingestion. The top soil layer and the vegetative layer will be monitored and maintained on a periodic basis. Additional soil cover and topsoil will be added to portions of the landfill to prevent erosion and ensure the stability of the vegetative layer.

This alternative includes the development and implementation of a public awareness program about the hazards present at the site for the residents in the area surrounding the site. This program would include the preparation and distribution of informational press releases and circulars and conducting public meetings to seek public involvement in the remedial actions/decisions. These activities will serve to enhance the public's knowledge of the conditions existing at the site.

This alternative also involves implementation of land-use restrictions to limit on-site excavation, groundwater usage, and future land use. These restrictions will be incorporated into the Base Master Plan. The land use restrictions will be revisited only if the base property is transferred outside Navy's control in the future.

A chain-link fence around the perimeter of the site can prevent unknowing and unauthorized humans from gaining access to the surface water. Such a fence is already present along portions of the site. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Under this alternative, further fortification of this fence will be performed as appropriate. Warning signs will be placed along the fence.

As hazardous wastes remain onsite, long-term environmental monitoring of the site is necessary to monitor contaminant migration. Monitoring consists of semi-annual sampling of groundwater from nine existing monitoring wells as well as limited surface water and sediment sampling. Groundwater, surface water, and sediment samples will be analyzed for SVOCs, PCBs, and metals. Details of the monitoring activities will be finalized in the remedial planning stage. During this stage, trigger levels will be identified for the contaminants of concern. If trigger levels are exceeded, the remedial options may need

reevaluation. The trigger levels will be established by taking into consideration the RAOs for the site, the ARARs, and the fact that drinking water MCLs may not be the relevant trigger levels for this site.

Semi-annual monitoring analytical results will be reviewed at least every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. The data will be evaluated for contaminant migration trends, and will be compared to trigger levels. The remedy implemented will be re-evaluated against the new data and a determination shall be made as to whether any additional remedial action(s) are necessary.

4.2.2 Overall Protection of Human Health and the Environment: Alternative 2

Under this alternative, a reduction in short-term and long-term human health risks are anticipated, compared to Alternative 1, the "No Further Action" alternative. Contact with contaminants in site media is largely eliminated by fortifying the existing perimeter fence, keeping people away from the surface water, and by installing soil cover, reducing soil contact and ingestion.

It is anticipated that site-related health risks will be reduced by this alternative. Contact with contaminated soils would be reduced to acceptable levels due to the addition of top soil and land-use restrictions. The soil and vegetative cover will further reduce infiltration and subsequent migration of contaminants for site groundwater to nearby surface water. In addition, groundwater monitoring at the perimeter of the landfill will also ensure that such migration is not taking place. Thus, remedial action objectives are satisfied.

4.2.3 Compliance with ARARs: Alternative 2

This alternative does not remove contaminated materials, but lowers the potential for receptors coming into contact with contaminated media. The potential for contaminants to migrate from the area is reduced but not eliminated.

Federal and Virginia MCLs and health advisories are not achieved as this alternative does not involve any treatment and hence does not enable compliance with these criteria.

Actions triggering ARARs for this alternative include fence construction, posting warning signs, and addition of the soil and topsoil cover on the landfill. Requirements for these activities include OSHA health and safety standards. It is expected that these action-specific ARARs will be met by providing proper personal protective equipment, specified training, and safety equipment to all workers who perform remedial activities.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, are met under this alternative since the wetlands and floodplains would not be disturbed. However, this alternative does not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands.

4.2.4 Long-Term Effectiveness and Permanence: Alternative 2

The implementation of Alternative 2 mitigates part of the risks identified in the baseline risk assessment. The non-carcinogenic risk from ingestion of surface soil is mitigated by interrupting the exposure pathway. Installation of a six inch top soil cover effectively isolates the contaminated soils from potential receptors, thereby greatly reducing the potential risks. The carcinogenic and non-carcinogenic risks for ingestion of surface water and groundwater by trespassers and future residents is reduced to some extent by land-use restrictions, fencing, and a public awareness program. The residual risks should meet the criteria for carcinogenic and non-carcinogenic risks.

Long-term management activities would include semi-annual inspections and monitoring, top soil cover repair, vegetation control, and a five-year review as previously described. Over time, it is likely that the fence will be breached, requiring repair and additional education effort. However, regular fence inspection and repair ensures that frequent or routine exposures to surface water do not occur. Land-use restrictions are not completely effective as they could be disregarded by individuals unfamiliar with them or intent on performing actions in violation of the restrictions. It is anticipated that this alternative is effective for human health for the foreseeable future. However, it cannot be considered permanent as it relies on maintenance of the top soil and vegetative cover, land-use restrictions, and semi-annual inspections.

4.2.5 Reduction of Toxicity, Mobility, or Volume: Alternative 2

This alternative does not involve reduction of toxicity, mobility, or volume of the source of contamination or the contaminated soils. Reduction of the rainfall infiltration will minimize the source of surface water and groundwater contamination. This alternative provides no means for groundwater remediation. The water table aquifer at the site is not used or likely to be used for drinking water purposes as the City of Virginia Beach Public Utilities Department has indicated that it is standard practice to prohibit the use of the shallow water aquifer as a potable source.

4.2.6 Short-Term Effectiveness: Alternative 2

The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. The soil and topsoil cover on the landfill will be reinforced after surveying the areas which need the reinforcement. Because the addition and reinforcement of the soil and topsoil cover involves a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is a potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. Risk to workers due to dermal contact with contaminated soils is also possible. Risks will be mitigated by ensuring that workers are required to wear personal protection equipment.

The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. An appropriate local traffic control plan would be implemented to manage trucks and other vehicles. Air monitoring will be performed during site remediation activities to evaluate emissions. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions. Habitat impacts due to remedial activities will occur for a short period of time.

4.2.7 Implementability: Alternative 2

- Technical Feasibility

The installation of the fence and the reinforcement of the soil and topsoil cover are easily implementable tasks. The sampling and analysis of the samples, and the five-year site status reviews could also be accomplished with little difficulty.

- Availability of Services and Materials

The services and materials required to successfully implement this alternative are readily available in the area. Numerous contractors are available for competitive bidding to perform the work related to this alternative.

- Administrative Feasibility

Implementation of this alternative involves a fair amount of institutional administration. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. The development and implementation of the monitoring program and subsequent five-year site status reviews require the involvement of many concerned environmental agencies, such as, USEPA, Virginia Department of Health, and Virginia Department of Environmental Quality.

Implementation of this alternative involves the development and implementation of institutional controls in the form of land use restrictions that will limit on-site excavation. groundwater usage, and future development. To ensure land use restrictions are effectively implemented, they will be documented in the NAB Little Creek Master Plan, the comprehensive planning document consulted by Base personnel when making planning, development, and construction decisions. In addition, steps will be taken to document the land use restrictions in the NAB Little Creek and Atlantic Division, Naval Facilities Engineering Command real estate files.

Additional steps also will be taken to ensure if the Site is ever transferred to another Federal government entity or out of the Federal government's possession, the land restrictions would continue in effect if necessary based on the results of long term monitoring. If the Site were to be transferred to another Federal entity, the land restrictions would be included in the appropriate transfer documents, with monitoring conducted to ensure adherence to the restrictions. If the Site were to be transferred out of Federal possession, the land use restrictions would be included in the deed effecting the transfer, unless further remedial efforts were agreed upon or required by law. It should be noted that Federal government entities are subject to extensive requirements under CERCLA §120 (h) regarding cleanup of real property to be transferred out of Federal hands.

4.2.8 Cost: Alternative 2

The total present worth of Alternative 2, over a 30 year period with five percent discount rate, is approximately $1,380,864. This cost covers fence fortification, reinforcement of the soil/topsoil and

vegetative cover, semi-annual monitoring, a five-year review, management of vegetative cap on the open areas, public meetings, and administrative costs associated with land-use restrictions. For estimating purposes, it is assumed that a 1-foot thick cover will have to be reworked on 5% of the landfill, approximately 2 acres, and topsoil/vegetative cover on 25% of the landfill, approximately 10 acres. The details of these costs are shown on Table 4-1.

4.3 Detailed Evaluation of Alternative 3: A Geosynthetic Clay Liner on the landfill; monitor groundwater and surface water quality; institutional controls such as warning signs and prohibition of intrusive activities.

The major components of Alternative 3 include:

- Fortification of the existing perimeter fence
- Land-use restrictions to restrict site access
- Implementation of a public awareness program including warning signs
- Installation of a Geosynthetic Clay Liner (GCL) to minimize percolation of precipitation
- Performance of semi-annual long-term environmental monitoring
- Performance of a five-year review of site conditions

4.3.1 Detailed Description of Alternative 3

This is a total containment alternative with no treatment. In this alternative, a Geosynthetic Clay Liner (GCL) will be installed within the landfill boundary; this liner effectively substitutes for a clay cap. A geomembrane such as HDPE will be placed on top of the GCL, and a vegetative layer will be maintained over this cap configuration.

