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NAB LITTLE CREEK
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DRAFT FEASIBILITY STUDY FOR SITE 12 AND 13 NAB LITTLE CREEK VA
6/23/1995
BAKER ENVIRONMENTAL, INC.

DRAFT
FEASIBILITY STUDY

SITE 12: EXCHANGE LAUNDRY WASTE DISPOSAL AREA
SITE 13: PUBLIC WORKS PCP DIP-TANK AND WASH RACK
NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CONTRACT TASK ORDER 0247

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NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under:

Contract N62470-89-D-4814

Draft Feasibility Study
Naval Amphibious Base
Site 12 - Exchange Laundry Waste Disposal Area
Site 13 - Public Works PCP Dip-Tank and Wash Rack

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EXECUTIVE SUMMARY

BACKGROUND

The Naval Facilities Engineering Command, Atlantic Division, has contracted Foster Wheeler Environmental Services (FWES) to perform this Feasibility Study (FS) through Baker Environmental, Incorporated (Baker) under Contract Task Order 0247 (Contract N62470-89-D-4814) as part of the Installation Restoration Program (IRP). This FS covers two IRP sites within the Naval Amphibious Base (NAB) Little Creek, which are designated as:

Site 12: Exchange Laundry Waste Disposal Area; and
Site 13: Public Works PCP Dip-Tank and Wash Rack.

A Supplemental Remedial Investigation (SRI) was performed by FWES and a draft SRI report submitted in January 1996. This report presents a feasibility study for the two sites utilizing results obtained in the SRI draft report.

The objective of this FS is to develop and screen feasible remedial alternatives for remediation of environmental contamination present at the sites. The alternatives are evaluated against a range of factors and compared against one another to provide a basis for the Navy to select the most promising remedial alternatives for each site.

NATURE AND EXTENT OF CONTAMINATION

The draft SRI report presents data collected during previous studies at Sites 12 and 13, including data from the Remedial Investigation, performed by FWES in 1993. Based on the RI/SRI data contained in the draft SRI report, the following media have been identified as requiring remedial action:

- Site 12 Groundwater;
- Site 13 Groundwater; and
- Site 13 "Hotspot" Soil.

Analyses of groundwater samples collected from Sites 12 and 13 indicate the presence of both volatile organic and inorganic constituents at levels exceeding U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCLs) for drinking water. Chemicals of concern (COCs) exceeding MCLs at Site 12 groundwater include the volatile organic compounds tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and vinyl chloride. COCs exceeding MCLs in Site 13 groundwater include the volatile organic compound TCE and the semivolatile organic compound pentachlorophenol (PCP). At both sites, COCs also included inorganic constituents such as chromium and lead, which were detected at levels exceeding MCLs in unfiltered samples only.

Concentrations of compounds detected in soil samples collected from both sites were compared to USEPA Region III Risk-Based Concentrations (RBCs) for industrial soils. This comparison indicated the presence of a highly localized "hotspot" of soil containing PCP in excess of the RBCs at Site 13. The hotspot is located in the immediate vicinity of monitoring well LC13-GW8. Confirmatory samples collected during the SRI (1995) indicated that the area of PCP contamination was limited to this hotspot.

A potential risk was also identified in the SRI Risk Assessment (RA) for exposure to Site 12 surface water via ingestion, dermal contact, and ingestion of fish. Because the drainage canal is not used for drinking or recreation, the potential risk of actual exposure via these pathways is low. In addition, analytical results for surface water/sediment samples collected during the RI (1993) and the SRI (1995) indicate that natural processes are effectively reducing levels of the chemicals of concern within these media. Therefore, surface water/sediments in the Site 12 drainage canal have not been addressed in this FS.

DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

Based on the review of the data and risk assessment, the following remedial action objectives for the site are identified:

- Restore contaminated groundwater beneath both sites to MCLs.
- Prevent exposure to areas of high PCP concentrations in hotspot soils at Site 13 (concentrations greater than the USEPA guidance level of 48 mg/kg).
- Prevent further contamination of Site 13 groundwater via infiltration through the hotspot soils above the water table.

Remedial alternatives to meet the remedial objectives were developed by combining representative process options from technically feasible technology types. A total of 12 alternatives were developed: four (4) for Site 12 groundwater, four (4) for Site 13 groundwater, and four (4) for Site 13 hotspot soils. Because of the similarity of the contaminants present in Sites 12 and 13 groundwater, the same alternatives were developed and evaluated for each.

Each alternative was subject to detailed evaluation against the seven USEPA criteria. Initial screening of remedial alternatives was not necessary due to the relatively small number of alternatives.

The following four alternatives were developed to address chemicals detected in groundwater at Sites 12 and 13:

- Alternative GW12/13-1: No Action
- Alternative GW12/13-2: Limited Action (Institutional Controls)
- Alternative GW12/13-3: Extraction/Pretreatment/Discharge to POTW
- Alternative GW12/13-4: In Situ (Biological) Treatment

The No Action alternative would include only five-year reviews of data to determine the need for additional action. Groundwater would be left in place with no treatment. The Limited Action alternative would include a long-term monitoring program; limitations on the use of the aquifer;

and institutional measures such as public awareness/education programs. Similar to the No Action alternative, no groundwater treatment would take place.

Alternatives GW12/13-3 and GW12/13-4 are similar in that both would involve treatment of groundwater underlying the sites. Alternative GW12/13-3 would consist of extraction of the groundwater via pumping; pretreatment consisting of filtration (for metals removal); and discharge to the local publicly owned treatment works (POTW). The local POTW is operated by the Hampton Roads Sanitation District (HRSD). HRSD has indicated a potential willingness to accept groundwater for treatment in their system, subject to certain pretreatment limitations.

Alternative GW12/13-4 consists of biological treatment of the groundwater in place, without extracting. Treatment would be effected by introducing the necessary nutrients and electron acceptors to microorganisms present in the groundwater; these microorganisms then degrade organic chemicals of concern to simpler compounds (e.g., CO_2, H_2O, etc.).

The following four alternatives were developed to address PCP detected in the hotspot soils at Site 13:

- Alternative S13-1: No Action
- Alternative S13-2: Limited Action (Institutional Controls)
- Alternative S13-3: Capping
- Alternative S13-4: Excavation/Off-Site Treatment and Disposal

The No Action alternative would include only five-year reviews of data to determine the need for additional action. Soil would be left in place with no treatment. The Limited Action alternative would include a long-term monitoring program and installation of site security measures to prevent access. Institutional controls such as deed restrictions and public awareness/education programs would also be implemented. Similar to the No Action alternative, soil would remain on-site and no treatment would take place.

Alternative S13-3 would consist of the construction of an asphalt cap over the soil hotspot. Because the soil would remain on-site, reviews would be conducted every five years to determine the need for further action. Alternative S13-4 would include the excavation and removal of the soil hotspot for treatment and disposal at a properly licensed off-site facility. The area would be restored using certified clean backfill. No additional monitoring or assessment would be required.

COMPARISON OF REMEDIAL ALTERNATIVES

Comparison of groundwater alternatives indicate that in general, the No Action and Limited Action alternatives are the least protective and do not provide for any reduction in contaminant levels. The Limited Action alternative provides a reduction in exposure risks due to monitoring and institutional measures. The two treatment alternatives, (GW12/13-3 and GW12/13-4) are generally more protective since both provide for reduction of contaminant levels and a corresponding reduction in potential exposure risks. These treatment alternatives differ in that Alternative GW12/13-4 (In Situ (Biological)Treatment) would not address inorganic chemicals of concern, although it would reduce the organic COCs more quickly than Alternative GW12/13-3 (Extraction/Pretreatment/Discharge to POTW).

The estimated Net Present Value (NPV) costs for the Site 12 and Site 13 groundwater alternatives are listed below:

Site 12 - Exchange Laundry Waste Disposal Area
Groundwater Alternative Costs (NPV)

Alternative No.	Description	Cost
GW12-1	No Action	$ 43,200
GW12-2	Limited Action (Institutional Controls)	$ 326,000
GW12-3	Extraction/Pretreatment/Discharge to POTW	$ 984,400
GW12-4	In Situ (Biological) Treatment	$1,094,700

Site 13 - Public Works PCP Dip-Tank and Wash Rack
Groundwater Alternative Costs (NPV)

Alternative No.	Description	Cost
GW13-1	No Action	$ 43,200
GW13-2	Limited Action (Institutional Controls)	$ 326,000
GW13-3	Extraction/Pretreatment/Discharge to POTW	$1,048,100
GW13-4	In Situ (Biological) Treatment	$ 897,100

Comparison of the Site 13 hotspot soil alternatives indicate that in general, the No Action and Limited Action alternatives are the least protective and do not provide for any reduction in contaminant levels. The Limited Action alternative provides a reduction in exposure risks due to such measures as access restriction and institutional controls. Alternatives S13-3 (Capping) provides protection from exposure and prevents infiltration through the hotspot soils, but does not include removal of any soils. Alternative S13-4 (Excavation/Off-Site Treatment and Disposal) includes removal of the hotspot soils and thus effects a permanent reduction of PCP levels in Site 13 soils.

The estimated Net Present Value (NPV) costs for the Site 13 hotspot soil alternatives are listed below:

Site 13 - Public Works PCP Dip-Tank and Wash Rack
Soil Hotspot Alternative Costs (NPV)

Alternative No.	Description	Cost
S13-1	No Action	$ 43,200
S13-2	Limited Action (Institutional Controls)	$ 389,400
S13-3	Capping	$ 85,300
S13-4	Excavation/Off-Site Treatment and Disposal	$ 30,100

1.0 INTRODUCTION

This report presents the results of a Feasibility Study (FS) for two sites within the Naval Amphibious Base Little Creek (NAB Little Creek), in Virginia Beach, Virginia as part of the Installation Restoration Program (IRP). These two IRP sites are designated as follows:

Site 12: Exchange Laundry Waste Disposal Area; and
Site 13: Public Works PCP Dip-Tank and Wash Rack.

This FS report is being submitted by Foster Wheeler Environmental Services (FWES) under Contract Task Order 0247 of Contract N62470-89-D-4814 through Baker Environmental, Incorporated.

1.1 PURPOSE AND ORGANIZATION OF THE REPORT

The purpose of the Sites 12 and 13 FS was to develop and screen feasible remedial technologies in order to evaluate the most appropriate and cost effective alternatives to address contamination present at the sites. The most promising alternatives were evaluated against a range of factors and compared against one another. This evaluation will provide a basis for selection of the most appropriate remedial alternatives for the sites. Specifically, FS objectives were:

- Identify feasible remedial technologies for containment, removal, or treatment of contaminated soil and groundwater;
- Screen and assemble the feasible technologies into remedial alternatives for detailed analysis; and
- Evaluate and compare the remedial alternatives to provide the basis for selection of the most appropriate remedial alternative.

This FS report was prepared using the data and information presented in the Supplemental Remedial Investigation (SRI) report (FWES, 1996), and consists of the following four sections:

Section 1.0 summarizes background information regarding the site, such as location, features, geology and hydrogeology, history and regulatory actions. The nature and extent of contamination and risk assessment, as discussed in the SRI Report, are also summarized.

Section 2.0 presents the remedial action objectives along with a summary of applicable health and environmental criteria and standards.

Section 3.0 presents the potential technologies identified to meet the general response actions, the technical criteria; the site-specific requirements used in the technology selection process; the results of the remedial technology screening; and the remedial alternatives developed by combining the technologies that passed the screening.

Section 4.0 presents the detailed evaluations of the alternatives developed in Section 3.0. This section presents the detailed descriptions of the cost and non-cost features of each remedial alternative. The analysis of each alternative against nine standard assessment criteria is presented. Finally, this section compares the remedial alternatives to one another.

All of the references and previous studies cited in this report, as well as the other documents used to conduct the FS, are listed in the References section at the end of this report.

1.2 SITE BACKGROUND AND SETTING

NAB Little Creek, located in Virginia Beach, Virginia, was commissioned on July 30, 1945. The facility 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. Chub Lake, Lake Bradford, Little Creek Reservoir/Lake Smith, and Lake Whitehurst are located on, or adjacent to, the facility.

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 Initial Assessment Study (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).

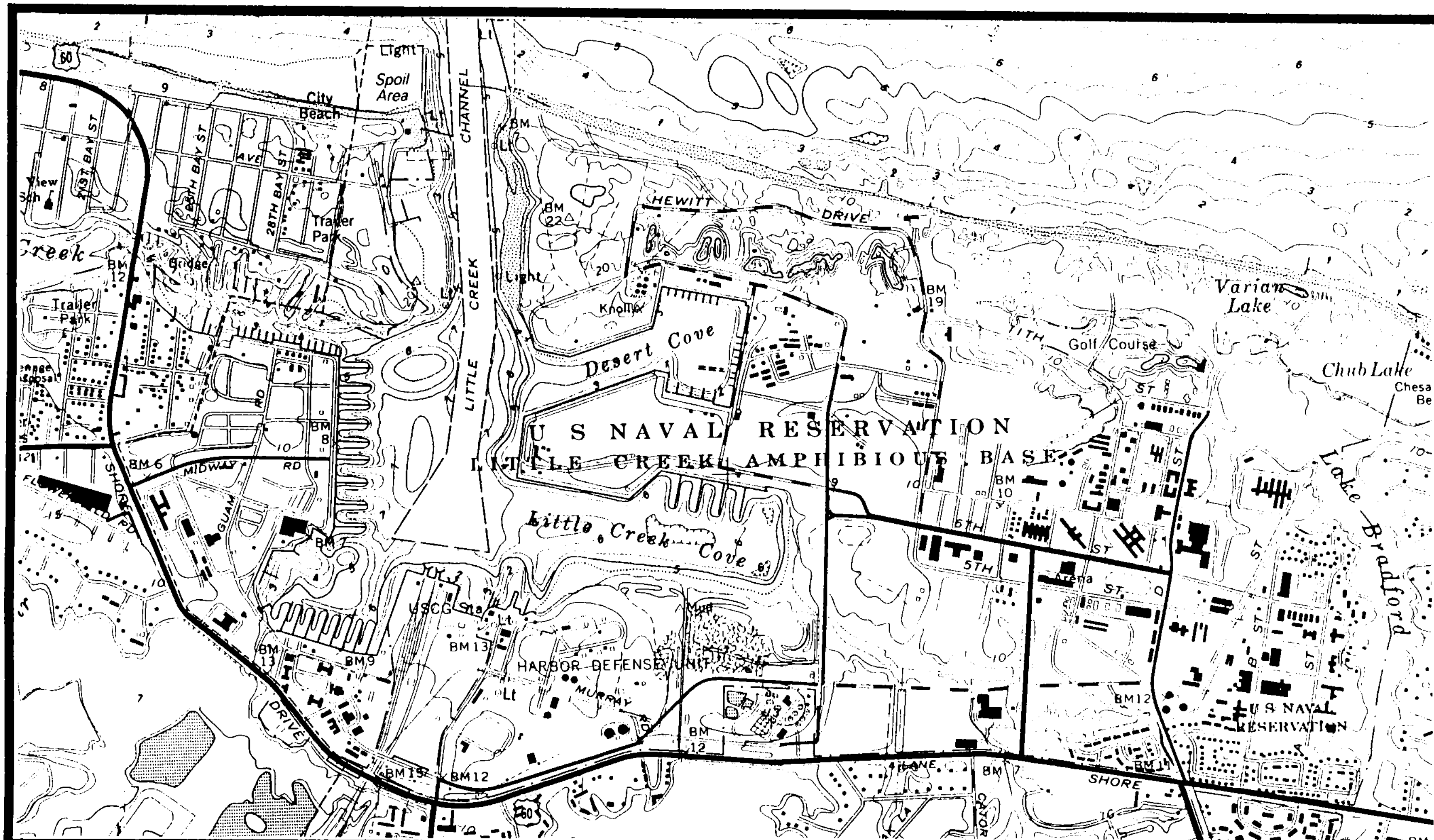
1.3 GENERAL SITE CHARACTERISTICS, LOCATION AND HISTORY

The following sections focus on the overall facility and are common to both Sites 12 and 13 at NAB Little Creek.

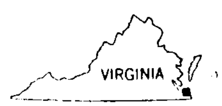
1.3.1 <u>Facility Description</u>

1.3.1.1 Location

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. Figure 1-1 shows the base location. 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. Land use at the base is primarily industrial, while land surrounding the site is suburban and industrial. The industrial development supports the large shipyards located in the area.

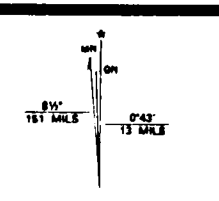


LITTLE CREEK AMPHIBIOUS BASE
VIRGINIA BEACH, VIRGINIA
SITE LOCATION MAP



QUADRANGLE LOCATION

Little Creek, VA Quadrangle
7.5 Minute Series (Topographic)



UTM GRID AND 1986 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Prepared by:
Foster Wheeler Environmental Services

Figure 1-1
Scale: 1" = 2000'

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 ten feet above mean sea level. The primary surface features of the Hampton Roads Area are many rivers, lakes, and marshy areas.

1.3.1.2 Climate

The climate of the Hampton Roads Area is affected by the proximity of the Chesapeake Bay and Atlantic Ocean. These two large water bodies attenuate seasonal climatic changes resulting in mild winters and warm summers. Average total annual precipitation is 45 inches, with approximately 56 percent of the rainfall occurring from April to September. The maximum 24-hour rainfall reported at Norfolk is 11.4 inches in August 1964. Snowfall in the area averages approximately 7.2 inches per year. Temperatures for the region range from a winter average of 42°F to a summer average of 77°F. The hottest temperature recorded is 104°F in August 1980 and the lowest temperature on record for the area is -3°F in January 1985.

Relative humidity in the area ranges from an average of 57 percent at mid-afternoon to an average high of 78 percent at dawn. The prevailing wind direction is to the southwest with an average speed of 10.6 mph.

1.3.1.3 Population Distribution

At full complement, NAB Little Creek currently has approximately 13,650 personnel. The base population increases during the summer, when much of the amphibious training of Navy and Marine Corps Reservists occurs. Approximately 24 ships are homeported at the base.

1.3.1.4 Site Descriptions

The locations of the two sites being studied are shown on Figure 1-2. A discussion of past activities and a physical description of each site are provided in the following paragraphs. Information concerning each site was obtained from the reports of the earlier studies conducted, as identified in Section 1.3.2.

Site 12 - Exchange Laundry Waste Disposal Area

The former Exchange Laundry/Dry Cleaning Facility was located in the area of the present Building 3445, as shown on Figure 1-3, near the intersection of 3rd and B Streets, in the eastern portion of NAB Little Creek installation. Building 3323, which housed the laundry facility, was torn down in 1987. A catch basin and a portion of a storm sewer line were also removed at that time. The sewer line received dry cleaning wastes from the former Naval Exchange (NEX) laundry and drained to a canal that flows between Lake Bradford and Little Creek Cove. The remains of the storm sewer were removed and the area regraded for the construction of the existing commissary.