The public awareness program is identical to that described in Alternative 2, Section 4.2.1. It would include public RAB meetings and presentations and informational releases to ensure public awareness about the hazards present on site.

This alternative also involves implementation of land-use restrictions to limit on-site excavation, groundwater usage, and future land use as described for Alternative 2, Section 4.2.1.

A chain-link fence around the perimeter of the site can prevent unknowing and unauthorized humans from gaining access to the surface water. Such a fence is already present at portions of the site. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Under this alternative, further fortification of this fence will be performed as appropriate. Warning signs will be placed along the fence.

Prior to installation of a GCL, the top surface will be regraded and compacted to provide a stable foundation for placement of the GCL. The GCL will include an HDPE liner placed on top of the prepared surface of the landfill to serve as an impervious base. Then the GCL (a low permeability material) will be installed on top of the HDPE liner. It is estimated that the size of the landfill is about 38

TABLE 4-1

COST ESTIMATE SUMMARY
ALTERNATIVE 2 INSTITUTIONAL CONTROL ACTIONS AND MONITORING
SITE 7 - AMPHIBIOUS BASE LANDFILL

ITEM	Quantity	Capital Cost	Annual O&M	Present Worth O&M/Replacement 30 years, 5%
1. INSTITUTIONAL ACTIONS				
1. Public Awareness Program	NA	$10,000	$2,000	
2. Institutional Controls	NA	$10,000	$1,000	
3. Monitoring (15 samples semiannually)	30		$30,000	
4. Site Reviews	NA		$5,000	
5. 1-foot Soil Cover on Bare Areas	2 acres	$65,000		
6. Reinforcement of Topsoil/Vegetative Cover	10 acres	$160,000		
7. Management of Vegetative Cap	NA		$20,000	
8. Site Fencing Fortification (in linear ft.)	6,600	$66,000	$1,000	
Subtotal:			$59,000	$906,978
CONSTRUCTION SUBTOTAL		$311,000		
Health and Safety 5%		$15,550		
Bid Contingency 10%		$31,100		
Scope Contingency 10%		$31,100		
CONSTRUCTION TOTAL		$388,750		
Permitting and Legal 5%		$19,438		
Services During Construction 10%		$38,875		
TOTAL IMPLEMENTATION COST		$447,063		
Engineering & Design 6%		$26,824		
TOTAL CAPITAL COSTS		$473,886		
TOTAL PRESENT WORTH				$1,380,864

NOTES:

NA: Not Applicable

* Monitoring period of 30 years. Environmental sampling includes: groundwater, surface water, and sediment, which are sampled semi-annually (a total of 15 samples assumed for estimation purposes).

acres. Installation of this GCL will require approximately 1,655,280 square feet of HDPE liner and 1,655,280 square feet of GCL. This liner is considered extremely effective in limiting infiltration, and subsequent leaching of contaminants from the underlying soil. Periodic maintenance of the liner would be required to ensure its continued integrity.

As wastes remain onsite, long-term environmental monitoring of the site is necessary to monitor contaminant migration. Monitoring consists of semi-annual sampling of groundwater from nine existing monitoring wells as well as limited surface water and sediment samples. Groundwater, surface water, and sediment samples will be analyzed for SVOCs, PCBs, and metals. Details of the monitoring activities will be finalized in the remedial planning stage. During this stage, trigger levels will be identified for the contaminants of concern. If trigger levels are exceeded, the remedial options may need reevaluation. The trigger levels will be established by taking into consideration the RAOs for the site, the ARARs, and the fact that drinking water MCLs may not be the relevant trigger levels for this site.

Semi-annual monitoring analytical results will be reviewed at least every five years to ensure the remedy continues to provide adequate protection of human health and the environment. The data will be evaluated for contaminant migration trends, and will be compared to trigger levels. The remedy implemented will be re-evaluated against the new data and a determination shall be made as to whether any additional remedial action(s) are necessary.

4.3.2 Overall Protection of Human Health and the Environment: Alternative 3

Under this alternative, a short-term increase in human health risks and a reduction in long-term human health risks are anticipated, compared to Alternative 1, the "No Further Action" alternative. Contact with contaminants in site media is largely eliminated by the following control measures: installation of the liner; prevention of contact with contaminated soils; installation of a perimeter fence and warning signs; prevention of contact with surface water; and implementation of institutional controls preventing contact with groundwater. Human health impacts from various site activities can be minimized so that short-term risks are not excessive.

It is anticipated that site-related health risks are reduced by this alternative. Contact with contaminated soils is reduced greatly due to the presence of the liner, fencing, and land-use restrictions. Infiltration is reduced and therefore, so is the potential for migration of contaminants of concern from site groundwater to nearby surface water. Thus, remedial action objectives are satisfied.

4.3.3 Compliance with ARARs: Alternative 3

Actions triggering ARARs for this alternative include fence construction, posting warning signs, and installation of the liner within the landfill. Requirements for these activities include: OSHA health and safety standards, and RCRA facility standards pertaining to installation of the liner. It is expected that these action-specific ARARs will be met by providing proper personal protective equipment, specified training, and safety equipment to all workers who perform remedial activities, and by following RCRA facility standards properly.

This alternative does not remove contaminated materials, but provides containment of contaminated soils. The potential for contaminants to migrate from the area is greatly reduced as the liner would reduce the amount of contaminants discharged to the aquifer below the landfill by significantly reducing percolation of precipitation.

Federal and Virginia MCLs and health advisories are not achieved as this alternative does not involve any treatment. The water table aquifer at the site is not currently used for drinking water purposes, and therefore, restoration of the aquifer to drinking water levels is not considered a remedial action objective.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, could be met under this alternative with proper mitigation. However, this alternative does not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands. Construction activities related to the installation of a cap/slurry wall could be potentially destructive and severely disruptive to the flora and fauna indigenous to the wetlands.

4.3.4 Long-Term Effectiveness and Permanence: Alternative 3

The implementation of Alternative 3 mitigates part of the risks identified in the baseline risk assessment. The non-carcinogenic risk from ingestion of surface soil is mitigated by interrupting the exposure pathway. Installation of a geosynthetic clay liner effectively isolates the contaminated soils from potential receptors, thereby greatly reducing the potential risks. The carcinogenic and non-carcinogenic risks for ingestion of surface water and groundwater by trespassers and future residents is reduced to some extent by land-use restrictions, fencing, warning signs, and public awareness program. The residual risks should meet the criteria for carcinogenic and non-carcinogenic risks. As the contaminated materials are not treated, a failure of the liner may result in the recurrence of health risks via the direct contact scenario. Resulting risks in the event of a failure of the liner tend to be small compared to baseline risks.

Long-term management activities would include semi-annual inspections and monitoring, liner repair, and a five-year review as previously described. Over time, it is likely that the fence will be breached, requiring repair and additional education effort. However, regular fence inspection and repair ensures that frequent or routine exposures to surface water do not occur. Land-use restrictions are not completely effective as they could be disregarded by individuals unfamiliar with them or intent on performing actions in violation of the restrictions. It is anticipated that this alternative is effective for human health for the foreseeable future. However, it cannot be considered permanent as it relies on maintenance of the liner, land-use restrictions, and semi-annual inspections and monitoring.

4.3.5 Reduction of Toxicity, Mobility, or Volume: Alternative 3

This alternative does not involve reduction of toxicity or volume of the source of contamination or the contaminated soils. The installation of a liner and the slurry wall, however, reduces the mobility of the contaminants. Significant reduction of the rainfall infiltration will minimize the source of surface water and groundwater contamination. This alternative provides no means for groundwater remediation. The possibility of groundwater being used as a potable water supply is highly unlikely because the aquifer underlying the site is not currently used for drinking water purposes.

4.3.6 Short-Term Effectiveness: Alternative 3

The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. Because the installation of the liner within the landfill involves a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is a potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. Risk to workers due to dermal contact with contaminated soils is also possible. Risks will be mitigated by ensuring that workers are required to wear personal protection equipment.

The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. An appropriate local traffic control plan would be implemented to manage trucks and other vehicles. Air monitoring will be performed during site remediation activities to evaluate emissions. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions. During remedial activities, the site habitat will be impacted due to traffic, noise, odor, and dust; however, these impacts will be minimized.

4.3.7 Implementability: Alternative 3

- Technical Feasibility

The technical feasibility of installing a cap will require extensive investigation to determine the boundaries of the landfill since currently, the boundaries are only estimated. Construction activities conducted on site wetlands would require special attention. Preparation of the site would require the use of standard construction procedures and equipment for grading and compaction. These traditional earth working operations and equipment are readily available in the local area. The materials required for the installation of the liner should be available in surrounding locales. The installation of the fence and warning signs is a readily available service and is easily accomplished. The sampling and analysis of the samples and the five-year site status reviews could also be accomplished with little difficulty.