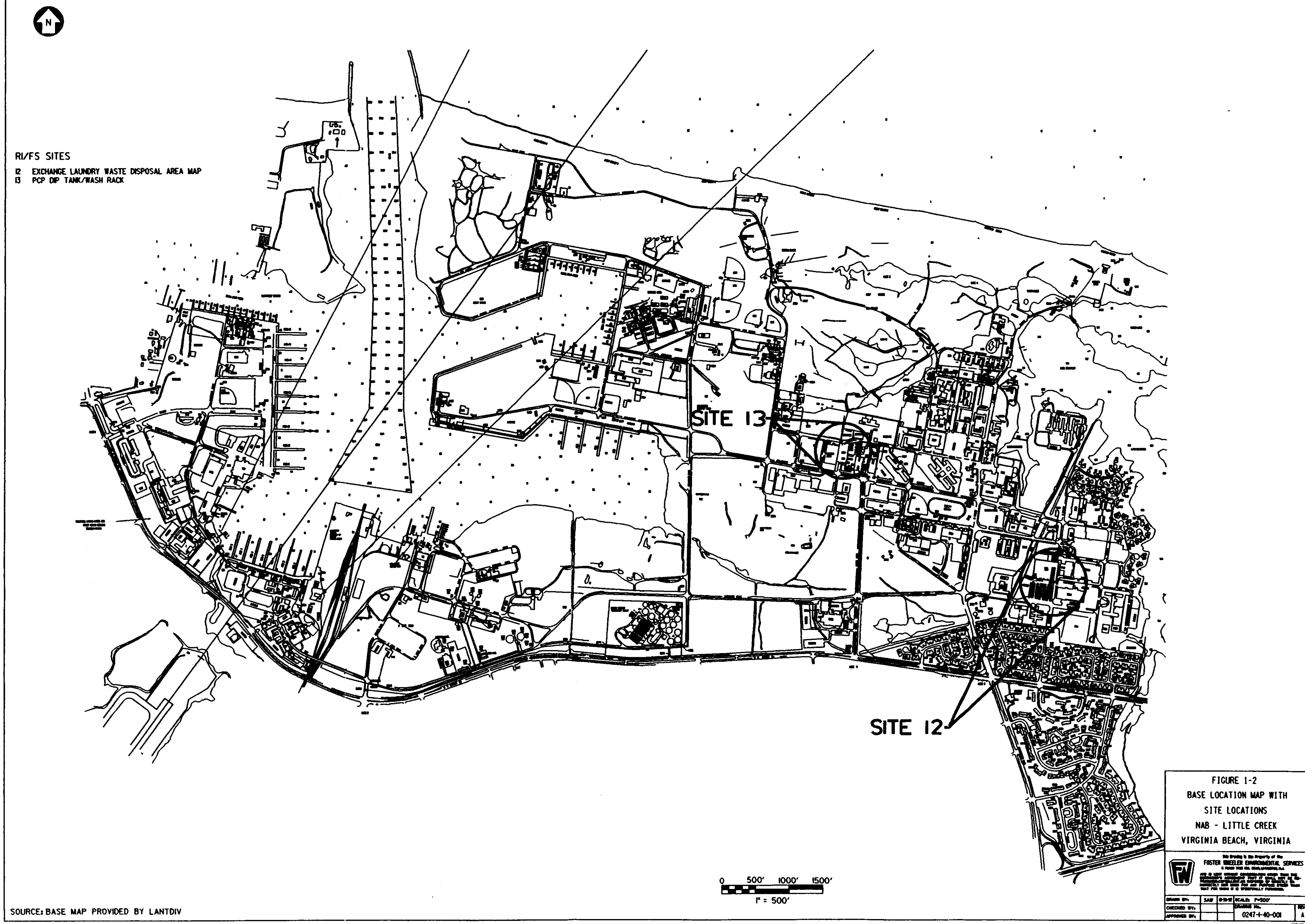


FIGURE 1-2
BASE LOCATION MAP WITH
SITE LOCATIONS
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

FOSTER WHEELER ENVIRONMENTAL SERVICES

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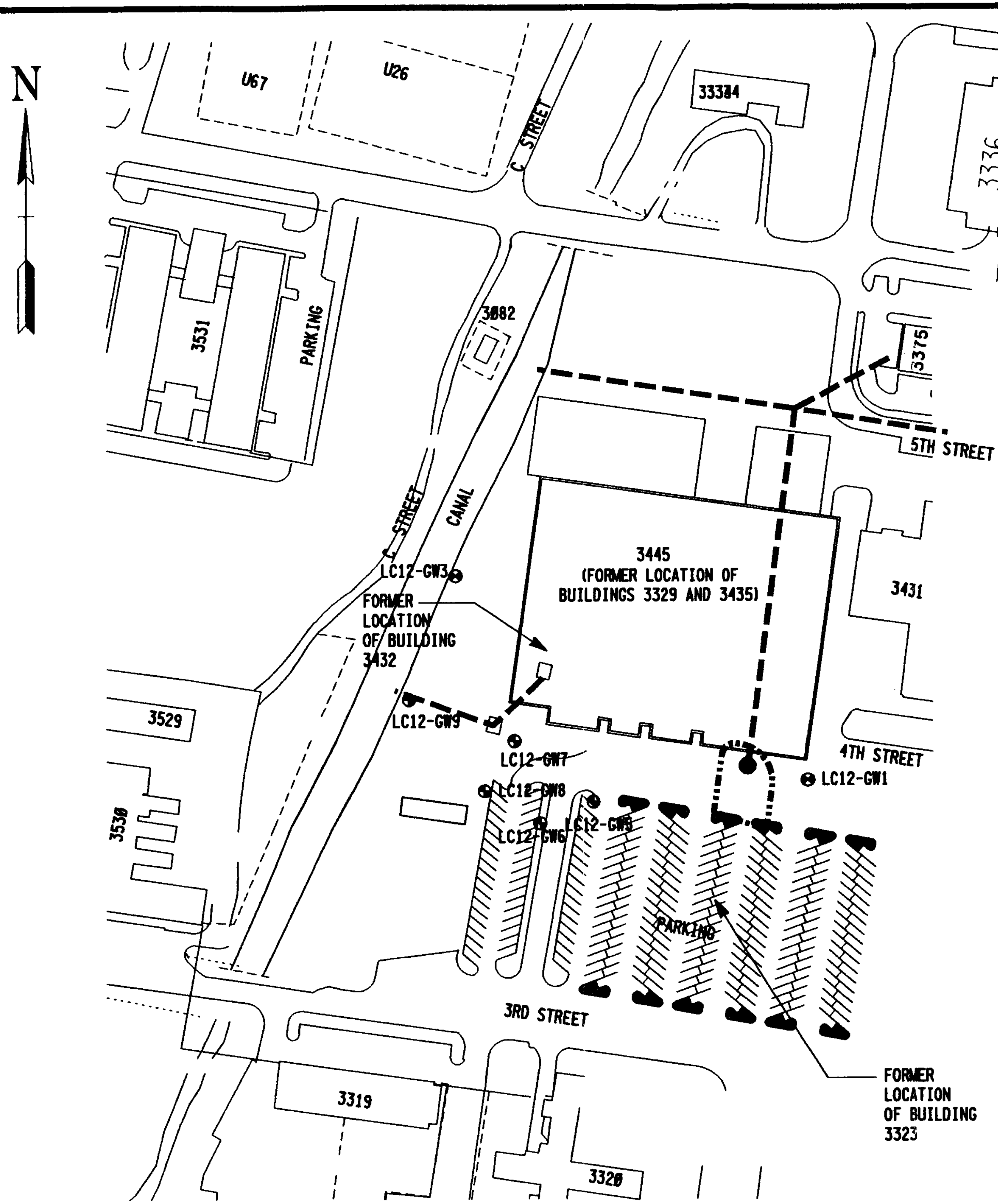
APPROVED BY:				



LEGEND

- FORMER WATER AND STORM SEWER LINE
- SITE BOUNDARY
- LC12-GW5 — MONITORING WELL INSTALLED BY FWES
- LC12-GW1 — EXISTING MONITORING WELL INSTALLED BY FWES

GRAPHIC SCALE

Ø 150′ 300′ 450′

1" =150′ -Ø"

REV.	DATE	DESCRIPTION	APPR.

REVISIONS

FIGURE 1-3

SITE MAP

SITE 12

NAB - LITTLE CREEK

VIRGINIA BEACH, VIRGINIA

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Site 12 encompasses the area immediately surrounding a former storm drain catch basin previously used for disposal of laundering-related materials (i.e., soaps, sizing, sludges, etc.). Site 12 also includes the area where sampling was conducted. The entire site is approximately 11 acres in size. Site 12 is located in a heavily used commercial area. The site is bordered to the east by what was previously B Street (the former B Street has been included in the new parking area for the Base Commissary); to the south by 3rd Street; to the west by a drainage canal, and to the north by 5th Street. The maximum length of the site is approximately 960 feet, and the average width is approximately 515 feet.

The Commissary building, which was constructed and completed in May 1993, covers approximately 20 percent of the site. A car wash and a waste water transfer station are located in the southwest corner of the site. Paved parking areas cover a large portion of the remaining surface area of Site 12. Grass covered areas lie between the Commissary and parking lots, and between the Commissary and the wooded area along the drainage canal.

The site is relatively level with an average elevation of approximately 11.5 feet above mean sea level (msl). The lowest elevations surveyed on the site occur along the western boundary where previous sediment samples were collected in the drainage canal. Surface water drainage on the site is controlled by a network of storm sewers, with the outflow being directed into the drainage canal. Water in the drainage canal is shallow (less than 1 foot in depth) and appeared stagnant, or very slow moving to the north during SRI field activities.

As reported in the IAS, wastes were dumped into the storm sewer and thought to flow into the drainage canal via an outfall located immediately west of the former laundry building. However, review of the storm sewer configuration, conducted by Little Creek personnel in the summer of 1991, revealed that drainage from the catch basin reportedly used for the dumping actually flows north along B Street and then west along the north side of Building 3329, before flowing into the canal. Based on this information, the outfall for wastes dumped into the catch basin was approximately 350 feet north of the outfall sampled during the IRI investigation and the 1986 investigation. Drainage into the outfall pipe sampled during the IRI comes from a relatively small area of the parking lot around Building 3432. Based on recommendations made by the Site Characterization report, dated June 1992, for the Commissary Construction Project, the storm sewer was removed and the area regraded.

The drainage canal is approximately 20 feet wide and 9 feet deep from grade. The sides of the canal are steep and covered with a relatively thick growth of vegetation. At the time of the April 1991 IRI site visit, the canal contained approximately 2 to 3 feet of water, i.e., the water level was 5 to 6 feet below grade. The canal is bordered by a 50-foot wide strip of vegetation on either side containing abundant trees, bushes, and weeds. Water within the canal was brownish in color and appeared to be stagnant during the IRI. During a January 1992 field visit, the water in the canal was flowing in a southwest direction. Miscellaneous trash and refuse were observed in many places along the banks of the canal and the wooded areas.

The IAS reported that wastes dumped into the storm sewer and canal included tetrachloroethane (PCE) sludges, soap, sizing, and dyes. The period of operation and disposal lasted from 1973 until 1978, during which an estimated 1,320 gallons of waste were dumped into the storm sewer drain. Of this total, approximately 200 gallons were PCE sludges. In addition to the dumping, smaller quantities of PCE and other wastes may have entered the storm sewer through run-off from spills or overflow of waste containers.

Site 13 - Public Works PCP Dip Tank and Wash Rack

Site 13 is located in an area with numerous buildings which house utility and maintenance departments for the base. The majority of the area surrounding the site is covered by either asphalt or buildings. There are buildings located east and south of the site; west of the site is another secure storage area surrounded by a chain link fence; and north of the site is 7th Street. Just south of 7th Street is a narrow strip of lawn area.

Site 13 covers approximately 12,000 square feet, as shown on Figure 1-4. Nearly all of the northern half of the site is located in an asphalt covered secure storage area surrounded by a chain link fence. The southern half of the site is a gravel parking area or weeded area. The site is relatively level with an average elevation of approximately 7.5 feet above msl. The lowest ground elevations occur along 7th Street at monitoring well LC13-GW2.

The location of the former PCP dip tank and wash rack, shown on Figure 1-4, was near the intersection of 7th and F Streets, in the eastern portion of NAB Little Creek installation. The site consisted of the dip tank formerly used to treat wood with pentachlorophenol (PCP), an adjacent area that contained drying racks for the PCP-treated wood, an open area formerly used by the Public Works Department for storage of supplies and equipment, and a concrete wash rack at the southwestern end of that area.

The PCP Dip Tank was located behind Building 3165E and used from the early 1960s until 1974. The dimensions and construction materials are unknown, but it reportedly contained 300 to 400 gallons of PCP. Wood was dipped into the tank and set on racks for drying. These racks were located immediately north of the dip tank between the tank and 7th Street. The area formerly containing the PCP dip tank and drying racks has since been paved with asphalt, fenced, and converted to a Public Works Department storage area. The dip tank was cleaned out approximately every 6 months, at which time the approximately 55 gallons of PCP sludge generated are believed to have been disposed of in the Amphibious Base Landfill (IAS, 1984). All remaining PCP solution and associated sludges were removed from the tank in 1975. The tank itself was dismantled and disposed of in 1982.

The wash rack and associated storage area, both of which were immediately south of the dip tank and west of Building 3165D, continue to be used by the Public Works Department. The wash rack, located at the southwestern corner of the storage area, is a concrete pad with bermed sides and centrally-located deck drain. The rack is used by the Public Works Department to clean vehicles, equipment, and miscellaneous objects with steam and chemical cleaners. Wash water and other run-off from the rack drains through the central deck drain into an oil/water separator located under the paved driveway between the wash rack and Building 3165. The oil/water separator is accessible via a rectangular steel manhole located in the driveway. The contents of the separator, as observed in April 1991, included both oily sludge and oil.

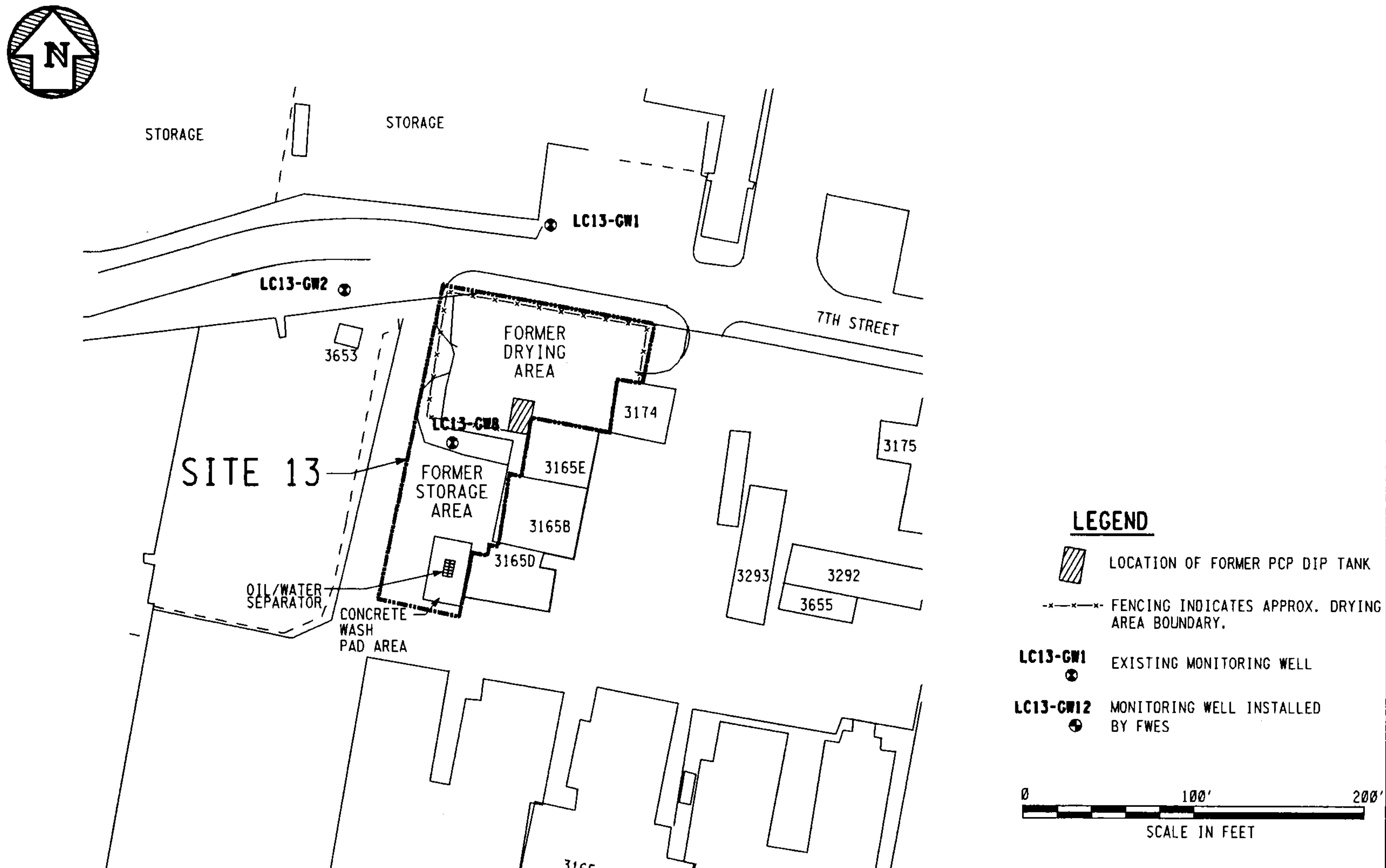


FIGURE 1-4
SITE MAP
SITE 13
PUBLIC WORKS PCP DIP TANK AND WASH RACK AREA MAP
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

This Drawing is the Property of the FOSTER WHEELER ENVIRONMENTAL SERVICES, 8 PEACH TREE HILL ROAD, LIVINGSTON, N.J. AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT, OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED.

SOURCE: BASE MAP PROVIDED BY LANTDIV

The unpaved storage area immediately north of the wash rack, between the wash rack and the former location of the PCP dip tank, was used for the storage of various materials and equipment. The IAS reported evidence of readily observable solvents, paint, fuel, and tar staining the surface in this area. At the time of the April 1991 site investigation during the IRI, the graveled area was free of surface staining, indicating that although the area continues to be used as a storage yard by Public Works, the occurrence of spillage and other releases has been significantly reduced.

1.3.1.5 Geology

NAB Little Creek area is located within the Atlantic Coastal Plain physiographic province. The region is underlain by several thousand feet of unconsolidated deposits of gravel, sand, and clay ranging in age from Lower Cretaceous to Holocene. These sediments overlie a bedrock basement of Precambrian and Triassic/Jurassic age. Generally, the unconsolidated deposits dip and thicken gently eastward, with thicknesses ranging from 2,000 to 4,000 feet. The Coastal Plain of Virginia is divided into six units. From oldest to youngest, they are:

The Patuxent Formation of Early Cretaceous age overlies the bedrock "basement." The Patuxent is an alternating sequence of fine gravel, coarse sand, and silty sandy clay. Sand within the Patuxent is mainly tan, gray, or white and characteristically feldspathic.