- Availability of Services and Materials

The services and materials required to successfully implement this alternative are readily available in the area. Numerous contractors are available for competitive bidding to perform the work related to this alternative.

- Administrative Feasibility

Implementation of this alternative involves a fair amount of institutional administration. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Construction on and near wetlands would require appropriate permits. The development and implementation of the monitoring program and subsequent five-year site status reviews require the involvement of many concerned environmental agencies, such as, USEPA, Virginia Department of Health, and Virginia Department of Environmental Quality.

Implementation of this alternative involves the development and implementation of institutional controls in the form of land use restrictions that will limit on-site excavation. groundwater usage, and future development. To ensure land use restrictions are effectively implemented, they will be documented in the NAB Little Creek Master Plan, the comprehensive planning document consulted by Base personnel when making planning, development, and construction decisions. In addition, steps will be taken to document the land use restrictions in the NAB Little Creek and Atlantic Division, Naval Facilities Engineering Command real estate files.

Additional steps also will be taken to ensure if the Site is ever transferred to another Federal government entity or out of the Federal government's possession, the land restrictions would continue in effect if necessary based on the results of long term monitoring. If the Site were to be transferred to another Federal entity, the land restrictions would be included in the appropriate transfer documents, with monitoring conducted to ensure adherence to the restrictions. If the Site were to be transferred out of Federal possession, the land use restrictions would be included in the deed effecting the transfer, unless further remedial efforts were agreed upon or required by law. It should be noted that Federal government entities are subject to extensive requirements under CERCLA §120 (h) regarding cleanup of real property to be transferred out of Federal hands.

4.3.8 Cost: Alternative 3

The total present worth of Alternative 3, over a 30 year period with five percent discount rate, is approximately $5,621,686. This cost covers fence fortification, semi-annual monitoring, the five-year review, installation and maintenance of the liner, public meetings, and the associated administrative costs. The details of these costs are shown on Table 4-2.

4.4 Detailed Evaluation of Alternative 4: Liner and Slurry Wall

The major components of Alternative 4 include:

- Fortification of the existing perimeter fence
- Land-use restrictions to restrict site access
- Implementation of a public awareness program including warning signs
- Installation of a GCL to minimize percolation of precipitation
- Construction of a slurry wall around the landfill
- Performance of semi-annual long-term environmental monitoring
- Performance of a five-year review of site conditions

4.4.1 Detailed Description of Alternative 4

This is a total containment alternative with no treatment. In this alternative, the GCL will be installed within the landfill, as in Alternative 3, and a soil-bentonite slurry wall will be constructed around the perimeter of the landfill.

TABLE 4-2

COST ESTIMATE SUMMARY
ALTERNATIVE 3: CAPPING USING GEOSYNTHETIC CLAY LINER (GCL)
SITE 7 - AMPHIBIOUS BASE LANDFILL

ITEM	Quantity	Capital Cost	Annual O&M	Present Worth O&M/Replacement 30 years, 5%
I. INSTITUTIONAL ACTIONS				
1. Public Awareness Program	NA	$10,000	$2,000	
2. Institutional Controls	NA	$10,000	$1,000	
3. Monitoring (15 samples semiannually)	30		$30,000	
4. Site Reviews	NA		$5,000	
5. Site Fencing Fortification (in linear ft.)	6,600	$66,000	$1,000	
Subtotal:		$86,000	$39,000	$599,528
II. SPECIFIC REMEDIAL ACTION				
1. Site Preparation	NA	$50,000		
2. Clearing & Grubbing (in acres)	38	$57,000		
3. Mobilization/ Demobilization	NA	$50,000		
4. Geosythetic Clay Liner (GCL) (in sq. feet)	1,655,280	$1,241,460		
5. Geomembrane/HDPE liner (in square feet)	1,655,280	$1,241,460		
6. Topsoil and Vegetative Layer (in acres)	38	$570,000	$20,000	
Subtotal:		$3,209,920	$20,000	$307,450
CONSTRUCTION SUBTOTAL		$3,295,920		
Health and Safety 5%		$164,796		
Bid Contingency 10%		$329,592		
Scope Contingency 10%		$329,592		
CONSTRUCTION TOTAL		$4,119,900		
Permitting and Legal 5%		$205,995		
Services During Construction 10%		$411,990		
TOTAL IMPLEMENTATION COST		$4,737,885		
Engineering & Design 6%		$284,273		
TOTAL CAPITAL COSTS		$5,022,158		
TOTAL PRESENT WORTH				$5,621,686

NOTES:

NA: Not Applicable

* Monitoring period of 30 years. Environmental sampling includes: groundwater, surface water, and sediment, which are sampled semi-annually (a total of 15 samples assumed for estimation purposes).

The public awareness program is identical to that described in Alternative 2, Section 4.2.1. It would include public RAB meetings and presentations and informational releases to insure public awareness about the hazards present on site.

This alternative also involves implementation of land-use restrictions to limit on-site excavation, groundwater usage, and future land use as described for Alternative 2, Section 4.2.1.

A chain-link fence around the perimeter of the site can prevent unknowing and unauthorized humans from gaining access to the surface water. Such a fence is already present along portions of the site. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Under this alternative, further fortification of this fence will be performed as appropriate. Warning signs will be placed along the fence.

A full description of the geosynthetic clay liner is provided in Section 4.3.1 as part of Alternative 3. A slurry wall will be constructed around the landfill, for a linear distance of approximately 6,600 feet, extending to a depth of about 20 feet below the ground surface and keyed into an underlying clay layer. The confining clay layer is encountered between 8 feet bgs to 20 feet bgs at the site. The slurry wall is constructed as a vertical trench that is excavated under a slurry, typically a mixture of soil-bentonite backfill. The slurry essentially acts as a drilling fluid which shores the walls of the trench to prevent collapse, and at the same time forms a cake on the bench walls to minimize fluid losses to the surrounding ground. For the purposes of a cost estimate, the approximate measurement of 6,600 linear feet represents a slurry wall around the entire landfill. In the event that Alternative 4 is selected, further evaluation will be conducted to determine the boundaries of the landfill, because currently they are only estimated.

As wastes remain onsite, long-term environmental monitoring of the site is necessary to monitor contaminant migration. Monitoring consists of semi-annual sampling of groundwater from nine existing monitoring wells as well as limited surface water and sediment sampling. Groundwater, surface water, and sediment samples will be analyzed for SVOCs, PCBs, and metals. Details of the monitoring activities will be finalized in the remedial planning stage. During this stage, trigger levels will be identified for the contaminants of concern. If trigger levels are exceeded, the remedial options may need reevaluation. The trigger levels will be established by taking into consideration the RAOs for the site, the ARARs, and the fact that drinking water MCLs may not be the relevant trigger levels for this site.

Semi-annual monitoring analytical results will be reviewed at least every five years to ensure that the remedy continues to provide adequate protection of human health and the environment. The data will be evaluated for contaminant migration trends, and will be compared to trigger levels. The slurry wall will divert horizontal groundwater flow into the landfill and therefore prevent groundwater contact with the contaminated soil in the landfill.

4.4.2 Overall Protection of Human Health and the Environment: Alternative 4

Under this alternative, a short-term increase in human health risks and a reduction in long-term human health risks are anticipated, compared to Alternative 1, the "No Further Action" alternative. Contact with contaminants in site media is largely eliminated by the following control measures: installation of the liner;

prevention of contact with contaminated soils; installation of a perimeter fence and warning signs; prevention of contact with surface water; and implementation of institutional controls preventing contact with groundwater. Installation of the slurry wall will reduce infiltration and therefore reduce migration and leaching of contaminants from the landfill, although the source of the contamination is not removed. Human health impacts from various site activities can be minimized so that short-term risks are not excessive.

It is anticipated that site-related health risks will be reduced by this alternative. The residual risk from ingestion of surface water and dermal contact with soils will be within the target risk range of 10^{-6} to 10^{-4}. Contact with contaminated soils is reduced greatly due to the presence of the liner and land-use restrictions. Infiltration is reduced and therefore, so is the potential for migration of contaminants of concern from site groundwater to nearby surface water. In fact, the slurry wall will completely eliminate any migration of contaminants of concern away from the landfill. Thus, remedial action objectives are satisfied.

4.4.3 Compliance with ARARs: Alternative 4

Actions triggering ARARs for this alternative include fence construction and warning sign posting, installation of a liner within the landfill, and installation of a soil-bentonite slurry wall around the perimeter of the landfill. Requirements for these activities include: OSHA health and safety standards, and RCRA facility standards pertaining to installation of the GCL and slurry wall. It is expected that these action-specific ARARs can be met by providing proper personal protective equipment, specified training, and safety equipment to all workers who perform remedial activities, and by following RCRA facility standards properly.

This alternative does not remove contaminated materials, but provides containment of contaminated soils. The potential for contaminants to migrate from the area is greatly reduced as the liner would reduce the amount of contaminants discharged to the aquifer below the landfill by significantly reducing percolation of precipitation. The slurry wall will divert horizontal groundwater flow into the landfill and therefore prevent groundwater contact with the contaminated soil in the landfill.