In southeastern Virginia, transitional beds of Early Cretaceous age are found above the Patuxent Formation. The transitional beds consist of sand, silt, and clay. These beds are either intermediate in composition and texture or comprise alternations of lithotypes characteristic of the Patuxent and Mattaponi Formations.

The Mattaponi Formation is of Upper Cretaceous, Paleocene, and Eocene age. The formation is of marine origin and characterized by beds of quartz-glauconite sand, glauconitic clay, and shells (Teifke, 1973).

- Patuxent Formation (Transitional Beds),
- Mattaponi Formation
- Nanjemoy Formation,
- Calvert Formation,
- Yorktown Formation, and
- Columbia Group (Teifke, 1973).

The Calvert Formation of Miocene age, which is commonly consolidated, consists largely of clay and silty clay. A basal sand member consisting of medium-to-coarse sand may be present in the Calvert Formation, with some beds or lenses of phosphatic clay.

The Yorktown Formation consists of more abundant and markedly coarser sand and gravel beds, and more abundant and thicker shell beds, than the underlying Calvert Formation. The Yorktown is also lighter in color than the upper member of the Calvert.

The uppermost geologic unit, the Columbia Group, is characterized by beds of light-colored clay, sand, and silt. The average thickness of the unit ranges from 20 feet in the western part to 50 feet in the eastern part of the physiographic province (Oaks and Coch, 1973).

The natural surficial geologic units at NAB Little Creek are an unnamed Holocene sand, which forms the coastal barrier islands and beach-dune ridges bordering Chesapeake Bay, and the Lynnhaven Member of the Upper Pleistocene Age Tabb Formation (Mixon et al., 1989).

Sites 12 and 13 are located in the Lynnhaven Member of the Upper Pleistocene Age Tabb Formation. This unit consists of clayey and silty sand and sandy silt grading downward into a pebbly and cobbly fine to coarse gray sand. The thickness of the Lynnhaven Member of the Tabb Formation ranges from 0 to 20 feet (Mixon et al., 1989). This unit contains the Columbia, or water table aquifer, at the project site.

Site 12 - Geology

At Site 12, the top 4 to 6 inches consists of top soil and organic materials such as grass and root matter or a pavement layer. A clay layer approximately four to six feet thick is found immediately below top soil in borings LC12-GW1, LC12-GW3, and LC12-GW9. At LC12-GW5, LC12-GW6 and LC12-GW8, a sand layer was found to a depth of two to three feet immediately below the top soil or pavement layer. Below this layer, a clay layer three to four feet thick was generally observed. Beneath the clay layer is a sand layer; this layer ranged in depth from 21 feet bgs in borings LC12-GW5, LC12-GW6, and LC12-GW9 to 24 feet bgs in boring LC12-GW7. Below the sand layer is a solid gray clay. The locations of these borings are shown in Figure 1-3.

Site 13 - Geology

At Site 13, the majority of the area is paved or gravel covered. Below the initial layer of asphalt and/or gravel is a layer of clay. This clay layer was observed at the majority of Site 13 monitoring well locations and ranged in thickness from 2 feet at well LC13-GW12 to 8 feet at well LC13-GW8. Sand is then encountered at all boring locations at Site 13. Monitoring well LC13-GW1, installed during a previous study, encountered a second clay layer at a depth of approximately 19 feet below grade. The locations of these borings are shown in Figure 1-4.

1.3.1.6 Soil Sequences

The natural soils at NAB Little Creek have been largely disturbed by construction activities. The IAS estimated that 90 percent of the surface sediments at the base are either urban or dredged from the surrounding waterways, and other soils have been imported. Only 14 acres of undisturbed marsh land remain out of the total 2,147 acres present at NAB Little Creek.

The US Department of Agriculture, Soil Conservation Service (SCS, 1985) lists two general soils for the NAB Little Creek:

- Newhan-Duckston-Corolla - occurring in the coastal region along Chesapeake Bay, characterized as excessively to poorly drained and formed in marine or eolian sediments.

- Udorthents-Urban Lands - occurring throughout the rest of the site, characterized as well to moderately drained with a loamy substratum, and formed primarily in disturbed sediments.

1.3.1.7 Hydrogeology

The hydrogeology of the Virginia Coastal Plain has been characterized by many authors. The uppermost water table aquifer, known as the Columbia Aquifer, is the primary unit of concern at the NAB Little Creek installation. The Columbia Aquifer extends from the ground surface to a depth of 20 feet below mean sea level in the Little Creek area and is underlain by the upper unit of the Yorktown Formation.

The hydrogeologic framework of the Norfolk area includes four principal aquifers, one unconfined and three confined. These aquifers, and their geologic unit equivalents, are:

- The unconfined water table aquifer, mostly in the Columbia Group,

- The Yorktown Aquifer, in the upper part of the Yorktown Formation,

- The Eocene-Upper Cretaceous aquifer, in the lower part of the Calvert and Mattaponi Formations, and

- The lower Cretaceous aquifer, in the Potomac Group.

Confining beds, or aquitards, between and within the aquifers retard, but do not prevent, vertical movement of groundwater. Overall, the water-bearing units comprise a leaky-aquifer system with groundwater generally flowing easterly towards the Chesapeake Bay. The lower Cretaceous Aquifer exhibits the most confinement (Siudyla, et al., 1981).

The Columbia Aquifer lies in beds and lenses of sand and some gravel, shell beds, silt, sandy clay, and clay. The major water-bearing strata, consisting of sand and shell beds and lenses, are highly heterogeneous and discontinuous due to the marine estuarine environments in which they were deposited. The sand units yield quantities adequate for domestic and small industrial demands for non-potable water. The Columbia Aquifer is not used as a potable source of water in the Virginia Beach-Norfolk area. Individual well yields range from 5 to 50 gallons per minute (gpm), and specific capacities range from about 1 to 2 gallons per minute per foot (gpm/ft) (Siudyla, et al., 1981). Groundwater in coastal regions has been found to be saline (Hamilton and Larson, 1988).

Recharge for the Columbia Aquifer comes primarily through infiltration of precipitation. The IAS estimated that approximately 50 percent of the precipitation which falls in the area infiltrates, and 78 percent of the water which infiltrates reaches the water table. Regional hydraulic gradients within the water table aquifer are quite low because of the lack of topographic relief.

The Yorktown Aquifer underlies the Columbia Aquifer. Major water-bearing zones comprising the Yorktown Aquifer are found in the upper 50 to 100 feet of the Yorktown Formation. These water-bearing zones are made of beds of fine to coarse sand, gravel, and shells approximately 5 to 20 feet thick. The Yorktown Aquifer generally is separated from the overlying water table aquifer by beds of silt, clay, and sandy clay about 20 to 40 feet thick (Siudyla, et al., 1981). Groundwater in coastal regions may be saline in the lower part of the aquifer (Hamilton and Larson, 1988).

Well yield and specific capacity data for the Yorktown Aquifer are limited. Reported well yields range from 12 to 304 gpm with an average of 87 gpm. Specific capacities range from 0.5 to 14.4 gpm/ft with an average of 5 gpm/ft. Area domestic well drillers indicate that smaller diameter, 1-1/4 inch to 2 inch, well yields range from 5 to 50 gpm (Siudyla, et al., 1981).

The Eocene-Upper Cretaceous Aquifer is found at a minimum depth of 500 feet in the western section of the Norfolk area to depths of approximately 1,000 feet in the eastern section. The aquifer generally lies in one or two fine- to medium-grained glauconitic sand beds, 10 to 30 feet thick, interbedded with silt and clay (Siudyla, et al., 1981).

The Lower Cretaceous Aquifer lies in interbedded gravel, sand, silt, and clay. In most cases, it is separated from the Eocene-Upper Cretaceous Aquifer by clay and silt units 50 feet or more thick. Beds of clay divide the aquifer into several prolific zones. The top of the aquifer ranges from 600 feet below land surface in the northwestern study area to about 1,100 feet in the eastern section. The bottom of the aquifer rests on basement bedrock at a depth of 2,000 feet in the west to about 4,000 feet in the east. Well yields for this aquifer range from 200 to 1,000 gpm and specific capacities range from 2.9 to 30.8 gpm/ft (Siudyla, et al., 1981).

Site 12 - Hydrogeology

Groundwater beneath Site 12 is located in the undisturbed natural soils and sediment. Monitoring wells were installed within the sand layer to investigate hydrologic conditions, including:

- Depth to groundwater,
- Groundwater flow patterns, and
- Groundwater hydraulic gradients.

On September 21, 1995, groundwater elevations ranged from 4.29 feet above msl in monitoring well LC12-GW8 to 4.85 feet above msl in monitoring well LC12-GW1. Groundwater flow is to the south/southwest, in the general direction of the drainage canal. Previous investigations have concluded that groundwater flow is to the west, also towards the drainage canal. The average hydraulic gradient calculated for the site from the September 21, 1995 water level data is 1.2×10^{-3} ft/ft. The RI/FS provided a hydraulic gradient for the site of 8.69×10^{-4} ft/ft. The IRI investigation provided a hydraulic gradient of 1.6×10^{-3} ft/ft. The monitoring wells used during that study were destroyed during the construction of the Base Commissary.

A number of factors may have contributed to the apparent change in groundwater flow direction noted during the investigation, as well as the differences in the average hydraulic gradient. The differences may be attributed to the installation of additional monitoring wells during the past two studies, and differences in local climatological conditions. The acquisition of data from additional monitoring wells would provide a greater insight into the actual groundwater flow direction and hydraulic gradient at the site. Local climatological conditions (i.e. drought, heavy rain) may temporarily change both flow direction and hydraulic gradient. Also, recent utilities excavation was conducted in the area of the car wash (between the commissary and the drainage canal). These subsurface activities also may have influenced the groundwater table, shifting the flow direction to the south/southwest.

Extended periods of rain or drought are known to influence groundwater levels, especially of the water table aquifer. Because only one round of water levels were collected at this site, no comparisons can be made using local climatological data. Site 12 is located within approximately one mile of Chesapeake Bay. During the RI/FS, a tidal survey and long-term groundwater table monitoring was conducted. As a result, the RI/FS determined that only a slight tidal influence would be expected in the monitoring wells at this location.

Slug Testing

The estimates of hydraulic conductivity (K) at Site 12 were prepared with the data generated from the slug tests, and using the Bouwer-Rice method (Bouwer, H., 1976). The AQTESOLV™ program (Geraghty and Miller, 1989) was utilized to calculate and present the data collected in the field. The tests indicated the horizontal hydraulic conductivities of the sediments were 1.9×10^{-4} ft/sec, 1.9×10^{-4} ft/sec, 3.5×10^{-4} ft/sec, and 3.6×10^{-4} ft/min for LC12-GW2, LC12-GW3,LC12-GW4, and LC12-GW8, respectively. An average hydraulic conductivity of 2.7×10^{-4} ft/sec was calculated for the site.

The groundwater flow velocity has been calculated by the following method:

$$V = Ki/n_e$$

where:

V = velocity in ft/day
K = hydraulic conductivity in ft/sec
i = groundwater gradient in feet/foot
n_e= effective porosity in percent as represented by a decimal

The hydraulic conductivity has been estimated from the slug test data to be 2.7×10^{-4} ft/sec. The gradient is estimated to be 1.2×10^{-3} ft/ft. The effective porosity has been estimated based on the soil boring logs to be 0.3 (Todd, 1980). Thus, the groundwater flow velocity is estimated to be 0.093 ft/day.

Pumping Test

The results of the step test indicated the aquifer underlying Site 12 is very productive. Based on the drawdown observed in the test well, LC12-GW6, the maximum pumping rate used for the test was less than the potential aquifer yield. A discharge rate of 12 gpm was selected for the constant rate pumping test.

The pumping test was started at 11:30 am at a discharge rate of 12 gpm. Water levels were monitored in each observation well and the pumping well. After determining elapsed time and corresponding drawdown in each well, the water level data were plotted in the field on semilog paper to permit field analysis of the pumping test. The pumping test duration was 6.5 hours.

Although all four observation wells, LC12-GW2, LC12-GW5, LC12-GW7, and LC12-GW8, exhibited minor aquifer drawdowns in response to pumping in well LC12-GW6, the semilog plots of drawdown versus time demonstrate clear trends sufficient for analysis. Test data from each observation well was analyzed using the modified non-leaky artesian formula developed by Cooper and Jacob in 1946 (Selected Analytical Methods for Well and Aquifer Evaluation, Walton 1962). This method also is known as the straight line method of aquifer analysis.

Aquifer transmissivity beneath Site 12 ranged from approximately 23,000 gallons per day per foot (gpd/ft) in observation well LC12-GW2 to 35,000 gpd/ft in observation well LC12-GW7. The transmissivity average for the four observation wells equaled approximately 28,000 gpd/ft. A check on the straight line segment (T_{sl}) used to calculate each observation well transmissivity indicates each transmissivity value is valid. Transmissivity calculated for pumping well LC12-GW6 ranged from 14,000 to 40,000 gpd/ft.

Aquifer storativity ranged from approximately $1.3x10^{-3}$ in observation well LC12-GW5 to $8.8x10^{-3}$ in observation well LC12-GW8. The storativity average for the four observation wells equaled approximately $3.3x10^{-3}$.

Results of the pumping test indicate the aquifer underlying Site 12 is very transmissive. Although the results are based on a testing time of only 6.5 hours, the preliminary results indicate a pump and treat system would effectively operate if selected as a remedial option for the site. An extended pumping test prior to a final pump and treat system design would be required to determine water table dewatering effects on extended pumping periods and optimal long term pumping rates to maximize contaminant capture without excess water withdrawal.

Site 13 - Hydrogeology

Groundwater beneath Site 13 is located in the soils and sediment. During water sampling performed as part of this study, water level data was recorded for the monitoring wells at the site. During this investigation the following were established:

- Depth to groundwater,
- Groundwater flow patterns, and
- Groundwater hydraulic gradients.

On September 21, 1995, groundwater elevations ranged from 2.34 feet above msl in monitoring well LC13-GW11 to 2.65 feet above msl in monitoring well LC13-GW1. Groundwater flow is predominatly to the west, with a slight trend towards the southwest. Previous investigations at

Site 13 have similarly concluded groundwater flow is to the west/southwest. The average hydraulic gradient calculated for the site from the September 21, 1995 water level data is 1.46×10^{-3} ft/ft. The RI/FS provided a hydraulic gradient for the site of 4.7×10^{-4} ft/ft.

Extended periods of rain or drought are known to influence groundwater levels, especially that of the water table aquifer. Because only one round of water levels were collected at this site, no comparisons can be made using local climatological data. Site 13 is located within approximately one mile of Chesapeake Bay. From previous work on the base, only a slight tidal influence would be expected in the monitoring wells at this location.

Aquifer Testing

The estimates of hydraulic conductivity (K) at Site 13 were prepared with the data generated from the slug tests, and using the Bouwer-Rice method (Bouwer, H., 1976). The AQTESOLV™ program (Geraghty and Miller, 1989) was utilized to calculate and present the data collected in the field. The tests indicated the horizontal hydraulic conductivities of the sediments were 2.9×10^{-4} ft/sec, 4.8×10^{-4} ft/sec, 2.7×10^{-4} ft/sec, and 1.6×10^{-4} ft/sec for LC13-GW6, LC13-GW7, LC13-GW11, and LC13-GW12, respectively. An average hydraulic conductivity of 3.0×10^{-4} ft/sec was calculated for the site.

The groundwater flow velocity has been calculated by the following method:

$$V = Ki/n_e$$

where:

V = velocity in ft/day
K = hydraulic conductivity in ft/sec
i = groundwater gradient in feet/foot
n_e= effective porosity in percent as represented by a decimal

The hydraulic conductivity has been estimated from the slug test data to be 3.0×10^{-4} ft/sec. The gradient is estimated to be 1.46×10^{-3} ft/ft. The effective porosity has been estimated based on the soil boring logs to be 0.3 (Todd, 1980). Thus, the groundwater flow velocity is estimated to be 0.13 ft/day.

1.3.1.8 Surface Water

NAB Little Creek is located adjacent to Chesapeake Bay, as shown on Figure 1-1. Based on topographic mapping of the site, most surface drainage flows into the Little Creek Tidal Inlet, which consists of Little Creek, Desert Cove, Little Creek Channel, and Little Creek Cove, and then into Chesapeake Bay through the inlet. On the eastern part of the base, surface drainage flows via unlined canals into five lakes, of which Lake Bradford and Chub Lake are the largest. These lakes do not have surface outlets into Chesapeake Bay.

Chub Lake and Lake Bradford are interconnected freshwater lakes, not directly connected with other surface water bodies. The water level in these two lakes is regulated by the release of overflow into a canal which drains to the southwest and eventually into Little Creek Cove. Chub

Lake and Lake Bradford may receive significant amounts of salt water from the Chesapeake Bay during extreme storm events (IAS, 1984).

As described in the IAS, NAB Little Creek is influenced by tidal fluctuations. Little Creek and Little Creek Cove experience a semidiurnal tide of approximately 2.5 feet, but because of the limited areal extent of the harbor, tidal currents are limited. As a result of previous studies, the effects of the tidal fluctuations on the groundwater flow and contaminant migration at the Base vary by location. Tidal effects on the groundwater flow direction at Sites 12 and 13 have been discussed previously.

A narrow east-west trending canal, located south of NAB Little Creek, carries outflow from the freshwater Lake Whitehurst Reservoir and Little Creek Reservoir/Lake Smith to Little Creek Cove. The 4,000-foot long drainage canal originates from Little Creek Reservoir. Lake Smith is designated as an emergency source of potable water.

1.3.2 Previous Investigations

Several studies were performed previously for the NAB Little Creek sites of concern. Findings of each of these studies as they pertain to Sites 12 and 13 are briefly summarized in the following sections. Foster Wheeler Environmental Corporation was responsible for the performance of the Remedial Investigation (RI) and the SRI. The results of these studies are the basis of this FS and are summarized in Section 1.3.3.

1.3.2.1 Site 12 - Exchange Laundry Waste Disposal Area

Initial Assessment Study (IAS): This study was completed in December 1984. Its objectives were to identify and assess sites posing a potential threat to human health or the environment due to contamination resulting from past hazardous waste management activities. The study entailed the collection and evaluation of archival and activity records relating to waste generation; handling and disposal; characterization of physical conditions (soil, hydrogeology, etc.); and identification of migration pathways and potential receptors. The results of the data evaluation efforts were used to develop recommendations for confirmation studies which would verify the presence of contamination and determine the need for further characterization and/or remediation.

The IAS presented a number of detailed recommendations concerning the installation and sampling of monitoring wells; sampling of soils, sediments and surface water; and types of analyses to be performed. In the area of Site 12, because of the time that had passed since the disposal practices ended, the IAS anticipated that PCE-laden sediments may have been buried by more recent material. It was recommended that a total of six lake and canal sediment samples be collected.

Round 1 Verification Step (RVS): The RVS was the first step in the confirmation study process at NAB and was completed in October 1986. Its purpose was to verify the presence and/or absence of contamination at sites identified in the IAS. This study included the collection of six surface water and six sediment samples. Volatile organic compounds (VOCs) were detected in four of the surface water and all of the sediment samples. Total VOCs in the surface water ranged from not detected to 43.3 μg/l. Total VOCs in the sediment ranged from 11 μg/l to 598 μg/l.

The RVS concluded the primary potential pathway for contaminant migration from the site was likely to be surface water transport southwest toward Little Creek Cove from Lake Bradford. However, at the time of sampling, the direction of surface water flow was not easily discernible. The presence of VOC contaminants downstream of the site indicated a potential for contamination leaving the site to pose a threat to human health. However, because there may have been other sources of VOCs in the surface water, contamination could not be directly attributed to the site. The RVS recommended a second round of sampling including six surface water and two sediment samples; the RVS recommended the sediment samples be collected near the outlet of the drainage pipe.

Phase II Environmental Site Study: A two-phase environmental study was performed by ATEC Environmental Consultants in the Exchange Laundry Waste Area. The initial phase was performed in June through August of 1990, and the follow-up was performed in March 1991. Soil and groundwater samples were collected. Methylene chloride and chloroform were detected in soil samples, and 1,1,1-trichloroethane was detected in one groundwater sample. Several other VOCs were detected in the groundwater samples at levels ranging from not detected to 470 μg/l. The extent of VOCs was not fully delineated during this study. ATEC stated groundwater appeared to be migrating from the site to the drainage ditch and recommended additional monitoring wells be installed and sampled for VOCs in order to delineate the extent and magnitude of the contamination plume.

Interim Remedial Investigation (IRI): The IRI was conducted to determine whether further characterization activities or remedial action was warranted at several of the NAB sites, including Sites 12 and 13. IRI field activities at Site 12 consisted of the collection and analysis of surface water and sediment samples from the drainage canal linking Lake Bradford and Little Creek Cove. The sediment samples were both collected directly adjacent to the southern discharge pipe from depths of 0 to 6 inches and 6 to 12 inches. A total of seven surface water and three sediment samples were collected from the canal for analysis. The data generated by these activities were used to confirm the RVS findings concerning whether discharge of wastes from the former laundry facility had resulted in contamination of the canal.

Groundwater flow and contamination data were not generated as part of the IRI, but were the subject of a separate study completed by ATEC. The results of this study have also been incorporated into the IRI. Potentiometric data presented in the 1991 ATEC report indicated groundwater flow at Site 12 was westward, toward the drainage canal. Given the assumed depth of the canal, the drainage canal probably functions as a local hydrologic boundary, or discharge area, for the water table aquifer. If so, groundwater in the water table aquifer beneath the site would eventually discharge into the drainage canal.

Surface water and sediment samples were collected in December 1990; no VOCs were detected in any of the surface water or sediment samples. As a result of the sampling and analysis operations, the IRI concluded there had been a significant decline in the number of contaminants and magnitude of contamination in the drainage canal that formerly received discharges from the laundry waste disposal area. The apparent clean-up of the canal is most likely a result of both the discontinued discharge of waste from the storm sewer, as well as natural processes. Specific mechanisms to account for the reduction in contamination in the canal include volatilization, dilution, and biodegradation. Periodic flushing of the canal occurs during heavy precipitation events and overflows of Lake Bradford. These flushings could remove contaminated surface water and, if the flow rate is great enough, contaminated sediment as well.

Site Characterization: A Site Characterization study for the construction of the new commissary building at Site 12 was conducted in January 1992. A subsurface investigation evaluated the lateral and vertical extent of potentially contaminated environmental media at the site. Soil borings were drilled in proximity to the location of the former USTs, and each boring was converted into a monitoring well. Soil and groundwater samples from the borings and wells were analyzed to evaluate the extent of contamination. PCE was detected in the soil samples at concentrations ranging from 4 µg/kg to 120 µg/kg. Trace levels of TPH were detected in three of the groundwater samples at concentrations ranging from 30 µg/l to 250 µg/l, well below the Virginia Water Quality Standard of 1,000 µg/l.

A geophysical investigation and soil gas survey also were conducted to identify potential contaminated areas of concern for subsequent sampling. The geophysical data indicated the presence of existing utilities and buried metal objects from the demolition at the site. The soil gas survey indicated the presence of tetrachloroethane, primarily in the southeast corner of the site. The Site Characterization recommended the installation of a passive soil gas reduction system with a liner to reduce the possibility of vapor migration into the proposed new building, and the removal of the storm sewer.

Remedial Investigation/Feasibility Study (RI/FS): The RI phase of this study for Site 12 was performed by FWES in 1993. The purpose of the RI was to fill information gaps and collect additional site-specific data necessary to fully evaluate site conditions, determine potential risks, and to provide information for the development of remedial alternatives. As part of the RI effort, a Geoprobe® investigation was conducted and four monitoring wells were subsequently installed at Site 12. In addition, groundwater, surface water, and sediment samples were collected and analyzed during this investigation. The data obtained during the RI was used in developing a basis for the FS; results are discussed in Section 1.3.3.

1.3.2.2 Site 13 - Public Works PCP Dip Tank and Wash Rack

Initial Assessment Study: The IAS recommended the installation of five monitoring wells to sample and analyze the groundwater. The sampling of the groundwater was to occur quarterly for one year. In addition, six composite soil samples were to be collected in the open lot between the wash rack and the paved compound where the PCP dip tank and layout yard were located to determine the extent of contamination.

Round 1 Verification Step: The RVS involved the collection of five groundwater and six soil samples from the area near Site 13. Individual VOCs were detected in four of the groundwater samples at levels ranging from 6.4 to 21 µg/l. Individual semi-volatile organic compounds

(SVOCs) were detected in four groundwater samples at levels ranging from 1.6 µg/l to 55 µg/l. Oil and grease were detected in three of the groundwater samples at 7,000 µg/l.

Individual VOCs were detected in all six of the soil samples at levels ranging from 0.0016 to 0.4 µg/l. Individual SVOCs were detected in three of the six soil samples at levels ranging from 1.2 to 79 µg/l. Oil and grease also were detected in the soil samples at levels ranging from 115 µg/l to 5,805 µg/l.

The RVS results indicated contamination present in the soil near the location of the former dip tank and in groundwater. The RVS suggested that potential human health risks could be posed by the site contaminants if groundwater from the site is used as a drinking water supply, or if contact is made with the soil beneath the asphalt at the former dip tank location. The RVS recommended a second round of samples be collected from the five monitoring wells.

Interim Remedial Investigation: The IRI field activities at the Public Works PCP dip tank and wash rack consisted of the collection and analysis of groundwater samples and water level data from the monitoring wells at the site. A total of five groundwater samples were collected and analyzed. The data generated by these activities were used to determine groundwater circulation patterns and whether the site has impacted groundwater quality in the area. VOCs and base neutral compounds were detected only in one well. TPH were not detected in any of the five groundwater samples. Metals were detected in all five groundwater samples.

Water level data were collected from the five monitoring wells at Site 13 in December 1990 and March 1991. Groundwater flow at the PCP dip tank changed markedly between January and March 1991. In January, the direction of flow was south-southeast. In March, the elevation of the water table declined significantly in well LC13-GW2, indicating both southward and northward components of flow. The reasons for this reversal in direction are not known, but may be related to precipitation or seasonal variations. The need for additional water level measurements was identified to support a more definitive explanation of the observed trend.

The presence of increasing concentrations of PCP in well LC13-GW1 between 1986 and 1990 suggested the source of PCP contamination was still present during that time. The occurrence of PCP in wells LC13-GW2 and LC13-GW3, both of which are west of the former dip tank and drying yard location, supported earlier interpretations regarding the highly variable nature of groundwater flow at the site, including occasional reversals in the direction of flow. PCP contamination in well LC13-GW4, located south-southeast of the former dip tank location, was attributed to the southward gradient that had also been documented for the site.

Volatile organic contamination detected in well LC13-GW4 indicated the source of contamination at the site was still present. The probable source of this contamination was identified as leaky drains and/or sewer lines located adjacent to Building 3165, or the oil/water separator that lies beneath the driveway, midway between well LC13-GW4 and the wash rack. The use of TCE and other solvents on the wash rack would have resulted in temporary storage in the separator. A sustained release from the separator would have created a significant volume of contaminated soil. A similar situation would have been created if the source was leaky sewer lines beneath Building 3165.

The extent of volatile organic contamination decreased considerably between 1986 and 1990. The decline in TCE concentrations between 1986 and 1990 in wells LC13-GW1, LC13-GW3, and LC13-GW5 was most likely due to the on-going depletion of the source. This depletion would be expected considering TCE and other chlorinated solvents are no longer used at the wash rack or in Building 3165. Fluctuations in the gradient and direction of groundwater flow, as observed with the December 1990 and March 1991 water level data, appear to occur regularly and have probably minimized migration of contamination in any one direction.

The IRI recommended groundwater monitoring should continue at Site 13 to confirm whether a natural clean-up of the aquifer is occurring. However, no additional remedial response was recommended unless the current land use changes or human and/or environmental receptors are identified.

RI/FS: As part of the RI effort completed by FWES at NAB Little Creek in the summer of 1993, three new monitoring wells were installed. In addition, groundwater, surface, and subsurface soil samples were collected and analyzed during this investigation. Results are discussed in the following section.

1.3.3 Nature and Extent of Contamination

The nature and extent of contamination at NAB Little Creek Sites 12 and 13 was further delineated during the RI and SRI. Data from these two studies form the basis for this FS, and include analytical results of soil, groundwater, surface water, and sediment sampling efforts.

1.3.3.1 Site 12

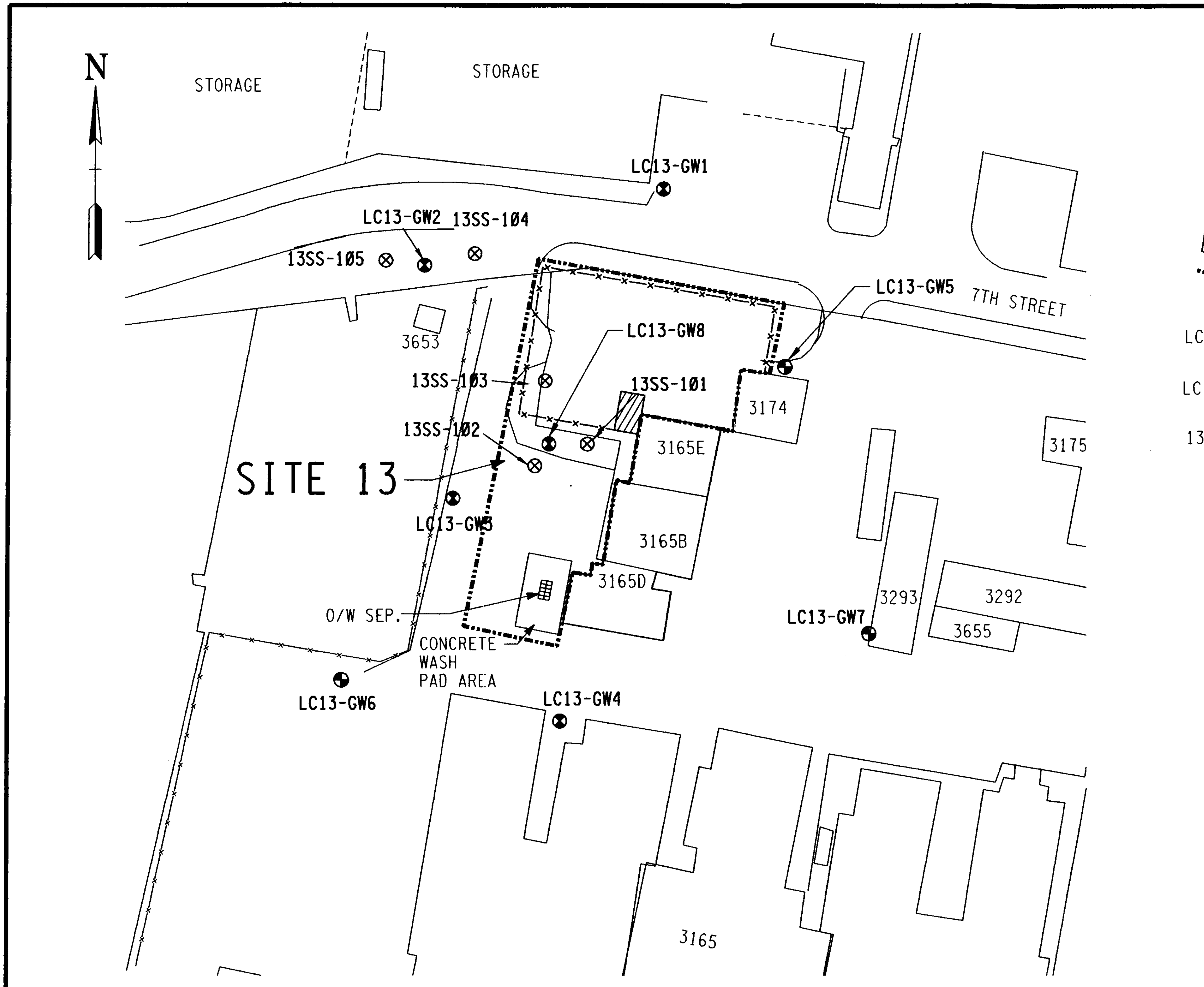
Remedial Investigation

Groundwater, surface water and sediment samples were collected at Site 12 during the RI. The locations of these samples are shown in Figure 1-5.

Four groundwater samples were collected from the four groundwater monitoring wells (i.e., LC12-GW1, LC12-GW2, LC12-GW3 and LC12-GW4) at Site 12 and were analyzed for VOCs. 1,2-dichloroethene (total), trichloroethene, and tetrachloroethene were among the VOCs detected in groundwater samples at Site 12. The highest total VOCs were 18,200 µg/L at LC12-GW2. Table 1-1 presents a summary of this data.

Four surface water samples were collected from the stream adjacent to Site 12. These samples were analyzed for VOCs and TAL metals. The highest total VOCs was 144 µg/L at LC12-SW102. Table 1-2 presents a summary of the surface water VOC and TAL metals data.

Four sediment samples were collected at Site 12; two from the location of LC12-SW102 at depths from 0-6 inches and 6-12 inches, and two from the location of LC12-SW103 at the same depths. These samples were analyzed for VOCs and TAL metals. Table 1-3 presents a summary of the VOC and TAL metals sediment sampling data.



LEGEND

LOCATION OF FORMER PCP DIP TANK

SITE BOUNDARY

EXISTING MONITORING WELL (LC13-GW1)

MONITORING WELL INSTALLED BY FWES (LC13-GW5)

SURFACE SOIL SAMPLES (13SS-104)

GRAPHIC SCALE

0 50' 100' 150'

1" = 50' - 0"

REV.	DATE	DESCRIPTION	APPR.
REVISIONS			

FIGURE 1-5

PREVIOUS SAMPLING LOCATIONS
FWES RI/FS
SITE 13
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

DRAWN BY:	SAW	9/30/93	SCALE: 1"=50'-0"
CHECKED BY:			DRAWING No. 0247-4-48-1301
APPROVED BY:			REV.

CAD Rev No 03 15-MAR-96

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TABLE 1-1

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER[1]

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA REMEDIAL INVESTIGATION (JUNE 1993)

COMPOUND	RANGE DETECTED (ug/L)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
1,2-Dichloroethene (total)	2J-11,000	LC12-GW2	2/4
Trichloroethene	2J-2,300	LC12-GW2	2/4
Tetrachloroethene	2J-4,900	LC12-GW2	3/4

Notes:

J indicates an estimated value.

[1]No analyses performed for SVOCs, Pesticides/PCBs or inorganic compounds.

TABLE 1-2

SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TAL METALS DETECTED IN SURFACE WATER

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA REMEDIAL INVESTIGATION (JUNE 1993)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/L)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
1,2-Dichloroethene (total)	11	LC12-SW103	1/4
2-Butanone	36	LC12-SW102	1/4
Trichloroethene	3J	LC12-SW103	1/4
Tetrachloroethene	3J	LC12-SW103	1/4
Toluene	2J-58	LC12-SW102	3/4
TAL METALS	**RANGE DETECTED (ug/L)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	4,320J-81,800J	LC12-SW102	2/4
Arsenic	2.2J-234J	LC12-SW102	3/4
Barium	25.3J-669J	LC12-SW102	4/4
Beryllium	3.1J	LC12-SW102	1/4
Cadmium	7.5J	LC12-SW102	1/4
Calcium	15,600J-84,500J	LC12-SW102	4/4
Chromium	143J-148J	LC12-SW102	1/4
Cobalt	64.0J	LC12-SW102	1/4
Copper	4.7J-305J	LC12-SW102	4/4
Iron	2,900J-94,800J	LC12-SW102	4/4
Lead	2.05J-312J	LC12-SW102	4/4
Magnesium	5,150J-26,600J	LC12-SW102	4/4
Manganese	507J-1,240J	LC12-SW102	4/4
Mercury	0.79J	LC12-SW102	1/4
Nickel	143J2	LC12-SW102	1/4
Potassium	2,800J-21,300J	LC12-SW102	4/4
Sodium	13,300J-26,200J	LC12-SW102	4/4
Vanadium	11.8J-162J	LC12-SW102	2/4
Zinc	39.1J-3,800J	LC12-SW102	4/4

Notes:

J indicates an estimated value.

The RI/FS concluded groundwater contamination (VOCs) was primarily restricted to monitoring well LC12-GW2. The surface water was also an affected media at the site, with the constituents of concern being primarily TAL metals. As a result, the RI/FS recommended additional subsurface soil, groundwater, and surface water sampling at the site, as well as additional hydrologic testing.

Supplemental Remedial Investigation

Subsurface Soils

Eleven subsurface soil samples were collected at varying depths from soil borings at Site 12. In addition, three clay samples also were collected from the confining clay layer. The soil and clay samples were analyzed for VOCs, SVOCs, pesticides and PCBs, and TAL metals. The sample locations for this sampling event are shown in Figure 1-6; a summary of the results is presented in Table 1-4.

Groundwater

Groundwater samples were collected from the nine groundwater monitoring wells at Site 12. These samples were analyzed for VOCs, SVOCs, pesticides and PCBs, TAL total and dissolved metals, and anions. The sampling locations for this sampling event are shown in Figure 1-6; summaries of the results are presented in Tables 1-5 and 1-6.