Federal and Virginia MCLs and health advisories are not achieved as this alternative does not involve treatment and hence does not allow these criteria to be met. The water table aquifer at the site is not currently used for drinking water purposes, and therefore, restoration of the aquifer to drinking water levels is not considered a remedial action objective.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, could be met under this alternative with proper mitigation. However, this alternative does not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands, since the installation of a cap will be more detrimental to the wetlands than if no such action is taken. Construction activities related to the installation of a cap/slurry wall could be potentially destructive and severely disruptive to the flora and fauna indigenous to the wetlands.

4.4.4 Long-Term Effectiveness and Permanence: Alternative 4

The implementation of Alternative 4 mitigates part of the risks identified in the baseline risk assessment. The non-carcinogenic risk from ingestion of surface soil is mitigated by interrupting the exposure pathway. Installation of the GCL effectively isolates the contaminated soils from potential receptors, thereby greatly reducing the potential risks. The carcinogenic and non-carcinogenic risks for ingestion of surface water and groundwater by trespassers and future residents is reduced to some extent by land-use restrictions, fencing, warning signs, and a public awareness program. The residual risks should meet the criteria for carcinogenic and non-carcinogenic risks. As the contaminated materials are not treated, a failure of the liner or slurry wall may result in the recurrence of health risks via the direct contact scenario. Resulting risks in the event of a failure of the liner tend to be small compared to baseline risks.

Long-term management activities would include semi-annual inspections and monitoring, liner repair, and a five-year review as previously described. Over time, it is likely the fence will be breached, requiring repair and additional education effort. However, regular fence inspection and repair ensures that frequent or routine exposures to site soils do not occur. Land-use restrictions are not completely effective as they could be disregarded by individuals unfamiliar with them or intent on performing actions in violation of the restrictions. It is anticipated this alternative is effective for human health for the foreseeable future. However, it cannot be considered permanent as it relies on maintenance of the liner, slurry wall, land-use restrictions, and semi-annual inspections and monitoring.

4.4.5 Reduction of Toxicity, Mobility, or Volume: Alternative 4

This alternative does not involve reduction of toxicity or volume of the source of contamination or the contaminated soils. The installation of a liner and the slurry wall, however, reduces the mobility of the contaminants. Significant reduction of the rainfall infiltration will minimize the source of surface water and groundwater contamination. This alternative provides no means for groundwater remediation. The possibility of groundwater being used as a potable water supply is highly unlikely because the aquifer underlying the site is not currently used for drinking water purposes.

4.4.6 Short-Term Effectiveness: Alternative 4

The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. Because the installation of the liner within the landfill and slurry wall involves a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is a potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. Risk to workers due to dermal contact with contaminated soils is also possible. Risks will be mitigated by ensuring that workers are required to wear personal protection equipment.

The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. An appropriate local traffic control plan would be implemented to manage trucks and other vehicles. Air monitoring will be performed during site remediation activities to evaluate emissions. Proper dust control measures, such as water spray, would be provided to minimize

articulate emissions. During remedial activities, the site habitat will be impacted due to the traffic, noise, odor, and dust; however, these impacts will be minimized.

4.4.7 Implementability: Alternative 4

- Technical Feasibility

The technical feasibility of installing a cap and a slurry wall will require extensive investigation to determine the boundaries of the landfill since currently, the boundaries are only estimated. Construction activities conducted on site wetlands would require special attention. Preparation of the site would require the use of standard construction procedures and equipment for grading and compaction. These traditional earth working operations and equipment are readily available in the local area. The materials required for the installation of the liner and slurry wall should be available in surrounding locales. The installation of the fence and warning signs is a readily available service and is easily accomplished. The sampling and analysis of the samples and the five-year site status reviews could also be accomplished with little difficulty.

- Availability of Services and Materials

The services and materials required to successfully implement this alternative are readily available in the area. Numerous contractors are available for competitive bidding to perform the work related to this alternative.

- Administrative Feasibility

Implementation of this alternative involves a fair amount of institutional administration. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Construction on and near wetlands would require appropriate permits. The development and implementation of the monitoring program and subsequent five-year site status reviews require the involvement of many concerned environmental agencies, such as, USEPA, Virginia Department of Health, and Virginia Department of Environmental Quality.

Implementation of this alternative involves the development and implementation of institutional controls in the form of land use restrictions that will limit on-site excavation. groundwater usage, and future development. To ensure land use restrictions are effectively implemented, they will be documented in the NAB Little Creek Master Plan, the comprehensive planning document consulted by Base personnel when making planning, development, and construction decisions. In addition, steps will be taken to document the land use restrictions in the NAB Little Creek and Atlantic Division, Naval Facilities Engineering Command real estate files.

Additional steps also will be taken to ensure if the Site is ever transferred to another Federal government entity or out of the Federal government's possession, the land restrictions would continue in effect if necessary based on the results of long term monitoring. If the Site were to be transferred to another Federal entity, the land restrictions would be included in the appropriate transfer documents, with monitoring conducted to ensure adherence to the restrictions. If the Site were to be transferred out of

Federal possession, the land use restrictions would be included in the deed effecting the transfer, unless further remedial efforts were agreed upon or required by law. It should be noted that Federal government entities are subject to extensive requirements under CERCLA §120 (h) regarding cleanup of real property to be transferred out of Federal hands.

4.4.8 Cost: Alternative 4

The total present worth of Alternative 4, over a 30 year period with five percent discount rate, is approximately $13,667,086. This cost covers fence fortification, semi-annual monitoring, the five-year review, management of containment technologies, public meetings, and the associated administrative costs. The details of these costs are shown on Table 4-3.

4.5 Detailed Evaluation of Alternative 5: Selective Removal and/or Treatment of Soils

The major components of Alternative 5 include:

- Fortification of the existing perimeter fence
- Land-use restrictions to restrict site access
- Implementation of a public awareness program including warning signs
- Removal or Treatment of selected surface and subsurface areas of the landfill
- OR under Option B, conduct on-site stabilization of these selected soils
- Performance of semi-annual long-term environmental monitoring
- Performance of a five-year review of site conditions

4.5.1 Detailed Description of Alternative 5

In this alternative, limited quantities of surface and subsurface soils containing contaminants of concern will be excavated and transported to an off-site permitted TSD facility for disposal. The investigations to-date have not identified any hot spots in the surface and near-surface soils at the site. Therefore, additional investigations would be conducted to identify the areas of significantly elevated concentrations. The significant concentrations will be those above ten times the related concentration criteria, or any other multiple agreed upon by the regulatory parties and NAB Little Creek.

Under Option B of Alternative 5, the limited quantities of soils will be treated on-site using a soil stabilization technology, rather than disposing them off-site. Based on the nature of contaminants of concern, stabilization using lime and silicate should be effective in immobilizing them to the soil matrix.

Prior to investigations designed to identify potential hot spots, it is difficult to estimate the amount of excavation, treatment or disposal required. The landfill currently covers 38 acres and may consist of 500,000 cy of waste. For the purposes of estimation, a five percent area is assumed to potentially contain hot spots; this is approximately 1.9 acres or 82,650 sf. An average of threefeet is used for the vertical extent of the hot spot; three feet should be adequate for near-surface risks but higher extent is possible for groundwater concern. This yields a remediation target volume of 82,650 cy.

TABLE 4-3

COST ESTIMATE SUMMARY
ALTERNATIVE 4: CAPPING USING GEOSYNTHETIC CLAY LINER (GCL) & SLURRY WALL
SITE 7 - AMPHIBIOUS BASE LANDFILL

ITEM	Quantity	Capital Cost	Annual O&M	Present Worth O&M/Replacement 30 years, 5%
I. INSTITUTIONAL ACTIONS				
1. Public Awareness Program	NA	$10,000	$2,000	
2. Institutional Controls	NA	$10,000	$1,000	
3. Monitoring (15 samples semiannually)	30		$30,000	
4. Site Reviews	NA		$5,000	
5. Site Fencing Fortification (in linear ft.)	6,600	$66,000	$1,000	
Subtotal:		$86,000	$39,000	$599,528
II. SPECIFIC REMEDIAL ACTION				
1. Site Preparation	NA	$50,000		
2. Clearing & Grubbing (in acres)	38	$57,000		
3. Mobilization/ Demobilization	NA	$50,000		
4. Geosythetic Clay Liner (GCL) (in sq. feet)	1,655,280	$1,241,460		
5. Geomembrane/HDPE liner (in square feet)	1,655,280	$1,241,460		
6. Slurry Wall to a depth of 20 ft.(in linear ft.)	6,600	$5,280,000	$5,000	
7. Topsoil and Vegetative Layer (in acres)	38	$570,000	$20,000	
Subtotal:		$8,489,920	$25,000	$384,313
CONSTRUCTION SUBTOTAL		$8,575,920		
Health and Safety 5%		$428,796		
Bid Contingency 10%		$857,592		
Scope Contingency 10%		$857,592		
CONSTRUCTION TOTAL		$10,719,900		
Permitting and Legal 5%		$535,995		
Services During Construction 10%		$1,071,990		
TOTAL IMPLEMENTATION COST		$12,327,885		
Engineering & Design 6%		$739,673		
TOTAL CAPITAL COSTS		$13,067,558		
TOTAL PRESENT WORTH				$13,667,086

NOTES:

NA: Not Applicable

* Monitoring period of 30 years. Environmental sampling includes: groundwater, surface water, and sediment, which are sampled semi-annually (a total of 15 samples assumed for estimation purposes).

Various vendors including Laidlaw, Envirite Corporation, and Clean Harbor have indicated the feasibility of accepting the site soils at their transfer stations in Virginia for final destination to their disposal facilities in South Carolina, Pennsylvania, and Maryland. Total transportation and disposal costs are expected to range between $180 and $240 a ton, or between $270 and $360 a cubic yard.

The public awareness program is identical to that described in Alternative 2, Section 4.2.1. It would include public RAB meetings and presentations and informational releases to insure public awareness about the hazards present on site.

This alternative also involves implementation of land-use restrictions to limit on-site excavation, groundwater usage, and future land use as described for Alternative 2, Section 4.2.1.

A chain-link fence around the perimeter of the site can prevent unknowing and unauthorized humans from gaining access to the surface water. Such a fence is already present along portions of the site. Although the western border of the landfill is not fenced, it is heavily wooded and adjacent to the ammunitions magazine area and an equipment storage area. These areas are fenced and highly secured. Under this alternative, further fortification of this fence will be performed as appropriate. Warning signs will be placed along the fence.

As some hazardous wastes will remain onsite, long-term environmental monitoring of the site will be necessary to monitor contaminant migration. Monitoring will consist of semi-annual sampling of groundwater from nine existing monitoring wells as well as limited surface water and sediment samples. Groundwater, surface water, and sediment samples will be analyzed for SVOCs, PCBs, and metals. Details of the monitoring activities will be finalized in the remedial planning stage. During this stage, trigger levels will be identified for the contaminants of concern. If trigger levels are exceeded, the remedial options may need reevaluation. The trigger levels will be established by taking into consideration the RAOs for the site, the ARARs, and the fact that drinking water MCLs may not be the relevant trigger levels for this site.

Semi-annual monitoring analytical results will be reviewed at least every five years to ensure the remedy continues to provide adequate protection of human health and the environment. The data will be evaluated for contaminant migration trends, and will be compared to trigger levels. The remedy implemented will be re-evaluated against the new data and a determination shall be made as to whether any additional remedial action(s) are necessary.

4.5.2 Overall Protection of Human Health and the Environment: Alternative 5

Under this alternative, a short-term increase in human health risks and a reduction in long-term human health risks are anticipated, compared to Alternative 1, the "No Further Action" alternative. Contact with contaminants in site media is largely eliminated by excavation/treatment of soils around potential hot-spot areas, by installing a perimeter fence and warning signs, and by implementing institutional controls preventing contact with surface water and groundwater. Contaminant migration is reduced by this alternative, the source of contamination is either partially removed or treated. Human health impacts from various site activities can be minimized with appropriate measures, so that short-term risks are not excessive.

It is anticipated that site-related health risks are reduced by this alternative. Contact with contaminated soils is reduced greatly due to the removal/treatment of hot spots, fencing, and land-use restrictions. Potential for migration of contaminants of concern from site groundwater to nearby surface water is also reduced due to source removal/treatment. Thus, remedial action objectives are satisfied.

4.5.3 Compliance with ARARs: Alternative 5

Actions triggering ARARs for this alternative include fence construction, posting warning signs, and excavation and treatment of surface and subsurface soils around hot-spot areas. Requirements for these activities include: OSHA health and safety standards, RCRA excavation and fugitive dust requirements, RCRA land disposal restrictions, DOT regulations for hazardous materials transport, and Virginia solid waste regulations. It is expected that these action-specific ARARs can be met by providing proper personal protective equipment, specified training, and safety equipment to all workers who perform remedial activities, and by following RCRA facility standards and DOT regulations properly.

This alternative removes contaminated materials or provides containment through stabilization. The potential for contaminants to migrate from the area is greatly reduced as highly contaminated soils will be excavated or stabilized.

Federal and Virginia MCLs and health advisories are not achieved as this alternative does not involve treatment of the groundwater and hence does not allow these criteria to be met. The water table aquifer at the site is not used or likely to be used for drinking water purposes as the City of Virginia Beach Public Utilities Department has indicated that it is standard practice to prohibit the use of the shallow water aquifer as a potable source, and therefore, restoration of the aquifer to drinking water levels is not considered a remedial action objective.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, could be met under this alternative with proper mitigation. However, this alternative does not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands, since the soil removal activities will be more detrimental to the wetlands than if no such action is taken. Construction activities related to the removal of soils could be potentially destructive and severely disruptive to the flora and fauna indigenous to the wetlands.

4.5.4 Long-Term Effectiveness and Permanence: Alternative 5

The implementation of Alternative 5 mitigates part of the risks identified in the baseline risk assessment. The non-carcinogenic risk from ingestion of surface soil is mitigated by excavation and removal of soils around hot-spot areas, thereby removing/treating the exposure media. Institutional controls and selective stabilization effectively isolates the contaminated soils from potential receptors, thereby greatly reducing the potential risks. The carcinogenic and non-carcinogenic risks for ingestion of surface water and groundwater by trespassers and future residents is reduced to some extent by land-use restrictions, fencing, warning signs, and a public awareness program. The residual risks should meet the criteria for carcinogenic and non-carcinogenic risks. The recurrence of health risks via the direct contact scenario depends on the amount of residual contaminants left behind after removal or stabilization. Resulting risks would be very small compared to baseline risks.

Long-term management activities would include semi-annual inspections and monitoring, and a five-year review as previously described. Over time, it is likely that the fence will be breached, requiring repair and additional educational effort. However, regular fence inspection and repair ensures that frequent or routine exposures to site soils do not occur. Land-use restrictions are not completely effective as they could be disregarded by individuals unfamiliar with them or intent on performing actions in violation of the restrictions. It is anticipated this alternative is effective for human health for the foreseeable future. However, it cannot be considered permanent as it relies on maintenance of the land-use restrictions and semi-annual inspections and monitoring.

4.5.5 Reduction of Toxicity, Mobility, or Volume: Alternative 5

This alternative reduces both the mobility and volume of the source of contamination and the contaminated soils through excavation of soils around hot-spot areas. The stabilization option reduces mobility and toxicity. This alternative provides no means for groundwater remediation. The possibility of groundwater being used as a potable water supply is highly unlikely because the aquifer underlying the site is not currently used for drinking water purposes.

4.5.6 Short-Term Effectiveness: Alternative 5

The identifiable short-term risks associated with this alternative include on-site worker safety and environmental risks. Because excavation and off-site disposal of soils from hot-spot areas or on-site stabilization efforts involve a significant amount of earthwork and will require the use of heavy earthmoving equipment, there is a potential for work related accidents to occur. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. Risk to workers due to dermal contact with contaminated soils is also possible. Risks will be mitigated by ensuring that workers are required to wear personal protection equipment.

The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. An appropriate local traffic control plan would be implemented to manage trucks and other vehicles. Air monitoring will be performed during site remediation activities to evaluate emissions. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions. During remedial activities, the site habitat will be impacted due to the traffic, noise, odor, and dust; however, these impacts will be minimized.

4.5.7 Implementability: Alternative 5

- Technical Feasibility

Preparation of the site would require the use of standard construction procedures and equipment for grading and compaction. These traditional earth working operations and excavation equipment are readily available in the local area. Construction activities conducted on site wetlands would require special attention. Off-site facilities have been identified to accept excavated soils. The chemicals and materials required for the stabilization efforts should be available in surrounding locales. The installation of the fence and warning signs is a readily available service and is easily accomplished. The sampling and

analysis of the samples and the five-year site status reviews could also be accomplished with little difficulty.

- Availability of Services and Materials

The services and materials required to successfully implement this alternative are readily available in the area. Numerous contractors are available for competitive bidding to perform the work related to this alternative. Various vendors including Laidlaw, Envirite Corporation, and Clean Harbor have indicated the feasibility of accepting the site soils at their transfer stations in Virginia for final destination to their disposal facilities in South Carolina, Pennsylvania, and Maryland.

- Administrative Feasibility

Implementation of this alternative involves a fair amount of institutional administration. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Construction on and near wetlands would require appropriate permits. The transporter as well as the TSD facility will also need appropriate permits. The development and implementation of the monitoring program and subsequent five-year site status reviews require the involvement of many concerned environmental agencies, such as, USEPA, Virginia Department of Health, and Virginia Department of Environmental Quality.