Surface Water

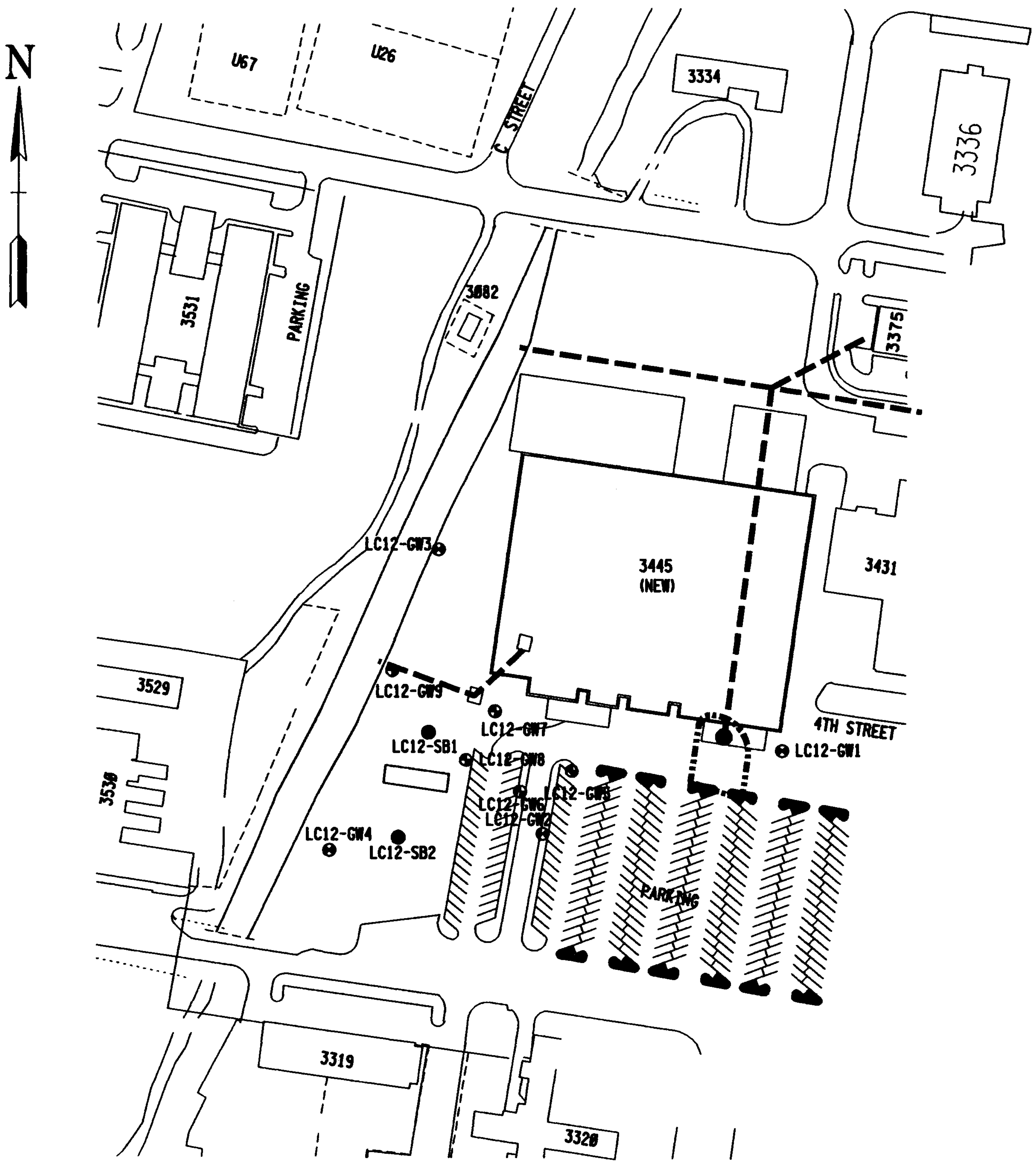
Surface water samples were collected from the drainage canal which is located along the west side of Site 12. Specifically, these samples were collected north of Site 12, between the site and Lake Bradford. Sediment samples were collected at the same locations as surface water samples. These samples were analyzed for VOCs and TAL metals. The sampling locations for this sampling event are shown in Figure 1-7; a summary of the results are presented in Tables 1-7 and 1-8.

1.3.3.2 Site 13

Remedial Investigation

Groundwater and soil samples were collected from Site 13 during the RI. The locations of these samples are shown in Figure 1-8.

Five surface soil samples were collected from the former location of the pentachlorophenol dip tank and a drainage ditch on-site. These samples were collected from a depth of 0 to 6 inches below ground surface and analyzed for VOCs and SVOCs. VOCs were detected at all five surface soil sampling locations. The highest total VOCs detected was 19 µg/kg at 13SS-104.



LEGEND

- FORMER WATER AND STORM SEWER LINE
- SITE BOUNDARY
- LC12-SB1 — SOIL BORING
- LC12-GW5 — MONITORING WELL INSTALLED BY FWES
- LC12-GW1 — EXISTING MONITORING WELL INSTALLED BY FWES

GRAPHIC SCALE

0 150' 300' 450'

1"=150'-0"

REV.	DATE	DESCRIPTION	APPR.

REVISIONS

FIGURE 1-6

SOIL BORING & MONITORING WELL SAMPLING LOCATIONS
SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

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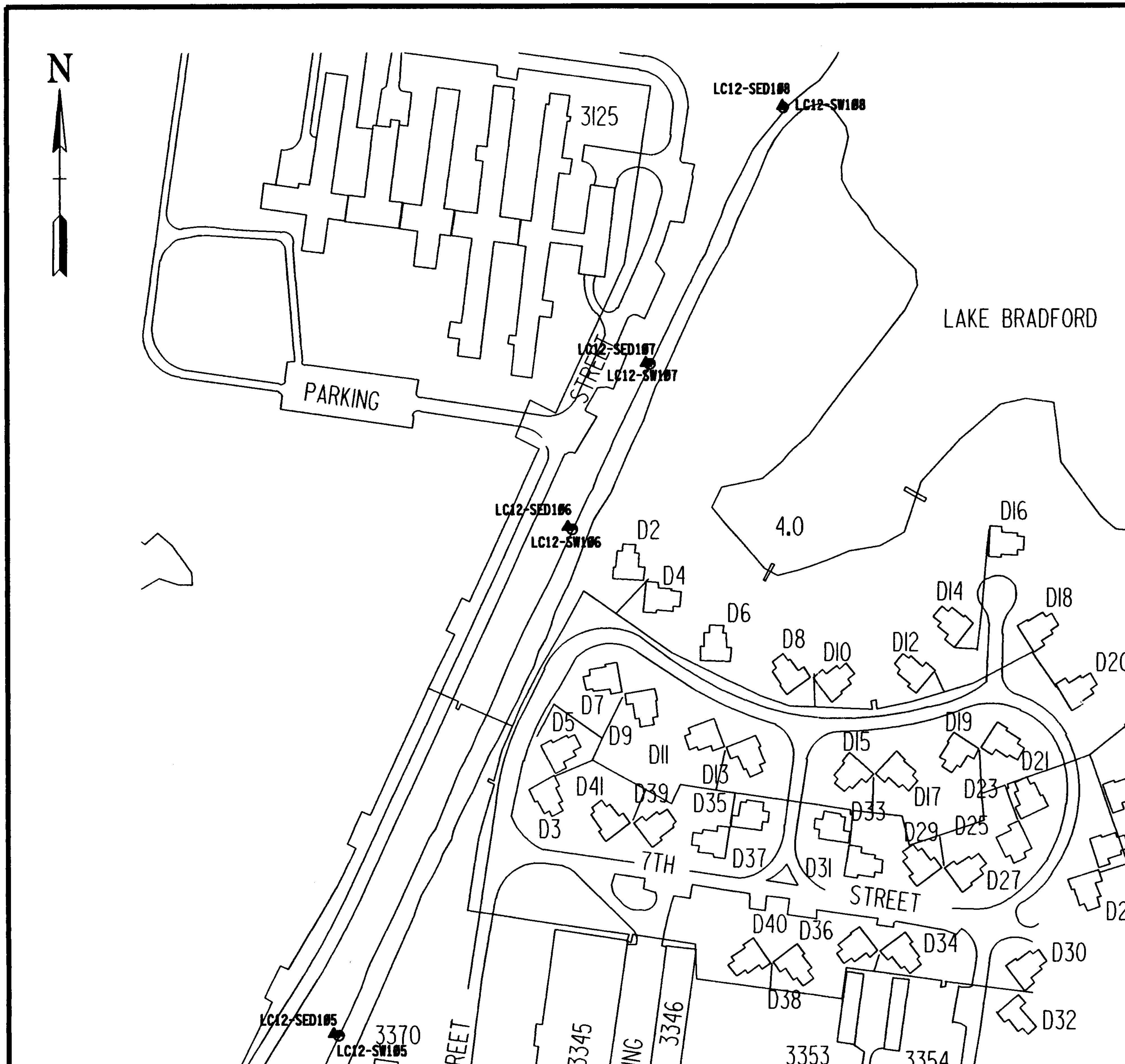

LEGEND

FORMER WATER AND STORM SEWER LINE

SITE BOUNDARY

SURFACE WATER SAMPLE LC12-SW104

SEDIMENT SAMPLE SED104

GRAPHIC SCALE

0 150' 300' 450'

1" = 150'-0"

REV.	DATE	DESCRIPTION	APPR.

REVISIONS

FIGURE 1-7

SEDIMENT/SURFACE WATER SAMPLING LOCATIONS SITE 12

NAB - LITTLE CREEK

VIRGINIA BEACH, VIRGINIA

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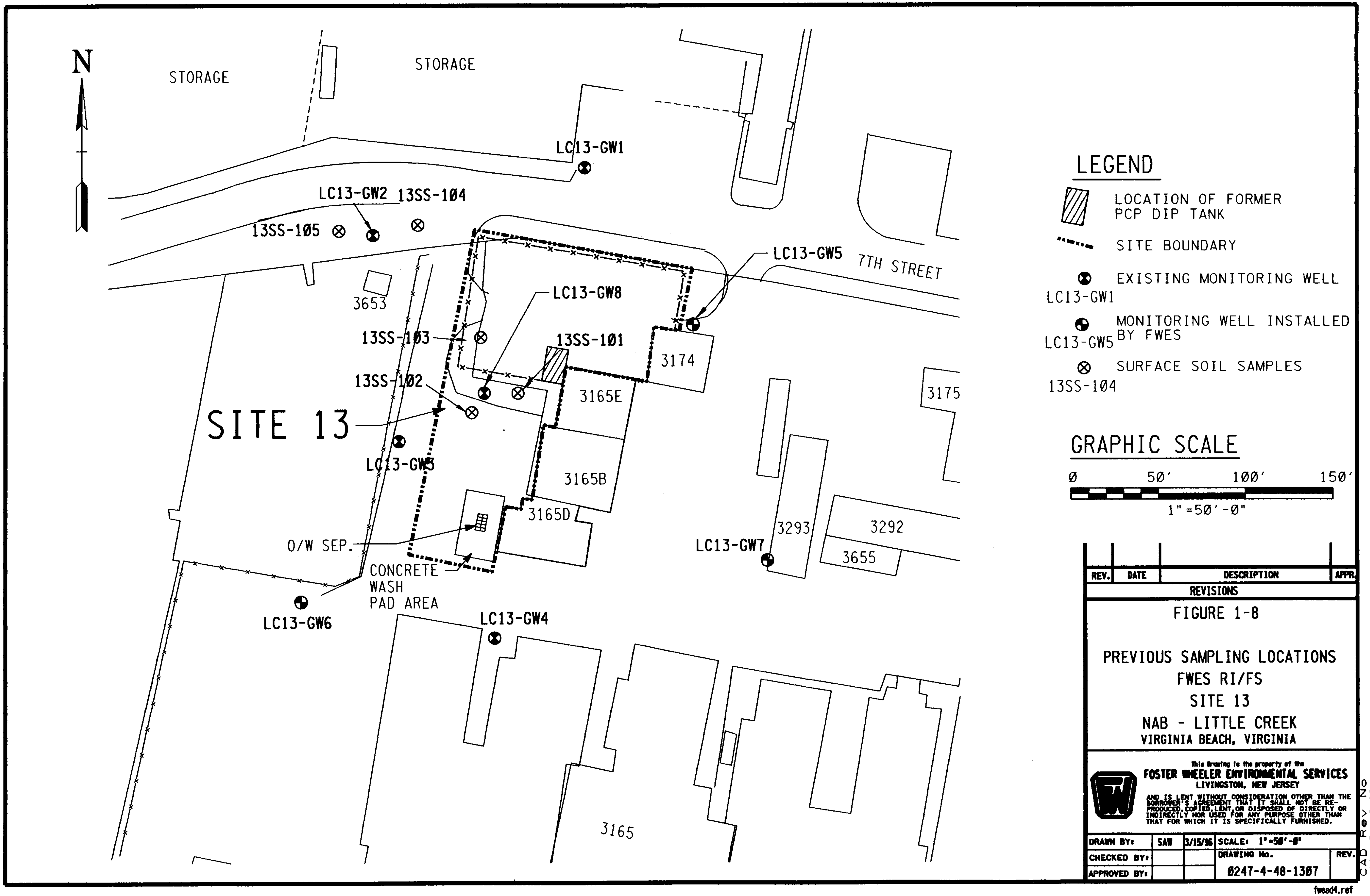

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TABLE 1-3

SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TAL METALS DETECTED IN SEDIMENT SAMPLES

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA REMEDIAL INVESTIGATION (JUNE 1993)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	8J-82J	LC12-SED102-06 (6-12 inches)	3/4
1,2-Dichloroethene	2J-14J	LC12-SED102-00 (0-6 inches)	2/4
Trichloroethene	3J-19J	LC12-SED102-00 (0-6 inches)	2/4
Tetrachloroethene	6J-15J	LC12-SED102-00 (0-6 inches)	2/4
Toluene	5J	LC12-SED103-06 (6-12 inches)	1/4
Xylene (Total)	4J	LC12-SED103-06 (6-12 inches)	1/4
TAL METALS	**RANGE DETECTED (mg/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	1,130J-11,700J	LC12-SED102-00 (0-6 inches)	4/4
Arsenic	0.64J-5.6J	LC12-SED102-00 (0-6 inches)	4/4
Barium	3.4J-72J	LC12-SED102-00 (0-6 inches)	1/4
Cadmium	1.25	LC12-SED102-06 (6-12 inches)	4/4
Calcium	72.5J-2,970J	LC12-SED102-06 (6-12 inches)	4/4
Chromium	1.3J-20.6J	LC12-SED102-00 (0-12 inches)	3/4
Cobalt	1.3J-48J	LC12-SED102-00 (0-6 inches)	4/4
Copper	2.3J-36.0J	LC12-SED102-00 (0-6 inches)	4/4
Iron	1,220J-12,900	LC12-SED102-00 (0-6 inches)	4/4
Lead	8.75-110J	LC12-SED102-00 (0-6 inches)	4/4
Magnesium	83.6J-1,990J	LC12-SED102-00 (0-6 inches)	4/4
Manganese	3.75-144J	LC12-SED102-00 (0-6 inches)	4/4
Mercury	0.28J	LC12-SED103-00 (0-6 inches)	4/4
Nickel	2.9J-13.8J	LC12-SED102-00 (0-6 inches)	3/4
Potassium	45.8J-1.350J	LC12-SED102-00 (0-6 inches)	4/4
Sodium	346J	LC12-SED102-00 (0-6 inches)	4/4
Vanadium	1.9J-26.9J	LC12-SED102-00 (0-6 inches)	4/4
Zinc	6.1J-383J	LC12-SED102-00 (0-6 inches)	4/4

Notes:

J indicates an estimated value.

TABLE 1-4

SUMMARY OF ORGANIC AND INORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA SUPPLEMENT REMEDIAL INVESTIGATION (AUGUST 1995)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	5J-7J	LC12-GW7	2/16
Tetrachloroethene	2J-16	LC12-SB1	2/16
Toluene	1J-4J	LC12-SB1	4/16
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED (ug/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Phenanthrene	55J	LC12-GW7	1/12
Di-n-Butyl phthalate	970	LC12-GW7	1/12
Fluoranthene	67J	LC12-GW7	1/12
Pyrene	52J	LC12-GW7	1/12
Benzo(a)anthracene	36J	LC12-GW7	1/12
Chrysene	58J	LC12-GW7	1/12
Bis(2-ethylhexyl) phthalate	43J-48J	LC12-GW8	1/12
Benzo(b) Fluoranthene	72J	LC12-GW7	1/12
Benzo(k) Fluoranthene	49J	LC12-GW7	1/12
Benzo(a) Pyrene	36J	LC12-GW7	1/12
PESTICIDE/PCB COMPOUNDS	**RANGE DETECTED (ug/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Heptachlor	0.88J	LC12-GW6	1/6
4-4'-DDE	1.7J	LC12-GW7	1/6
4-4'-DDT	3.5J-3.6	LC12-GW7	2/6
Alpha-chlordane	1.8J-9.1	LC12-GW7	4/6
Gamma-chlordane	1.7J-9.7	LC12-GW6	4/6
INORGANIC COMPOUNDS	**RANGE DETECTED mg/Kg**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	390-19,300	LC12-SB1	14/14
Arsenic	1.3J-4.6	LC12-GW9	13/14
Barium	52.70	LC12-SB1	1/14
Chromium	10.9-24	LC12-SB1	13/14
Copper	6.10	LC12-SB1	1/14
Iron	1350-19,000	LC12-GW7	14/14
Lead	5.7-11.7	LC12-GW7	13/14
Manganese	9.6-45.7	LC12-GW9	13/14
Nickel	12.7	LC12-GW7	1/14
Vanadium	2.20BJ-29.30J	LC12-SB1	14/14
Zinc	6.0-19.0	LC12-GW9	13/14

Notes:

J indicates an estimated value.
B indicates compound detected in blank sample.
(1) Indicates concentration shown was detected in duplicate sample.

TABLE 1-5

SUMMARY OF ORGANIC AND PESTICIDE COMPOUNDS DETECTED IN GROUNDWATER SAMPLES

SITE 12 - EXCHANGE LAUNDRY WASTE DISPOSAL AREA SUPPLEMENTAL REMEDIAL INVESTIGATION (AUGUST 1995)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/L)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Vinyl chloride	980	LC12-GW4	1/10
1,2-Dichloroethene	4J-15J	LC12-GW7	3/10
(Total)	1J-760	LC12-GW4	7/10
Trichloroethene	4J-1600	LC12-GW5	6/10
Tetrachloroetene			
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED (mg/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Bis(2-chloroisopropyl) ether	10J	LC12-GW3	1/10
Anthracene	1J	LC12-GW4	1/10
Fluoranthene	1J	LC12-GW4	1/10
Pyrene	1J	LC12-GW4	1/10
Bis(2-ethylhexyl) phthalate	0.9J-1.0J	LC12-GW3/GW4	3/10
COMPOUNDS	**RANGE DETECTED (ug/L)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aldrin	0.015J	LC12-GW2	1/10
Heptachlor epoxide	0.038J	LC12-GW6	1/10
Alpha-chlordane	0.081J	LC12-GW5	1/10
Gamma-chlordane	0.046J	LC12-GW5	1/10

Notes:

J indicates an estimated value.