Implementation of this alternative involves the development and implementation of institutional controls in the form of land use restrictions that will limit on-site excavation. groundwater usage, and future development. To ensure land use restrictions are effectively implemented, they will be documented in the NAB Little Creek Master Plan, the comprehensive planning document consulted by Base personnel when making planning, development, and construction decisions. In addition, steps will be taken to document the land use restrictions in the NAB Little Creek and Atlantic Division, Naval Facilities Engineering Command real estate files.

Additional steps also will be taken to ensure if the Site is ever transferred to another Federal government entity or out of the Federal government's possession, the land restrictions would continue in effect if necessary based on the results of long term monitoring. If the Site were to be transferred to another Federal entity, the land restrictions would be included in the appropriate transfer documents, with monitoring conducted to ensure adherence to the restrictions. If the Site were to be transferred out of Federal possession, the land use restrictions would be included in the deed effecting the transfer, unless further remedial efforts were agreed upon or required by law. It should be noted that Federal government entities are subject to extensive requirements under CERCLA §120 (h) regarding cleanup of real property to be transferred out of Federal hands.

4.5.8 Cost: Alternative 5

Costs to implement this alternative depend on the extent of potential hot spots identified during the pre-remedial investigation. Unit costs for off-site disposal range between $200 and $250 a ton; whereas unit costs for on-site stabilization will be approximately 25% of those costs. The decision of whether to expend a large (on the order of $750,000) amount for on-site setup of stabilization equipment will depend

on the quantity of soils. Therefore, an accurate estimate to implement this alternative can be presented during the remedial design stage, if appropriate.

For comparison purposes, costs have been calculated to remove and dispose of 82,600 cy of soils, along with other remedial components. The total present worth of Alternative 5, over a 30 year period with five percent discount rate, is approximately $43,224,529 with off-site disposal and $13,629,114 with on-site stabilization. This cost covers fence fortification, semi-annual monitoring, the five-year review, management of treatment, disposal and containment technologies, public meetings, and the associated administrative costs. The details of these costs are shown on Table 4-4A and B.

TABLE 4-4 A

COST ESTIMATE SUMMARY
ALTERNATIVE 5A: REMOVAL AND OFF-SITE LANDFILL
SITE 7 - AMPHIBIOUS BASE LANDFILL

ITEM	Quantity	Capital Cost	Annual O&M	Present Worth O&M/Replacement 30 years, 5%
I. INSTITUTIONAL ACTIONS				
1. Public Awareness Program	NA	$10,000	$2,000	
2. Institutional Controls	NA	$10,000	$1,000	
3. Monitoring (15 samples semiannually)	30		$30,000	
4. Site Reviews	NA		$5,000	
5. Site Fencing Fortification (in linear ft.)	6,600	$66,000	$1,000	
Subtotal:		$86,000	$39,000	$599,528
II. SPECIFIC REMEDIAL ACTION				
1. Site Preparation	NA	$50,000		
2. Pre-Remedial Investigation	NA	$100,000		
3. Mobilization/ Demobilization	NA	$50,000		
4. Excavation of Hot Spots (in cubic yards)	82,650	$2,066,250		
5. Disposal at Off-Site Landfill (in cy)	82,650	$24,795,000		
6. Backfill with Clean Soil (in cy)	82,650	$826,500		
Subtotal:		$27,887,750	$0	$0
CONSTRUCTION SUBTOTAL		$27,973,750		
Health and Safety 5%		$1,398,688		
Bid Contingency 10%		$2,797,375		
Scope Contingency 10%		$2,797,375		
CONSTRUCTION TOTAL		$34,967,188		
Permitting and Legal 5%		$1,748,359		
Services During Construction 10%		$3,496,719		
TOTAL IMPLEMENTATION COST		$40,212,266		
Engineering & Design 6%		$2,412,736		
TOTAL CAPITAL COSTS		$42,625,002		
TOTAL PRESENT WORTH				$43,224,529

NOTES:
NA: Not Applicable
* Monitoring period of 30 years. Environmental sampling includes: groundwater, surface water, and sediment, which are sampled semi-annually (a total of 15 samples assumed for estimation purposes).

TABLE 4-4 B

COST ESTIMATE SUMMARY
ALTERNATIVE 5B: STABILIZATION OF SELECTED SOIL MATERIALS
SITE 7 - AMPHIBIOUS BASE LANDFILL

ITEM		Quantity	Capital Cost	Annual O&M	Present Worth O&M/Replacement 30 years, 5%
I. INSTITUTIONAL ACTIONS					
1. Public Awareness Program		NA	$10,000	$2,000	
2. Institutional Controls		NA	$10,000	$1,000	
3. Monitoring (15 samples semiannually)		30		$30,000	
4. Site Reviews		NA		$5,000	
5. Site Fencing Fortification (in linear ft.)		6,600	$66,000	$1,000	
Subtotal:			$86,000	$39,000	$599,528
II. SPECIFIC REMEDIAL ACTION					
1. Site Preparation		NA	$50,000		
2. Pre-Remedial Investigation		NA	$100,000		
3. Mobilization/ Demobilization		NA	$50,000		
4. Soil Stabilization (in cy)		82,650	$8,265,000	$10,000	
Subtotal:			$8,465,000	$10,000	$153,725
CONSTRUCTION SUBTOTAL			$8,551,000		
Health and Safety	5%		$427,550		
Bid Contingency	10%		$855,100		
Scope Contingency	10%		$855,100		
CONSTRUCTION TOTAL			$10,688,750		
Permitting and Legal	5%		$534,438		
Services During Construction	10%		$1,068,875		
TOTAL IMPLEMENTATION COST			$12,292,063		
Engineering & Design	6%		$737,524		
TOTAL CAPITAL COSTS			$13,029,586		
TOTAL PRESENT WORTH					$13,629,114

NOTES:

NA: Not Applicable

* Monitoring period of 30 years. Environmental sampling includes: groundwater, surface water, and sediment, which are sampled semi-annually (a total of 15 samples assumed for estimation purposes).

5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the alternatives with respect to the evaluation criteria presented in Section 4.0. The comparison is presented qualitatively, identifying substantive differences between alternatives. A summary of the comparison is presented in Table 5-1.

5.1 Overall Protection of Human Health and the Environment

All of the alternatives, except Alternative 1 (no further action) provide adequate protection of human health and the environment. Risks through dermal contact of soils and ingestion of surface water are largely reduced by blocking human contact with site contaminants. As long as fencing, institutional control, soil cover, capping, and/or slurry wall are maintained, site related risks will remain low.

5.2 Compliance with ARARs

All alternatives, except Alternative 1, can be designed and implemented to satisfy all action-specific ARARs. Alternative 1 does not meet RCRA standards since the waste is neither removed nor contained.

Chemical-specific ARARs such as Federal and Virginia MCLs and health advisories are not achieved as none of the alternatives involve treatment of the entire contaminated landfill mass. The water table aquifer at the site is not currently used for drinking water purposes, and therefore, restoration of the aquifer to drinking water levels is not considered a remedial action objective.

Location-specific ARARs and TBCs, including federal and state wetland and floodplain regulations, could be met under all alternatives with proper design and management. However, these alternatives do not meet the intent of Executive Order 11990, which requires federal agencies to minimize wetland degradation and to preserve and enhance the beneficial uses of wetlands.

5.3 Long-Term Effectiveness and Permanence

Alternative 1 does not prevent or reduce the magnitude of risk to human health or the environment. It is the only alternative that fails to address human health risks associated with dermal contact of soils.

Alternatives 2 through 5 are expected to mitigate part of the risks identified in the baseline risk assessment. The non-carcinogenic risk from dermal contact of surface soil is mitigated by interrupting the exposure pathway. Installation of a top soil cover, single-layer cap, or excavation and removal of soils around hot-spot areas effectively isolates the contaminated soils from potential receptors, thereby greatly reducing the potential risks. The carcinogenic and non-carcinogenic risks for ingestion of surface water and groundwater by trespassers and future residents is reduced to some extent by land-use restrictions, fencing, and public awareness program.