TABLE 1-6

SUMMARY OF INORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA SUPPLEMENTAL REMEDIAL INVESTIGATION (AUGUST 1995)

COMPOUND	RANGE DETECTED		LOCATION OF MAXIMUM CONCENTRATION		# OF HITS/# OF SAMPLES	
	FILTERED	UNFILTERED	FILTERED	UNFILTERED	FILTERED	UNFILTERED
Aluminum	U/B	15,200-96,700	-	LC12-GW2	0/10	10/10
Arsenic	U	17.7-125	-	LC12-GW2	0/10	10/10
Barium	U/B	210-478	-	LC12-GW8	0/10	6/0
Calcium	7,400-19,900	7,460-32,300	LC12-GW4	LC12-GW4	10/10	10/10
Chromium	U/B	27.80-153	-	LC12-GW9	0/10	10/10
Copper	U/B	40.2-69.0	-	LC12-GW4	0/10	7/10
Iron	362-4,220	24,200-140,000	LC12-GW9	LC12-GW8	8/10	10/10
Lead	43.50	11.10-88.10	LC12-GW4	LC12-GW4	10/10	10/10
Magnesium	6,080-10,700	6,990-17,500	LC12-GW1	LC12-GW8	8/10	10/10
Manganese	112-736	232-1,270	LC12-GW2	LC12-GW2	10/10	10/10
Potassium	B	5,180-10,300	-	LC12-GW9	-	7/10
Sodium	11,600-35,300	11,800-34,900	LC12-GW5	LC12-GW5	10/10	10/10
Vanadium	U/B	65.3-282	-	LC12-GW9	-	8/10
Zinc	31.40J-45.2J	51.6J-262J	LC12-GW9	LC12-GW9	9/10	9/10
Cyanide	NA	6.00	-	LC12-GW1	-	1/10

Notes:

J indicates an estimated value
U indicates compound not detected above detection limit.
B indicates compound detected in laboratory blank.
NA indicates not analyzed

TABLE 1-7

SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND INORGANIC COMPOUNDS DETECTED IN SURFACE WATER SAMPLES

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA SUPPLEMENTAL REMEDIAL INVESTIGATION (SEPTEMBER 1995)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/L)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	13J-15J	LC12-SW105	2/5
INORGANIC COMPOUNDS	**RANGE DETECTED (ug/L)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	274-344	LC12-SW105	3/5
Barium	10	LC12-SW105	1/5
Calcium	5,570-8,870	LC12-SW105	2/5
Iron	951-1,440	LC12-SW107	5/5
Manganese	103-208	LC12-SW108	5/5
Zinc	27.45-34.4J	LC12-SW105	4/5

Notes:

J indicates an estimated value

TABLE 1-8

SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND INORGANIC COMPOUNDS DETECTED IN SEDIMENT SAMPLES

SITE 12-EXCHANGE LAUNDRY WASTE DISPOSAL AREA SUPPLEMENTAL REMEDIAL (SEPTEMBER 1995)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	73J	LC12-SED105	1/5
Chlorobenzene	2J	LC12-SED107	1/5
INORGANIC COMPOUNDS	**RANGE DETECTED (mg/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	974-3260	LC12-SED108	5/5
Arsenic	6.10-7.50	LC12-SED105	2/5
Chromium	3.70-4.80	LC12-SED108	3/5
Iron	1,450-3,900	LC12-SED108	5/5
Lead	3.8 - 101	LC12-SED107	5/5
Manganese	7.10 - 26.20	LC12-SED108	5/5
Zinc	10.30 -21.40	LC12-SED105	5/5

Notes:

J indicates an estimated value

SVOCs were detected at all five surface soil sampling locations. The highest concentrations of SVOC compounds were detected at the 13SS-103 sampling location. Total SVOCs detected ranged from 1,210 µg/kg (J) at 13SS-102 to 95,800 µg/kg (J) at 13SS-106 (duplicate of 13SS-103). Table 1-9 presents a summary of VOCs and SVOCs detected in surface soil samples at Site 13.

Three subsurface soil samples were collected at varying depths from the soil boring which was converted to monitoring well LC13-GW8. These samples were analyzed for VOCs and SVOCs. The highest total VOCs was 250 µg/kg (J). Total concentrations of SVOCs detected ranged from 11,260 µg/kg (J) to 890,000 µg/kg. Table 1-10 presents a summary of VOCs and SVOCs detected in subsurface soil.

Six groundwater samples were collected from monitoring wells at Site 13. These samples were analyzed for VOCs and SVOCs. VOCs were detected at all six groundwater sampling locations. Total VOCs ranged in concentration from 1 µg/l (J) at LC13-GW7 to 262 µg/l (J) at LC13-GW6. The highest concentration of total VOCs was at 13GW06. SVOCs were detected at four of the six groundwater sampling locations. Table 1-11 presents a summary of VOCs and SVOCs detected in groundwater samples at Site 13.

The RI/FS concluded that soils and groundwater are the affected media at the site. SVOCs were detected in surface soils, subsurface soils, and groundwater. PCP was detected in all media. One exceedance of vinyl chloride was detected in groundwater. As a result, the RI/FS recommended additional subsurface soil and groundwater sampling at the site, as well as additional hydrologic testing.

Supplemental Remedial Investigation

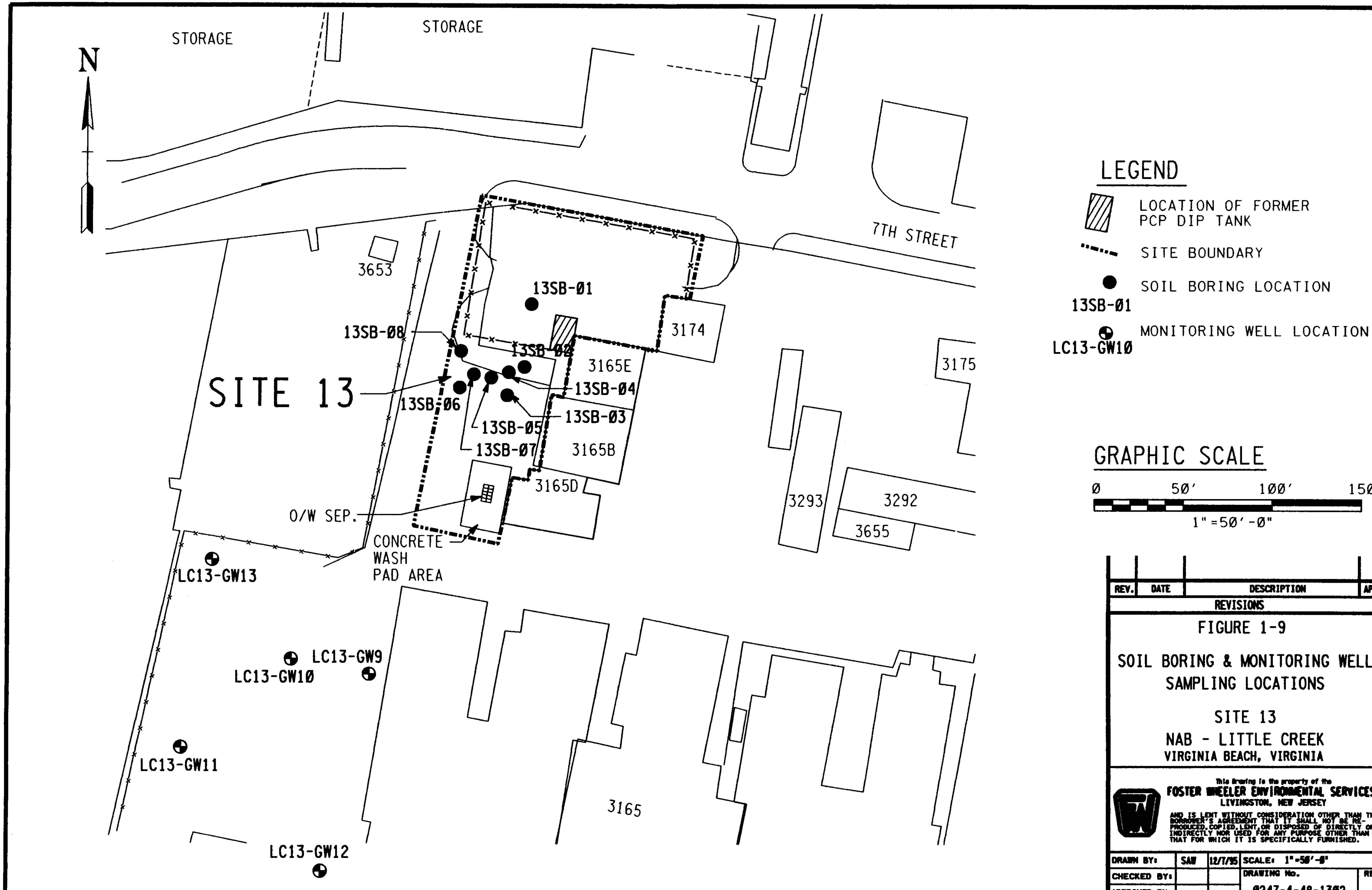
Subsurface Soils

Subsurface soil samples were collected at varying depths from soil borings at Site 13. All samples were analyzed for VOCs and SVOCs, while three samples were analyzed for pesticides, PCBs, and TAL metals. The sample locations for this sampling event are shown in Figure 1-9; a summary of the results is presented in Table 1-12.

VOCs

Groundwater

Groundwater samples were collected from monitoring wells at Site 13. All samples were analyzed for VOCs and SVOCs, while three of the samples were analyzed for pesticides, PCBs, and TAL metals. The sample locations for this sampling event are shown in Figures 1-8 and 1-9; summaries of the results are presented in Tables 1-13 and 1-14.



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REVISIONS

FIGURE 1-9

SOIL BORING & MONITORING WELL SAMPLING LOCATIONS

SITE 13

NAB - LITTLE CREEK

VIRGINIA BEACH, VIRGINIA

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TABLE 1-9

SUMMARY OF VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN SURFACE SOIL SAMPLES

SITE 13-PUBLIC WORKS PCP DIP-TANK AND WASH RACK REMEDIAL INVESTIGATION (JUNE 1993)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	8J-19	13SS-104	4/5
Toluene	2J-3J	13SS-103	3/5
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED (ug/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
2-Methylnaphthalene	410J	13SS-101	1/5
Acenaphthene	950J	13SS-101	1/5
Dibenzofuran	870J	13SS-101	1/5
Fluorene	1,300J	13SS-101	1/5
Pentachlorophenol	520J-13,300	13SS-103(1)	4/5
Phenanthrene	81J-7,900	13SS-101	4/5
Anthracene	1,800J	13SS-101	1/5
Fluoranthene	120J-9,800	13SS-103(1)	4/5
Carbazole	1,200J	13SS-101	1/5
Pyrene	410J-21,000	13SS-103(1)	4/5
Butylbenzylphthalate	38J-44J	13SS-104	2/5
Benzo(a) anthracene	110J-10,000	13SS-103(1)	4/5
Chrysene	120J-10,000	13SS-103(1)	4/5
Bis(2-ethylhexyl)-phtha3late	230J-630	13SS-103(1)	3/5
Benzo(b) Fluoranthene	140J-13,000	13SS-103(1)	5/5
Benzo(k) Fluoranthene	81J-3,400J	13SS-103(1)	4/5
Benzo(a) pyrene	100J-6,400	13SS-103(1)	4/5
Indeno (1,2,3-cd) pyrene	200J-4000J	13SS-103(1)	3/5
Dibenzo (a,h) anthracene	700J	13SS-101	1/5
Benzo (g,h,i) perylene	190J-3,600J	13SS-103(1)	3/5

Notes:

J indicates an estimated value.
(1) Concentration shown was detected in duplicate sample.

TABLE 1-10

SUMMARY OF VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN SUBSURFACE SOIL SAMPLES

SITE 13-PUBLIC WORKS PCP DIP-TANK AND WASH RACK REMEDIAL INVESTIGATION (JUNE 1993)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	130J	LC13-GW8	1/3
Ethylbenzene	17J	LC13-GW8	1/3
Xylene (Total)	120-190	LC13-GW8	2/3
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED (ug/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Naphthalene	85J	LC13-GW8	1/3
2-Methylnaphthalene	120J-6,300J	LC13-GW8	2/3
Pentachlorophenol	11,000-890,000	LC13-GW8	3/3
Bis(2-ethylhexyl) phthalate	55J	LC13-GW8	1/3

Notes:

J indicates an estimated value.

TABLE 1-11

SUMMARY OF VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES

SITE 13-PUBLIC WORKS PCP DIP-TANK AND WASH RACK REMEDIAL INVESTIGATION (JUNE 1993)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/l)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Vinyl chloride	4J	LC13-GW3	1/6
Carbon disulfide	2J	LC13-GW8	1/6
1,1 Dichloroethene	7J	LC13-GW6	1/6
1,2 Dichloroethene (Total)	5J	LC13-GW3	1/6
Trichloroethene	1J-5J	LC13-GW4	4/6
Tetrachlorethene	2J-7J	LC13-GW4	2/6
1,1,2,2,-Tetrachlorethene	55	LC13-GW6	1/6
Toluene	2J	LC13-GW8	1/6
Chlorobenzene	5J-15	LC13-GW5	2/6
Ethylbenzene	3J-110	LC13-GW4	2/6
Xylene (Total)	5J-77	LC13-GW8[(1)]	2/6
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED (ug/l)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
1,4-Dichlorobenzene	1J	LC13-GW3	1/6
Naphthalene	3J-96J	LC13-GW8	2/6
2-Methylnaphthalene	170J	LC13-GW8	1/6
Acenaphthene	1J	LC13-GW6	1/6
Dibenzofuran	2J	LC13-GW6	1/6
Fluorene	1J	LC13-GW6	1/6
Pentachlorophenol	20J-1,700	LC13-GW8	3/6

Notes:

J indicates an estimated value.
[(1)] Indicates concentration shown was detected in duplicate sample.

TABLE 1-12

SUMMARY OF COMPOUNDS
DETECTED IN SOIL SAMPLES

SITE 13-PUBLIC WORKS PCP DIP-TANK AND WASH RACK
SUPPLEMENTAL REMEDIAL INVESTIGATION (AUGUST 1995)

VOLATILE ORGANIC COMPOUNDS	RANGE DETECTED (ug/Kg)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Acetone	29J	13SB-03	1/15
Carbon disulfide	2J	LC13-GW12	1/15
1,1,1-Trichloroethane	9J-21	LC13-GW12	3/15
Benzene	3J-5J	LC13-GW12	2/15
Toluene	1J-4J	13SB-03	6/15
SEMIVOLATILE ORGANIC COMPOUNDS	**RANGE DETECTED ug/Kg**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Di-n-Butyl phthalate	43J-58J	LC13-GW11	4/15
Bis(2-ethylhexyl) phthalate	45J-570	13SB-01	7/15
Di-n-Octylphthalate	56J	13SB-01	1/15
2-Methylnaphthalene	69J	13SB-04	1/15
PESTICIDE AND PCB COMPOUNDS	**RANGE DETECTED (ug/Kg)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
4-4'-DDE	2.4J	13SB-01	1/3
4-4'-DDD	1.5J	13SB-01	1/3
INORGANIC COMPOUNDS	**RANGE DETECTED mg/Kg**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Aluminum	13,300-18,400	13SB-03	3/3
Antimony	3.5J	13SB-01	1/3
Arsenic	3.9-4.0	13SB-01	2/3
Barium	47.9-52.7	13SB-03	2/3
Calcium	492J	13SB-02	1/3
Chromium	13.8-21.2	13SB-01	3/3
Iron	9,150-15,200	13SB-03	3/3
Lead	7.5-9.4	13SB-03	3/3
Manganese	37.9-39.9	13SB-02	3/3
Vanadium	19.40-28.6J	13SB-01	3/3
Zinc	12.2-36.90	13SB-02	3/3

Notes:

J indicates an estimated value

TABLE 1-13

SUMMARY OF VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES

SITE 13-PUBLIC WORKS PCP DIP-TANK AND WASH RACK SUPPLEMENTAL REMEDIAL INVESTIGATION (AUGUST 1995)

VOLATILE ORGANIC COMPOUND	RANGE DETECTED (ug/L)	LOCATION OF MAXIMUM CONCENTRATION	# OF HITS/ # OF SAMPLES
Vinyl chloride	9J-130J	LC13-GW10	3/14
1,1-Dichloroethene	2J-3J	LC13-GW6	2/14
1,2-Dichloroethene (Total)	2J-530D	LC13-GW10	5/14
Trichloroethene	2J-570D	LC13-GW10	6/14
Tetrachloroethene	2J-1200D	LC13-GW6	7/14
Chlorobenzene	1J	LC13-GW6	1/14
Ethylbenzene	3J-4J	LC13-GW10	2/14
Xylene (Total)	49-53X	LC13-GW8	2/14
SEMIVOLATILE ORGANIC COMPOUNDS(1)	**RANGE DETECTED (ug/L)**	**LOCATION OF MAXIMUM CONCENTRATION**	**# OF HITS/ # OF SAMPLES**
Phenol	3J	LC13-GW8	1/12
4-Methylphenol	3J	LC13-GW8	1/12
Naphthalene	73	LC13-GW8	1/12
2-Methylnaphthalene	120	LC13-GW8	1/12
Pentachlorophenol	21J-480D	LC13-GW12	8/12
Phenanthrene	3J	LC13-GW8	1/12
Bis(2-ethylhexyl) phthalate	1J-5J	LC13-GW8	4/12

Notes:

J indicates estimated value
D indicates diluted sample
X indicates sample rejected
(1) September 1995 results

TABLE 1-14

SUMMARY OF PESTICIDES/PCBs AND INORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES

SITE 13-PUBLIC WORKS PCP DIP TANK AND WASH RACK SUPPLEMENTAL REMEDIAL INVESTIGATION (SEPTEMBER 1995)

PESTICIDE AND PCB COMPOUNDS	RANGE DETECTED (ug/L)		LOCATION OF MAXIMUM CONCENTRATION		# OF HITS/ # OF SAMPLES	
4,4'-DDD	0.053		LC13-GW11		1/4	
Alpha chlordane	0.044J		LC13-GW11		1/4	
Gamma chlordane	0.044J		LC13-GW11		1/4	
INORGANIC COMPOUNDS	**RANGE DETECTED (ug/L)**		**LOCATION OF MAXIMUM CONCENTRATION**		**# OF HITS/ # OF SAMPLES**	
	FILTERED	**UNFILTERED**	**FILTERED**	**UNFILTERED**	**FILTERED**	**UNFILTERED**
Aluminum	B	74,500-134,000	-	LC13-GW11	0/4	4/4
Arsenic	U	16.70-39.50	-	LC13-GW11	0/4	4/4
Barium	U	218-246	-	LC13-GW9	0/4	3/4
Calcium	8,610-24,800	11,000-30,400	LC13-GW10	LC13-GW10	4/4	4/4
Chromium	U	53.70-165	-	LC13-GW11	0/4	4/4
Copper	U	28.70-48.5	-	LC13-GW11	0/4	3/4
Iron	11.20J-106J	43,900-135,000	LC13-GW9	LC13-GW11	4/4	4/4
Lead	U	17.60-42.60	-	LC13-GW11	0/4	4/4
Magnesium	5,520-6,080	10,300-14,800	LC13-GW10	LC13-GW10	3/4	4/4
Manganese	109-844	526-1,390	LC13-GW9	LC13-GW9	4/4	4/4
Nickel	U	43.4-66.7	-	LC13-GW11	0/4	3/4
Potassium	B	5,730-9,380	-	LC13-GW10	0/4	4/4
Selenium	U	7.70-10.40	-	LC13-GW11	0/4	3/4
Sodium	15,100-16,700	16,700-17,000	LC13-GW10	LC13-GW11	4/4	4/4
Vanadium	U	82.90-208	-	LC13-GW11	0/4	4/4
Zinc	22.30-50.00	98.7J-192.0J	LC13-GW9	LC13-GW11	4/4	4/4

Notes:

U indicates compound not detected above detection limit
B indicates compound detected in laboratory blank
J indicates estimated value.