TABLE 5-1

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Criteria	Alternative 1 No Further Action	Alternative 2 Institutional Control Action: Land-Use Restrictions, Fencing, Top Soil and Vegetative Cover	Alternative 3 Single Layer Cap, Institutional Controls	Alternative 4 Single Layer Cap, Slurry Wall, Institutional Controls	Alternative 5 Removal or Treatment of Selected Soils, Institutional Controls
Overall Protectiveness					
Human Health Protection	No significant reduction in risk from baseline conditions. Risks to resident adult from dermal contact with soil exceed guidelines. Risks to resident or trespasser adult from ingestion of surface water exceed guidelines. If site groundwater was used as a potable water source, unacceptable risks could result.	Top soil cover reduces direct contact with soil risks to less than 10^{-6}. Institutional controls provide protection against risks from groundwater and surface water ingestion. Human health impacts from various site activities will be minimized as necessary.	Single layer cap reduces direct contact with soil risks to less than 10^{-6}. Institutional controls provide protection against risks from groundwater and surface water ingestion. Human health impacts from various site activities will be minimized as necessary.	Single layer cap reduces direct contact with soil risks to less than 10^{-6}. Institutional controls provide protection against risks from groundwater and surface water ingestion. Human health impacts from various site activities will be minimized as necessary.	Single layer cap reduces direct contact with soil risks to less than 10^{-6}. Institutional controls provide protection against risks from groundwater and surface water ingestion. Human health impacts from various site activities will be minimized as necessary.
Environmental Protection	Allows continued contamination of groundwater and surface water.	Continued contamination is curtailed to a lesser degree by use of a top soil cover.	Continued contamination is curtailed by use of a cap.	Continued contamination is curtailed by use of a cap and a slurry wall.	Continued contamination is curtailed to a greater degree by this alternative.
Compliance with ARARs					
Chemical-Specific ARARs	Federal and Virginia MCLs and health advisories are not met in both groundwater and surface water.	Federal and Virginia MCLs and health advisories are not met in both groundwater and surface water.	Federal and Virginia MCLs and health advisories are not met in both groundwater and surface water.	Federal and Virginia MCLs and health advisories are not met in both groundwater and surface water.	Federal and Virginia MCLs and health advisories are not met in both groundwater and surface water.
Location-Specific ARARs	Location-specific ARARs are not affected by this alternative.	Federal and state wetland floodplain regulations are met. Executive Order 11990 requirements regarding wetlands is not met.	Federal and state wetland floodplain regulations are met. Executive Order 11990 requirements regarding wetlands is not met.	Federal and state wetland floodplain regulations could be met with proper mitigation. Executive Order 11990 requirements regarding wetlands is not met.	Excavation in wetland results in need to restore wetlands. Executive Order 11990 requirements regarding wetlands is not met.
Action-Specific ARARs	None of the relevant and appropriate RCRA standards are met.	OSHA health and safety standards are to be met during construction.	OSHA health and safety standards are to be met during construction. RCRA facility standards pertaining to cap will be met.	OSHA health and safety standards are to be met during construction. RCRA facility standards pertaining to cap and slurry wall will be met.	OSHA health and safety standards are to be met during construction. RCRA excavation and fugitive dust requirements, and land disposal restrictions are to be met. DOT regulations for hazardous materials transport and Virginia solid waste regulations are to be met.

TABLE 5-1 (continued)

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Criteria	Alternative 1 No Further Action	Alternative 2 Institutional Control Action: Land-Use Restrictions, Fencing, Top Soil and Vegetative Cover	Alternative 3 Single Layer Cap, Institutional Controls	Alternative 4 Single Layer Cap, Slurry Wall, Institutional Controls	Alternative 5 Removal or Treatment of Selected Soils, Institutional Controls
Long-Term Effectiveness and Performance					
Magnitude of Residual Risk					
- Dermal contact with soil	Humans risks up to 10^{-4} for future resident adult are unchanged.	Reduces risks from soil exposure by interrupting the exposure pathway.	Reduces risks from soil exposure by interrupting the exposure pathway.	Reduces risks from soil exposure by interrupting the exposure pathway.	Risks are reduced to less than 10^{-4} by excavation and removal of soils.
- Future groundwater ingestion	Humans risks up to 10^{-4} for future resident adult are unchanged if groundwater to be used as a potable water supply source.	Institutional control used to control use of contaminated groundwater. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated groundwater. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated groundwater. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated groundwater. Unauthorized use would result in increased risk.
- Current and future ingestion of surface water.	Risks of up to 10^{-4} from ingestion of surface water are unchanged.	Institutional control used to control use of contaminated surface water. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated surface water. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated surface water. Unauthorized use would result in increased risk.	Institutional control used to control use of contaminated surface water. Unauthorized use would result in increased risk.
Adequacy and Reliability of Controls	No controls over remaining contamination. No reliability.	Risk to groundwater and surface water controlled by institutional controls. However, they are limited in effectiveness. Top cover controls contaminated soil. Reliability of top cover can be high if maintained. Institutional controls are not very reliable. Environmental monitoring required to ensure the integrity of engineering controls.	Risk to groundwater and surface water controlled by institutional controls. However, they are limited in effectiveness. Top cover controls contaminated soil. Cap is effective in reducing infiltration and preventing exposure to contaminated soils. Reliability of cap can be high if maintained. Institutional controls are not very reliable. Environmental monitoring required to ensure the integrity of engineering controls.	Risk to groundwater and surface water controlled by institutional controls. However, they are limited in effectiveness. Top cover controls contaminated soil. Cap is effective in reducing infiltration and preventing exposure to contaminated soils. Slurry wall would reduce permeability of site soils and reduces groundwater flow through contaminated areas. Reliability of cap and slurry wall can be high if properly maintained. Institutional controls are not reliable. Environmental monitoring required to ensure the integrity of engineering controls.	Risk to groundwater and surface water controlled by institutional controls. However, they are limited in effectiveness. Top cover controls contaminated soil. Cap is effective in reducing infiltration and preventing exposure to contaminated soils. Removal of soil from hotspot areas reduces the amount of contamination on site. Institutional controls are not very reliable. Removal is very reliable. Stabilization is not as highly reliable. Environmental monitoring required to ensure the integrity of engineering controls.
Need for 5-Year Review	As waste remains on site, reviews are required.	Substantive review requirements will be met through periodic reviews of long-term monitoring data.	Substantive review requirements will be met through periodic reviews of long-term monitoring data.	Substantive review requirements will be met through periodic reviews of long-term monitoring data.	Substantive review requirements will be met through periodic reviews of long-term monitoring data.

TABLE 5-1 (continued)

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Criteria	Alternative 1 No Further Action	Alternative 2 Institutional Control Action: Land-Use Restrictions, Fencing, Top Soil and Vegetative Cover	Alternative 3 Single Layer Cap, Institutional Controls	Alternative 4 Single Layer Cap, Slurry Wall, Institutional Controls	Alternative 5 Removal or Treatment of Selected Soils, Institutional Controls
Reduction of Toxicity, Mobility, or Volume through Treatment					
Treatment Process Used	None	None	None	None	Stabilization in 5B.
Amount Destroyed or Treated	None	None	None	None	Approximately 82,600 cy.
Reduction of Toxicity, Mobility, or Volume	None	None	No reduction of toxicity, mobility, or volume will be accomplished.	No reduction of toxicity or volume. Mobility of groundwater outside the enclosure will be reduced.	Reduction in volume of contaminated soil achieved.
Irreversible Treatment	None	Top soil cover could be removed.	Cap could be removed although at great cost.	Cap and slurry wall could be removed, although at great cost.	Removal or treatment of soil is irreversible.
Type and Quantity of Residuals Remaining After Treatment	No treatment.	No treatment.	No treatment.	No treatment.	No treatment.
Short-Term Effectiveness					
Community Protection	No net increase in short-term risks.	Moderate increase in short-term risks associated with site disturbance.	Moderate increase in short-term risks associated with site disturbance. Inhalation hazard from dust emissions is mitigated by proper controls.	Moderate increase in short-term risks associated with site disturbance. Inhalation hazard from dust emissions is mitigated by proper controls.	Moderate increase in short-term risks associated with site disturbance. Inhalation hazard from dust emissions is mitigated by proper controls.
Worker Protection	No remedial worker exposures.	Compliance with OSHA standards will mitigate risks.	Compliance with OSHA standards will mitigate risks.	Compliance with OSHA standards will mitigate risks.	Compliance with OSHA standards will mitigate risks.
Environmental Impacts	Continued impact from existing conditions.	Disturbance of wetlands.	Disturbance of wetlands. Increase in traffic and noise levels.	Disturbance of wetlands. Increase in traffic and noise levels.	Disturbance of wetlands. Increase in traffic and noise levels.
Time Until Protection is Achieved.	Protection is never achieved.	Fencing, top soil, and vegetative cover installed in 6 months.	Cap will be installed in 6 months.	Protection will be achieved approximately 12 months after initiation of remedy.	Protection will be achieved approximately 12 months after initiation of remedy.