1.3.3.3 RI/SRI Data Comparison

The following presents a comparison of the chemical data generated during the 1993 RI/FS and that generated during the SRI.

Site 12 - Exchange Laundry Waste Disposal Area

Groundwater

In addition to the four monitoring wells installed and sampled during the RI/FS, five new monitoring wells were installed and sampled during the SRI.

A comparison between VOCs detected during the RI/FS sampling and those detected during the SRI sampling indicated the following:

- Four VOCs were detected in the samples from both studies, with 1,2-dichloroethene (total), TCE, and PCE being common to both studies. Chloroform, a common laboratory contaminant, was detected in one groundwater sample of the RI/FS, while vinyl chloride was detected in one groundwater sample of the SRI.

- The RI/FS indicated the highest levels of VOCs were detected in monitoring well LC12-GW2. Trace levels of VOCs were detected in monitoring wells LC12-GW3 and LC12-GW4. No VOCs were detected in monitoring well LC12-GW1.

  The SRI indicated the highest levels of VOCs were detected in monitoring well LC12-GW4, while no VOCs were detected in monitoring well LC12-GW2. This may indicate a west/southwesterly movement of the VOC groundwater plume. Monitoring well LC12-GW5, located to the northeast of monitoring well LC12-GW2, contained the next highest levels of VOCs. Trace to low levels of VOCs were detected in all of the other monitoring wells.

Surface Water

Four surface water samples were collected during both the RI/FS and the SRI. The samples collected as part of the RI/FS were collected in the drainage canal, immediately to the west of Site 12. The samples collected as part of the SRI were collected in the same drainage canal, approximately 500 to 1,000 feet to the north, towards Lake Bradford.

The samples collected during the RI/FS contained six VOCs, including acetone, 1,2-dichloroethene (total), 2-butanone, TCE, PCE and toluene. Only one VOC, acetone, was detected in the surface water samples collected during the SRI. Acetone is a common laboratory contaminant.

TAL metals were detected in the samples collected during both studies. The metals of most concern, such as arsenic, cadmium, copper, lead, and zinc, were detected at significantly lower levels in the samples collected during the SRI compared to those of the RI/FS.

The distance between the sampling areas of the two studies is likely the predominant reason for the discrepancies in the levels of compounds detected.

Sediment

Four sediment samples were collected during both the RI/FS and the SRI. The samples collected as part of the RI/FS were collected in the drainage canal, immediately to the west of Site 12. The samples collected as part of the SRI were collected in the same drainage canal, approximately 500 to 1,000 feet to the north, towards Lake Bradford. All sediment samples were collected at locations corresponding with the surface water samples.

The samples collected during the RI/FS contained six VOCs, including acetone, 1,2-dichloroethene (total), TCE, PCE, toluene, and xylenes (total). Only two VOCs, acetone and chlorobenzene, were detected in the sediment samples collected during the SRI. Acetone is a common laboratory contaminant, and chlorobenzene was detected at a trace level.

TAL metals were detected in the samples collected during both studies. The metals of most concern, such as arsenic, cadmium, copper, lead, and zinc, were detected at significantly lower levels in the samples collected during the SRI compared to those of the RI/FS.

The distance between the sampling areas of the two studies is likely the predominant reason for the discrepancies in the levels of compounds detected.

Site 13 - Public Work PCP Dip Tank and Wash Rack

Subsurface Soil

Surface soil samples were collected as part of the RI/FS and contained significant levels of VOCs, primarily those collected in the area of the former PCP dip tank. Subsurface soils collected during the RI/FS contained only trace levels of VOCs. Only trace levels of five VOCs were detected in the subsurface soils collected during the SRI. Of particular note is the presence of only trace levels of VOCs in four of the eight subsurface soil samples collected from the area of the former PCP dip tank. This indicates the contamination present in the source area only lies within the top 6 inches of soil.

PCP was the predominant SVOC detected in the subsurface soil samples collected during the RI/FS. Similarly, PCP was the only SVOC detected at a relatively high level in the subsurface soil samples collected during the SRI, though the levels detected were significantly lower than those observed during the RI/FS.

Groundwater

In addition to the eight monitoring wells installed and sampled during the RI/FS, five new monitoring wells were installed and sampled during the SRI.

A comparison between VOCs detected during the RI/FS sampling and those detected during the SRI sampling indicated the following:

- The highest levels of VOCs detected in both studies were at monitoring well LC13-GW6, though the levels detected in the sample collected during the SRI were significantly higher than those observed during the RI/FS.
- Trace levels of a number of other VOCs, including 1,2-dichloroethene, vinyl chloride, TCE, and PCE, were detected in the majority of samples of both studies.
- Moderate levels of 1,2-dichloroethene, vinyl chloride, TCE, and PCE, were detected in two of the new monitoring wells installed during the SRI. Trace levels were observed in the other three new monitoring wells.

As with the subsurface soil samples, PCP was the SVOC detected at the highest levels in both studies. The highest level of pentachlorophenol detected during the RI/FS was in monitoring well LC13-GW8. Similarly, monitoring well LC13-GW8 also contained the highest level of PCP during the SRI. The level of PCP detected during the SRI was slightly higher than that detected during the RI/FS.

1.3.4 Baseline Risk Assessment

An addendum to the Baseline Risk Assessment for Sites 12 and 13 was prepared as part of the SRI. The risk characterization bridges the gap between risk assessment and risk management, ultimately providing the impetus for the remediation of the site. Risks are characterized and evaluated by comparing indices to standard values. Cancer risks are expressed in the incremental cancer risk (ICR), and are said to be evident when the ICR is greater than or equal to 1×10^{-4}. Noncancer risks are expressed in the hazard index (HI), and are said to be evident when the (HI) exceeds 1.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COCs. These uncertainties are inherent in all inferential risk assessments. USEPA specified inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, therefore, not underestimating potential human health risks.

This risk assessment suggests that carcinogenic and noncarcinogenic risks exist at Sites 12 and 13 for a number of media, pathways, and receptors; these risks are summarized below.

1.3.4.1 Site 12

The Risk Assessment (RA) presented in the SRI report indicates that potential risks are posed at Site 12 by the following:

- Carcinogenic and/or non-carcinogenic risks from ingestion, inhalation, and dermal contact with groundwater due to the presence of VOCs;
- Carcinogenic and/or non-carcinogenic risks from ingestion and dermal contact with surface water due to the presence of inorganics and VOCs;
- Non-carcinogenic risks from ingestion of fish due to the presence of bioaccumulated arsenic, mercury and lead; and
- Non-carcinogenic risks from ingestion of subsurface soil due to the presence of arsenic and iron.

These risks are further discussed for current and future scenarios below.

Current Scenario

A number of health risks exist for the surface water ingestion pathway in the current scenario. The trespasser child HI and ICR were 68.3 and 2.81-04, respectively. In the ICR case, arsenic and beryllium were the controlling pollutants. Inorganics such as arsenic, barium, cadmium, copper, iron, manganese, vanadium, and zinc were the controlling pollutants in the exceedance of HI. The trespasser and worker adult ingestion scenario HIs and ICRs also exceed USEPA benchmarks. The surface water dermal contact exposure HI for a trespasser child is 4.70 due to several volatile organics and inorganics.

Future Scenario

A number of health risks may occur in the future scenario. Two groundwater pathways present a degree of risk on this site in the future scenario. Via ingestion, the resident child's and adult's HI were 3.77 and 2.89, respectively. Via dermal contact, the resident child's HI was 1.27, and the adult's HI and ICR were 1.78 and 2.94E-04, respectively. In each case, vinyl chloride, 1,2-dichloroethene, TCE, and PCE were the controlling pollutants. Trichloroethene, vinyl chloride and 1,2-dichloroethene (total) are most likely environmental degradation products of PCE. Inhalation ICRs for children and adults were 2.12E-04 and 4.55E-04, respectively, primarily due to vinyl chloride.

In addition to the groundwater, the surface water ingestion pathway may pose a risk in the future scenario. The HI and ICR for the resident child were 68.3 and 2.81E-04, respectively and for the adult were 14.6 and 3.01E-04, respectively. In the ICR case, arsenic and beryllium were the controlling pollutants. Moreover, inorganics such as arsenic, barium, cadmium, copper, iron, manganese, vanadium, and zinc were the controlling pollutants in the exceedance of HI. Dermal contact was also of concern with child HI and ICR values of 4.70 and 1.05E-04, respectively and adults HI and ICR values of 3.18 and 3.56E-04, respectively.

The Site 12 fish ingestion resident child and adult exposure HI were 8.38 and 1.78, respectively due to the presence of arsenic and mercury. The resident child ingestion exposure to subsurface soil HI was 1.11 due primarily to arsenic, iron, vanadium, and chromium.

IEUBK Lead Modeling

The IEUBK model results showed that child blood levels may exceed the USEPA's blood level of concern for a scenario involving consumption of fish from the ditch. These fish are assumed to contain bioaccumulated lead.

1.3.4.2 Site 13

The SRI RA indicates that potential risks at Site 13 consist of the following:

- Carcinogenic risk posed by dermal contact with surface soil due to the presence of SVOCs;

- Carcinogenic risk posed by dermal contact with subsurface soil due to the presence of PCP and beryllium; and

- Carcinogenic risk posed by ingestion and dermal contact with groundwater due to the presence of VOCs and SVOCs.

These risks are further discussed for current and future scenarios below.

Current Scenario

The ICR for worker adults exposed incidently to surface soil via dermal contact was 2.78 E-04, primarily due to benzo(a)anthracene, benzo(b)flouranthene, benzo(a)pyrene, and indeno (1.2.3-cd) pyrene.

Future Scenario

The groundwater pathway exhibited a number of risks. The resident adult groundwater ingestion pathway ICR exceeded USEPA's risk range at 3.12E-04. In this case, 1,1,2,2-tetrachloroethene and PCP were the controlling pollutants for ICR. Also in groundwater, some indices exceeded their thresholds in the dermal contact pathway. The resident adult ICR was 4.62E-04; PCP, TCE, PCE, and 1,1,2,2-tetrachloroethane were the controlling pollutants. The calculated ICR of 2.27E-04 for resident adults exposed to subsurface soil via dermal contact also exceeds the acceptable risk range due to the presence of PCP and beryllium.

2.0 REMEDIAL ACTION OBJECTIVES

2.1 DEVELOPMENT OF REMEDIAL OBJECTIVES

The remedial action objectives (RAOs) aimed at protecting human health and the environment will specify the contaminants of concern, exposure routes, receptors and acceptable contaminant levels for each exposure route.

2.1.1 Chemicals of Concern

As discussed in the SRI report (FWES, 1996) and Section 1.0 of this report, a number of organic and inorganic chemicals were detected at the site. A number of chemicals of potential concern were selected for evaluation in the detailed risk assessment performed during the SRI. Chemicals of concern (COCs) were selected separately for each environmental medium (groundwater, surface water, soils, and sediments). The COCs were selected based on validity of the analytical results, frequency of occurrence, and/or toxicological, physical, and chemical characteristics.

VOCs were the most prevalent chemicals of concern in groundwater at Site 12 and were also present in Site 13 groundwater. Site 13 groundwater also contained SVOCs, and inorganics were detected in groundwater samples from both sites. Inorganics were also found at concentrations of concern in sediment and surface water. A summary of the COCs evaluated in the quantitative human health risk assessment performed as part of the SRI is presented in Table 2-1.

2.1.2 Allowable Exposure Based on Risk Assessment (including ARARs)

The risk assessment identifies current and future human and environmental populations potentially exposed to site contaminants and the pathways through which they would potentially be exposed. To evaluate potential human health risks, several exposure pathways were selected for which a quantitative risk can be estimated. The pathways and the associated risks were summarized in Section 1.3.4. The exposure pathways evaluated under current/future use conditions that pose potential human health risks above or within USEPA target levels were:

- Ingestion/Dermal Contact with Groundwater
- Inhalation of Volatiles from Groundwater
- Ingestion/Dermal Contact with Surface Water
- Ingestion of Fish
- Ingestion/Dermal Contact with Surface Soil
- Ingestion/Dermal Contact with Sediments

Chemicals identified as contributing to potential carcinogenic or noncarcinogenic risks above USEPA target levels are considered in this FS. The predominant COCs include PCE, TCE and vinyl chloride in groundwater from both sites; PCP in Site 13 groundwater and soils; and inorganics in Site 12 groundwater.

Applicable or relevant and appropriate requirements (ARARs) are also used in determining allowable exposures; ARARs are identified and fully discussed in Section 2.2. Where chemical-specific or ambient ARARs are available for an environmental medium, they are

TABLE 2-1 (Sheet 1 of 2)

SRI RISK ASSESSMENT CHEMICALS OF CONCERN (COCs)

SITES 12 AND 13 - NAB LITTLE CREEK

Site 12

Groundwater

VOCs	Pest/PCBs	Inorganics		
Vinyl Chloride	Aldrin	Aluminum	Cobalt	Vanadium
1,2-Dichloroethene	Heptachlor	Arsenic	Iron	Zinc
Chloroform	Alpha Chlordane	Barium	Lead	
Trichloroethene	Gamma Chlordane	Cadmium	Manganese	
Tetrachloroethene		Chromium	Nickel	

Surface Water

VOCs	Inorganics			
1,2-Dichloroethene	Aluminum	Cadmium	Lead	Vanadium
Tricholoroethene	Arsenic	Chromium	Manganese	Zinc
Tetrachloroethene	Barium	Cobalt	Mercury	
	Beryllium	Iron	Nickel	

Sediment

VOCs	Inorganics			
1,2-Dichloroethene	Aluminum	Cadmium	Iron	Nickel
Trichloroethene	Arsenic	Chromium	Lead	Vanadium
Tetrachloroethene	Barium	Cobalt	Manganese	Zinc
Toluene	Beryllium	Copper	Mercury	

Fish

VOCs	Inorganics		
Tetrachloroethene	Arsenic	Copper	Zinc
	Beryllium	Mercury	

Subsurface Soils

VOCs	SVOCs	Pest/PCBs	Inorganics	
Tetrachloroethene	Chrysene	Aldrin	Aluminum	Iron
Toluene	Benzo(a)anthracene	Heptachlor	Arsenic	Lead
	Benzo(b)fluoranthene	Alpha Chlordane	Barium	Manganese
	Benzo(k)fluoranthene	Gamma Chlordane	Cadmium	Nickel
	Benzo(a)pyrene		Chromium	Selenium
			Cobalt	Vanadium
			Copper	Zinc

Notes: VOCs - Volatile organic compounds
SVOCs - Semivolatile organic compounds
Pest - Pesticides
PCBs - Polychlorinated biphenyls

TABLE 2-1 (Sheet 2 of 2)

SRI RISK ASSESSMENT CHEMICALS OF CONCERN (COCs)

SITES 12 AND 13 - NAB LITTLE CREEK

Site 13

Surface Soils

SVOCs
- Dibenzofuran
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(a)pyrene
- Benzo(g,h,i)perylene
- Indeno(1,2,3-cd)pyrene
- 2-Methylnaphthalene
- Pentachlorophenol
- Phenanthrene

Subsurface Soils

VOCs	SVOCs	Inorganics
Benzene	2-Methylnaphthalene	Antimony
	Naphthalene	Arsenic
	Pentachlorophenol	Barium
		Beryllium
		Manganese

Groundwater

VOCs	SVOCs	Inorganics
Chlorobenzene	Naphthalene	Manganese
1,2-Dichloroethene	Pentachlorophenol	
Trichloroethene		
Tetrachloroethene		
1,1,2,2-Tetrachloroethane		
Vinyl Chloride		

Notes: VOCs - Volatile organic compounds
SVOCs - Semivolatile organic compounds
Pest - Pesticides
PCBs - Polychlorinated biphenyls

compared with maximum concentrations observed in that medium at points of potential exposure. A comparison with ARARs of the concentrations of chemicals detected in groundwater during the SRI presented in Table 2-2 indicates that organics and metals are in exceedance of federal and state Maximum Contaminant Levels (MCLs). The chemicals of concern in groundwater which exceeded these ARARs at Site 12 include PCE, TCE, 1,2-DCE and vinyl chloride. At Site 13, PCP and TCE exceeded MCLs. At both sites, some inorganics exceeded MCLs in the unfiltered groundwater samples.

Concentrations of contaminants in soils were compared to USEPA Region III Risk-Based Concentrations (RBCs) for industrial soils. The only area of concern was the soil immediately surrounding monitoring well LC13-GW8. During the RI, soil samples were collected from this boring to a depth of 6 feet below grade; samples collected from the 0-2 ft. depth and the 4-6 ft. depth exceeded the RBC for PCP of 48 mg/kg. Additional soil sampling performed during the SRI in the immediate vicinity of well LC13-GW8 indicated that the PCP contamination was highly localized.

The SRI RA indicated that surface water posed a risk by ingestion and dermal contact pathways due to inorganics and the dermal contact pathway due to volatile organics. Because it is highly unlikely that the drainage ditch will be used as a drinking water source, and levels of metals have decreased over time (between the RI in 1993 and SRI in 1995), natural flushing appears to be effectively reducing COC levels. In addition, although the SRI RA indicates a dermal contact risk due to VOCs, this RA was based on data from both the RI (1993) and the SRI (1995). No VOCs were detected in samples collected during the SRI. This indicates that VOC levels in the surface water are also decreasing due to natural attenuation. Due to the minimal risk posed by surface water, this medium has not been addressed in this FS.

The SRI RA also noted a health risk to resident children which would result from ingesting fish taken from the Site 12 drainage ditch, due to bioaccumulation of metals such as lead, mercury and arsenic. There is no indication that the ditch is a significant fishery. In addition, samples collected during the RI/SRI indicate that elevated levels of metals in sediments is a highly localized condition, not indicative of extensive sediment contamination. Due to the relatively low risk posed by sediments as well as decreasing COC levels, it appears that natural flushing will effectively reduce COCs in this medium, and additional institutional restrictions on fishing will be imposed if deemed necessary after further assessment.