TABLE 5-1 (continued)

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Criteria	Alternative 1 No Further Action	Alternative 2 Institutional Control Action: Land-Use Restrictions, Fencing, Top Soil and Vegetative Cover	Alternative 3 Single Layer Cap, Institutional Controls	Alternative 4 Single Layer Cap, Slurry Wall, Institutional Controls	Alternative 5 Removal or Treatment of Selected Soils, Institutional Controls
Implementability					
Technical Feasibility					
- Constructability and Operational Reliability	Requires no construction or operation.	All components of this alternative are easily constructable.	All components of this alternative are easily constructable.	All components of this alternative are easily constructable.	All components of this alternative are easily constructable.
- Future Actions	Does not preclude future operations.	Future monitoring will be required to provide notice of containment failure before significant exposure occurs.	Future monitoring will be required to provide notice of containment failure before significant exposure occurs.	Future monitoring will be required to provide notice of containment failure before significant exposure occurs.	Future monitoring will be required to provide notice of containment failure before significant exposure occurs.
- Monitorability	Easily monitored.	Proposed 30-year monitoring of groundwater, surface water, and sediments to confirm no migration of remaining contamination.	Proposed 30-year monitoring of groundwater, surface water, and sediments to confirm no migration of remaining contamination.	Proposed 30-year monitoring of groundwater, surface water, and sediments to confirm no migration of remaining contamination.	Proposed 30-year monitoring of groundwater, surface water, and sediments to confirm no migration of remaining contamination.
Administrative Feasibility	Long-term coordination between EPA, Virginia DOH, and DOEQ is required for monitoring and reviews.	Long-term coordination between EPA, Virginia DOH, and DOEQ is required for monitoring and reviews.	Long-term coordination between EPA, Virginia DOH, and DOEQ is required for monitoring and reviews.	Long-term coordination between EPA, Virginia DOH, and DOEQ is required for monitoring and reviews.	Long-term coordination between EPA, Virginia DOH, and DOEQ is required for monitoring and reviews.
Availability of Services, Capacities, Equipment, Specialists, Materials, and Technologies.	None required.	Readily available equipment and materials for top soil cover. Experienced contractors readily available. Lawyers for instituting land use restrictions are readily available.	Readily available equipment and materials for top soil cover. Experienced contractors readily available. Lawyers for instituting land use restrictions are readily available.	Readily available equipment and materials for top soil cover. Experienced contractors readily available. Lawyers for instituting land use restrictions are readily available.	Readily available equipment and materials for top soil cover. Experienced contractors readily available. Lawyers for instituting land use restrictions are readily available.
COST (Net present worth over the next 30 years at a 5% discount rate)	$25,000	$1,380,864	$5,621,686	$13,667,086	$43,224,529 (disposal) $13,629,114 (stabilization)

Since the alternatives do not entirely remove the source of contamination from the site, the site remedy must be reviewed every 5 years. Semi-annual monitoring is proposed for a possible period of 30 years.

5.4 Reduction of Toxicity, Mobility, or Volume

The reduction of toxicity, mobility, or volume of the contaminants of concern vary between the alternatives evaluated. Alternative 1 provides no reduction in the toxicity, mobility, or volume of contaminated media.

Alternatives 2 through 4, which involve the installation of a soil cover, cap, or slurry wall, reduce the mobility of the source of contamination. A significant reduction of the rainfall infiltration will minimize the source of surface water and groundwater contamination. Alternatives 2 through 5 provide no means for groundwater remediation. The water table aquifer at the site is not used or likely to be used for drinking water purposes as the City of Virginia Beach Public Utilities Department has indicated that it is standard practice to prohibit the use of the shallow water aquifer as a potable.

Alternative 5, which involves the excavation of soils around hot-spot areas and installation of a cap and slurry wall, reduces both the volume and mobility of contaminants.

5.5 Short-Term Effectiveness

Alternative 1 is the best in terms of short-term effectiveness as it results in no site disturbance. Since there is no excavation or earth moving, site contaminants will not be released to the air at a significantly increased rate. This alternative best protects the community in the short term. This alternative does not achieve long-term protection of human health.

Alternatives 2 through 5 include a significantly greater amount of site disturbance compared to Alternative 1, resulting in the need for mitigation activities to reduce air emissions. Because these alternatives involve a significant amount of earthwork and will require the use of heavy earthmoving equipment, the potential for work related accidents to occur exists. The use of proper operational procedures and construction techniques will minimize the risk of any on-site accidents. The risk to workers due to dermal contact with contaminated soils is also possible. These risks will be mitigated by ensuring that workers are required to wear appropriate personal protection equipment.

The short-term impacts on the environment would be the traffic problems and an increase in noise levels due to the construction activity. An appropriate local traffic control plan would be implemented to manage trucks and other vehicles. Air monitoring will be performed during site remediation activities to evaluate emissions. Proper dust control measures, such as water spray, would be provided to minimize particulate emissions.

Alternatives 2 through 5 would also have a short-term impact on the site habitat due to traffic, noise, odor, and dust; however, these impacts will be minimized. This impact is minimal under Alternative 2 and highest under Alternative 4, with Alternatives 3 and 5 falling in between.

5.6 Implementability

- Technical Feasibility

As Alternative 1 involves no remedial measures, technical feasibility is not an issue. The earth working equipment, materials, and construction procedures required for Alternatives 2 through 5 are conventional and are used extensively in commercial and industrial applications and are available in surrounding locales. Under Alternatives 3 and 4, construction activities conducted on site wetlands would require special attention. The installation of the fence and warning signs is a readily available service and is easily accomplished. The sampling and analysis of the samples, and the five-year site status reviews could also be accomplished with little difficulty.

- Availability of Services and Materials

The services and materials required to successfully implement any of Alternatives 2 through 5 are readily available in the area. Numerous contractors are available for competitive bidding to perform the work related to these alternatives.

- Administrative Feasibility

Implementation of these alternatives involves a fair amount of institutional administration. Significant long-term management of an inspection and maintenance program to ensure the structural and functional integrity of the cap would be required. Construction on and near wetlands would require appropriate permits. The development and implementation of the monitoring program and subsequent five-year site status reviews require the involvement of many concerned environmental agencies, such as, USEPA, Virginia Department of Health, and Virginia Department of Environmental Quality.

Implementation of these alternatives involves the development and implementation of institutional controls in the form of land use restrictions that will limit on-site excavation. groundwater usage, and future development. To ensure land use restrictions are effectively implemented, they will be documented in the NAB Little Creek Master Plan, the comprehensive planning document consulted by Base personnel when making planning, development, and construction decisions. In addition, steps will be taken to document the land use restrictions in the NAB Little Creek and Atlantic Division, Naval Facilities Engineering Command real estate files.

Additional steps also will be taken to ensure if the Site is ever transferred to another Federal government entity or out of the Federal government's possession, the land restrictions would continue in effect if necessary based on the results of long term monitoring. If the Site were to be transferred to another Federal entity, the land restrictions would be included in the appropriate transfer documents, with monitoring conducted to ensure adherence to the restrictions. If the Site were to be transferred out of Federal possession, the land use restrictions would be included in the deed effecting the transfer, unless further remedial efforts were agreed upon or required by law. It should be noted that Federal government entities are subject to extensive requirements under CERCLA §120 (h) regarding cleanup of real property to be transferred out of Federal hands.

5.7 Cost

Cost estimates were developed for each of the potential remedial alternatives. The quantities of materials and equipment sizes utilized for these estimates are considered conservative due to data limitations and are biased toward the high side.

The details of the cost estimates are presented in Tables 4-1 through 4-4. The present worth costs were calculated using a discount rate of 5% and a 30-year time interval.

6.0 RECOMMENDATION

Based on the comparative analysis presented in Section 5.0, Alternative 2 is identified as the most cost-effective remedial action alternative. Alternative 2, Institutional Control Action, satisfies all of the RAOs for Site 7. RAOs were presented in Section 2.2 and are reproduced below:

- Reduce the human health risks associated with the ingestion of site soils and groundwater;

- Mitigate the migration of constituents of concern from the site groundwater to the nearby surface water streams, and to the interconnected aquifers, if any. The water table aquifer at the site is not used or likely to be used for drinking water purposes as the City of Virginia Beach Public Utilities Department has indicated that it is standard practice to prohibit the use of the shallow water aquifer as a potable source, and therefore, restoration of the aquifer to drinking water levels is not considered a remedial action objective; and

- Mitigate the human health risks attributable to Site 7 associated with ingestion of surface water in Little Creek Cove and local canals near the site.

Alternative 2 is designed to meet these RAOs through:

- Land use restrictions;
- Access restrictions including fence fortification;
- Installation, maintenance, and monitoring of a soil and vegetative cover on the landfill;
- Long-term monitoring of groundwater, surface water, and sediment quality; and
- Public information programs.

These actions are estimated to cost $1,380,864 over the next 30 years.

If this alternative is accepted by the state and the public, specifics of the remedial action's components will be prepared under a Remedial Design document.

REFERENCES

U.S. Environmental Protection Agency (USEPA), Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final, EPA/540/G-89/004, OSWER Directive 9355.3-01, 1988.

U.S. Environmental Protection Agency (USEPA), Handbook of Remedial Actions at Waste Disposal Sites, EPA/625/6-85/006, 1985.

Foster Wheeler, Final Remedial Investigation/Feasibility Study Naval Amphibious Base Little Creek, Report Prepared for Department of the Navy, October 1994.

Baker Environmental, Inc. ARAR Guidance developed with LANTDIV.

Telecommunication with vendors concerning costs of disposal.

Baker Environmental, Inc., Ecological Investigation at NAB Little Creek, CTO-0328 under Navy CLEAN, November 1995 (To Be Incorporated).