2.1.3 Development of Remediation Goals

Based on the review of available data and the results of the SRI RA, it was determined that health concerns exist at Site 12 due to potential exposures to surface water and groundwater. In addition, numerous contaminants are in exceedance of ARARs in groundwater. At Site 13, health concerns are posed by potential exposure to site soils and groundwater.

The remedial actions were developed to meet the following RAOs for the sites:

- Restore contaminated groundwater beneath both sites to MCLs;
- Prevent exposure to areas of high PCP concentration in soils at Site 13 (greater than the USEPA guidance level of 48 mg/kg);

TABLE 2-2

TARGET CHEMICALS OF CONCERN AND CLEANUP LEVELS FOR GROUNDWATER (BASED ON SRI DATA)

SITES 12 AND 13 - NAB LITTLE CREEK

Chemicals of Concern	Site 12 Maximum Concentration Observed - SRI	Site 13 Maximum Concentration Observed - SRI	SDWA MCLs
VOCS (ug/l)			
Vinyl Chloride	980	130 J	2
1,2-Dichloroethene	15 J	530	100
Trichloroethene	760	570	5
Tetrachloroethene	1,600	1,200	5
SVOCs (ug/l)			
Pentachlorophenol	U	480	1
Inorganics (mg/l)(1)			
Aluminum	96.7	134	--
Arsenic	0.125	0.039	--
Barium	0.478	0.246	2
Chromium	0.153	0.165	0.100
Iron	140	135	1 (2)
Lead	0.088	0.043	0.005
Manganese	1.27	1.39	--
Nickel	U	0.067	0.16 (2)
Vanadium	0.282	0.208	--
Zinc	0.262	0.192	0.11 (2)

J - indicates an estimated value.
U - compound not detected.
(1) Inorganic data obtained from unfiltered samples
(2) USEPA Water Quality Criteria (Fresh Chronic Criteria)
VOCs - Volatile organic compounds
SVOCs - Semivolatile organic compounds
MCL - Maximum contaminant level
SDWA - Safe Drinking Water Act

- Prevent further contamination of Site 13 groundwater via infiltration through hotspot soils above the water table.

- Allow surface water at Site 12 to continue flushing of contaminants by natural processes.

2.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

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 be attained under Section 121(d)(2)(c) of SARA if they are more stringent than the federal requirements; are legally enforceable; and are 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 facilities 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 to those encountered at the site, rendering their application appropriate. Relevant and appropriate requirements are intended to have the same weight as applicable requirements.

EPA has also indicated that other federal and state criteria, advisories, and guidelines are 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, yet they may be useful in establishing a cleanup level or in designing the remedial action. TBCs are especially useful when no specific ARARs exist or ARARs are not sufficiently protective. Examples of TBCs include EPA Drinking Water Health Advisories, Carcinogenic Potency Factors, Reference Doses and Risk-Based Concentrations.

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 used during the FS process to develop remedial action objectives; 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:

- <u>Chemical-Specific</u> - 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 and ambient air quality standards.

- <u>Location-Specific</u> - These ARARs and TBCs set restrictions on remedial activities at a site due to its proximity to specific natural or man-made features, including floodplains, wetlands, local historic buildings and/or other structures.

- <u>Action-Specific</u> - 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 and are also considered in the development of the remedial action objectives. Location-specific and 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 2-3 A, B, and C present potential federal action-specific, chemical-specific, and location-specific ARARs; Tables 2-4 A, B, and C present Virginia action-specific, chemical-specific, and location-specific ARARs which may be applicable to Sites 12 and 13.

TABLE 2-3 A (Sheet 1 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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 piles 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	
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	

TABLE 2-3 A (Sheet 2 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
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 2-3 A (Sheet 3 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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.
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 requirements may be ARARs for alternatives that include reinjection of treated groundwater.
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	

TABLE 2-3 A (Sheet 4 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
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	
	National Emission Standards for Hazardous Air Pollutants (NESHAPS)	Any stationary source for which a standard is prescribed under this regulation.	40 CFR 61	

TABLE 2-3 A (Sheet 5 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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.	
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	

TABLE 2-3 A (Sheet 6 of 6)

POTENTIAL FEDERAL ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Solid waste disposal	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 2-3 B (Sheet 1 of 2)

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

REQUIREMENT	PREREQUISITES	CITATION	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, stodge, 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).

TABLE 2-3 B (Sheet 2 of 2)

POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
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.
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 2-3 C

POTENTIAL FEDERAL LOCATION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

LOCATION	REQUIREMENT	PREREQUISITES	CITATION	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 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.
Wetland	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© 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 2-4 A (Sheet 1 of 4)

POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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 piled 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)	

TABLE 2-4 A (Sheet 2 of 4)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
Land Treatment	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	
	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.

TABLE 2-4 A (Sheet 3 of 4)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

ACTION	REQUIREMENT	PREREQUISITES	CITATION	COMMENTS
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	
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.

TABLE 2-4 A (Sheet 4 of 4)
POTENTIAL VIRGINIA ACTION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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.		VR 672-20-10, Part V, Section 5.1.C(12)	
Solid Waste Disposal	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)	
	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, land clearing 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 2-4 B
POTENTIAL VIRGINIA CHEMICAL-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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 2-4 C
POTENTIAL VIRGINIA LOCATION-SPECIFIC ARARs

SITES 12 AND 13 - NAB LITTLE CREEK

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 threaten 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.

2.2.1 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. A brief discussion of the chemical-specific ARARs and TBCs is presented below; additional information on ARARs is presented in Tables 2-3 and 2-4.

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 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. These standards are important when considering treatment system discharge to a surface waterbody.

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.

the feasibility of implementing them were not considered. The NAAQS allow for a margin of safety to account for unidentified hazards and effects.

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, 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 toxic substance (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.

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 are set by the Commonwealth of Virginia similar to those standards given by the Clean Water Act. The standards are important when considering treatment system discharge to a surface waterbody.

2.2.2 Location-Specific ARARs and TBCs

A partial listing and brief discussion of potential federal and state location-specific ARARs and TBCs is presented below. Additional information on ARARs is presented in Tables 2-3 and 2-4.

Wetlands Protection (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 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.) requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.

Endangered Species Act of 1973 (16 USC 1531) (40 CFR Part 502) 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 must be consulted. The report generated from this search provides information on managed areas, rare plants and animals, and their status.

Coastal Zone Management Act requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management. NAB Little Creek lies within the Virginia coastal zone.

Clean Water Act, Section 404 (Wetlands) regulates the discharge of dredged or fill material into certain waters (including wetlands). Dredge or fill material can 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) 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 maintains a list of Historic Places which can be used to identify any historic landmarks 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 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.

2.2.3 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. Additional information on ARARs is presented in Tables 2-3 and 2-4.

The Resource Conservation and Recovery Act (RCRA), as amended, governs the generation, transportation, storage, and the 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. 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, which may be a consideration for various treatment alternatives.

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 must 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) regulates the treatment, storage and disposal of hazardous waste. If RCRA hazardous wastes are found to be present on a site, remedial actions must comply with all applicable rules and regulations as stated in 40 CFR Part 264.

RCRA Excavation and Fugitive Dust Requirements (40 CFR 264.251 and 264.254) - Excavation activities must be conducted in accordance with all applicable regulations in these sections, in order to minimize the threat to public health and the environment from the release of constituents of concern. During the remedial activities, the site must be inspected and/or monitored for various conditions including 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) identifies those RCRA hazardous wastes that are restricted from land disposal. Waste that is land disposal restricted must be shipped off site for disposal with the proper labels, manifests, and notification forms indicating that the waste is land disposal restricted.

OSHA Regulations (29 CFR 1910, 1926, 1940) 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.

DOT Rules for Hazardous Materials Transport (49 CFR 107, 171.1 - 171.500) 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 are applicable to all remedial alternatives involving treatment or disposal of contaminated media or residues. Wastes from remedial activities must be classified for transportation based on the chemicals present in the material. Shipping papers (including hazardous waste manifests) must be prepared describing the hazardous material to be transported and must include such information as contents, shipper's name, proper shipping address, hazard class, identification number, total quantity, and certification of compliance with DOT regulations. All wastes must be packaged according to DOT regulations with the proper markings on each container.

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. 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) 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.

Virginia Hazardous Waste Management Regulations (VR-672-10-01) 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.

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, the action must comply with various VHWMR/RCRA requirements, 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.

Deposition 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 a 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.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 INTRODUCTION

The purpose of this section is to identify, screen, and select the most appropriate technologies to achieve the RAOs developed in Section 2.1 and to address contamination at NAB Little Creek Sites 12 and 13. The most appropriate technologies or process options will be combined into remedial alternatives, to be evaluated in detail in Section 4.0.

The screening of technologies consists of five general steps which are discussed below:

- Development of RAOs specifying the chemicals and media of interest, exposure pathways, and clean up goals that permit a range of treatment and containment alternatives to be developed. The RAOs are developed on the basis of available chemical-specific ARARs, health-based risk calculations drawing upon toxicity data (e.g., Rfds), and site-specific risk-related factors. RAOs for Sites 12 and 13 were developed in Section 2.1.

- Development of general response actions for each medium defining containment, removal, treatment or other actions that may be taken singly or in combination to satisfy the RAOs for the site.

- Identification of volumes or flow rates of the contaminated media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the site.

- Identification and screening of the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site. The general response actions are further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include physical, chemical, or biological technology types).

- Identification and evaluation of process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type. Utilizing process options provides a greater flexibility in the final design while simplifying the FS process. During the remedial design stage, any of the process options can be substituted for another to provide a broad range of viable alternatives.

3.2 GENERAL RESPONSE ACTIONS

At Site 12, groundwater samples collected indicate the presence of VOCs and inorganics in the shallow aquifer exceeding clean up levels (MCLs, as identified in Section 2.3). Between the RI (1993) and the SRI (1995) levels of VOCs in the wells decreased considerably, indicating that the aquifer is flushing naturally. Groundwater at Site 13 is contaminated with VOCs, SVOCs and inorganics at levels exceeding MCLs.

Projected groundwater pumping rates were calculated for Sites 12 and 13 in order to establish an approximate cleanup period. The width of the capture zone, normal to groundwater flow, was determined by the corresponding plume (compound exceedence) width for Sites 12 and 13. Groundwater data for this evaluation was obtained from the SRI. The projected capture zone width required for Site 12 is 225.0 feet at well LC12-GW4 and 275.0 feet across wells LC13-GW12 and LC13-GW13 for Site 13. Required groundwater extraction rates for each scenario were calculated using an analytical solution developed by Keely and Tsang (1983), which is rewritten as follows:

Q = Transmissivity (T) x Groundwater Gradient (I) x Capture Zone Width

Aquifer parameters were obtained from the pump test at Site 12 and groundwater elevation maps provided in the SRI. The model assumes homogeneous and isotropic aquifer conditions, a uniform flow field and discharge of the treated groundwater outside the influence (side or downgradient) of the system capture zone. Actual capture zone dimensions will be influenced by local variations in aquifer permeability, thickness and groundwater flow.

The extraction rate for Site 12 was calculated at approximately 30 GPM and would probably require installation of two groundwater recovery wells. Site 13 may require installation of three recovery wells, at a total groundwater extraction rate of approximately 30 GPM. Based upon the aforementioned assumptions, initial aquifer cleanup times are 17 years for Site 12 and 20 years for Site 13. Calculations and model data are summarized in Table 3-1. A detailed description of the groundwater flush model is contained in Appendix C.

At Site 13, RI soil sampling activities indicated the presence of one hotspot of PCP contamination in the unpaved area where monitoring well LC13-GW8 was installed. Levels of PCP in the soil samples taken from the well boring at depths of 0 to 2 and 4 to 6 feet below grade exceed USEPA guidance levels for PCP in industrial soils. Additional sampling performed during the SRI further delineated the contaminated area, which is assumed to cover approximately 250 sq. ft. and extend to a depth of 6 ft. Therefore, the estimated volume of PCP contaminated soil above the water table is approximately 55 cy.

To address the remedial objectives developed for the site, no action, limited action, and actions consisting of containment, treatment and/or disposal are considered. The No Action alternative involves no treatment but would implement reviews for periodic reevaluation of site conditions. Limited Action categories involve measures that restrict access to contaminated areas and the use of contaminated groundwater, and include long-term monitoring.

TABLE 3-1

PROJECTED CLEANUP TIME
COMPUTATIONAL SUMMARY
SITES 12 AND 13 - NAB LITTLE CREEK

Compounds Exceeding Standards	Maximum Concentration	MCL	OC	Log kow	Koc	Kd	Required Flush Vols.	Pumping Time (Years) at 30 gpm	Biodegrade Half Life (Months)	Time to Cleanup (Biodegrade) (Years)	Projected Cleanup Time (Years)
Site 12											
Vinyl Chloride	980	2	0.005	1.38	30	0.15	9	3	48	36	3
Trichloroethene	760	5	0.005	2.42	152	0.76	27	8	32	19	8
Tetrachloroethene	1600	5	0.005	3.4	303	1.515	57	17	18	13	17(1)
Site 13											
1,2-dichloroethene	530	70	0.005	2.06	217	1.085	15	1	48	12	1.0
Trichloroethene	570	5	0.005	2.42	152	0.76	25	2	32	18	2.0
Tetrachloroethene	1200	5	0.005	3.4	303	1.515	55	5	18	12	5.0
Pentachlorophenol	2300	1	0.005	5.01	900	4.5	220	20	26	24	20

Max: Maximum detected value
MCL: Federal value for groundwater ug/l
OC: Organic carbon content
KOW: Octanol/Water partition
KOC: Soil/Water partition
KcL: Organic chemical distribution coefficient

Notes:
(1) More conservative flushing cleanup period applied.
All concentrations in ug/l.

Containment actions include technologies that involve little or no treatment, but provide protection of human health and the environment by reducing mobility of contaminants and risks of exposure. Containment actions consist of covering contaminated areas and controlling groundwater movement through the use of low permeability barriers or containment walls.

Treatment actions include technologies that act to reduce the volume and/or toxicity of contaminants. These technologies include pumping, excavation, treatment (physical, chemical, or biological) and disposal technologies.

3.3 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

The screening of remedial technologies is performed in two steps; the identification and screening of technology types and process options, and evaluation and selection of representative process options.

3.3.1 Identification of Technologies and Screening Criteria

The remedial technology types associated with each of the general response actions typically considered for the cleanup of contaminated soil and groundwater were developed from the October 1988 Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a), Technology Screening Guide for Treatment of CERCLA Soils and Sludges (USEPA, 1988), the Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (USEPA, 1988b), the revised Handbook for Remedial Action at Waste Disposal Sites (USEPA, 1985), experience on other hazardous waste projects, knowledge of new technologies, and the professional judgment of engineers performing feasibility studies.

Remedial technology types associated with each response action are identified in Table 3-2. Most of these remedial technology types contain several different process options that could apply to the contaminated groundwater. These potentially applicable technology types and process options are screened based on technical implementability and effectiveness considering site-specific conditions, contaminant types and concentrations. Site-specific and contaminant-specific conditions to be addressed in the screening processes, identified from the remedial investigations, include the following:

- Sites 12 and 13 are located within the confines of NAB Little Creek in the Commonwealth of Virginia.

- Site 12 is approximately 11 acres in size and is currently occupied by the base commissary building, associated parking and a car wash. A drainage canal borders the eastern edge of the site and receives stormwater from the site.

TABLE 3-2 (Sheet 1 of 3)

REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

ENVIRONMENTAL MEDIA	REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS
Soil	For Human Health:	No Action/Institutional Actions:	No Action:	
	Prevent ingestion of and contact with contaminated soil that exceeds guidance concentrations.	No Action/Limited Action	Site reviews	Five-year review of site conditions.
	Remediate soil to guidance levels for industrial soils.		Limited Action:	
			Monitoring	Monitor and analyze soils, ground-water and sediment.
			Public Awareness	Post warning signs, inform local officials, hold public meetings, etc.
	For Environmental Protection:		Restricted Access/Use	Access restriction (fence), deed restrictions.
	Prevent transport of contaminants to groundwater via infiltration.			
		Containment Actions:	Containment Technologies:	
		Containment	Containment	Clay cap, synthetic membranes, chemical sealants, multimedia cap.
		Removal/Treatment Actions:	Removal Technologies:	
		Removal/Treatment/Disposal	Removal	Excavation
			Treatment Technologies:	
			Thermal treatment	Incineration, wet oxidation, thermal desorption
			Chemical treatment	Alkali metal dechlorination, soil washing and extraction, super critical fluid extraction, stabilization (solidification)
			Physical treatment	Mechanical aeration

REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

ENVIRONMENTAL MEDIA	REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS
			Biological Treatment	Biodegradation
			In Situ Treatment	Soil flushing, hydrolysis, vitrification, volatilization
			Vapor Phase Emission Control	Vapor phase carbon adsorption, afterburner, catalytic oxidation
			Disposal Technologies: Transportation	Truck, train
			Disposal	Construction of an on-site RCRA landfill, existing off-site RCRA landfill, on-site non-hazardous disposal, off-site non-hazardous disposal.
Groundwater	For Human Health: Prevent ingestion, direct contact and inhalation of contaminated groundwater that presents a significant risk.	No Action/Institutional Action: No Action/Limited Action	No Action: Site reviews	Five-year reviews of site conditions.
	Remediate groundwater to levels protective of human health.		Limited Action: Monitoring	Monitor and analyze ground-water
			Public Awareness	Post warning signs, inform local officials, hold public meetings, etc.
			Restricted Use	Well permit requirements
		Containment Actions: Containment	Containment Technologies: Containment	Sheet piling, slurry walls, grout curtains, bottom sealing, groundwater interception.

TABLE 3-2 (Sheet 3 of 3)

REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

ENVIRONMENTAL MEDIA	REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS
		Removal/Treatment Actions: Removal/Treatment/Disposal	Extraction Technologies: Extraction	Dewatering, pumping
			Treatment Technologies: Physical Treatment	Flocculation, clarification, filtration, air stripping, steam stripping, carbon adsorption.
			Chemical Treatment	Neutralization, chemical precipitation, ion exchange, UV oxidation.
			Biological Treatment	Aerobic, Anaerobic
			In Situ Treatment	Air sparging, biodegradation
			Disposal Technologies: Disposal	POTW, TSD facility, discharge to surface water.

- Site 12 previously consisted of laundry and dry cleaning operations, which reportedly discharged dry cleaning fluids, soaps, dyes and sizings to the storm sewer. The storm sewer in turn discharged to the drainage canal.

- Laundry and dry cleaning operations at Site 12 ceased in 1987; the associated building and part of the storm sewer were also removed at that time. The remaining portion of the storm sewer was removed in 1992, when the existing commissary was constructed.

- Site 13 is approximately 12,000 sq. ft. in size and is currently used as a storage area by the NAB Little Creek Department of Public Works (DPW). The majority of the area is paved with asphalt and fenced.

- The area of hotspot soils at Site 13 consists of an estimated 250 sq. ft. surrounding monitoring well LC13-GW8. This area is unpaved but is covered with gravel. Removal alternatives will address only those soils above the water table to an estimated depth of 6 ft. below grade. This small volume of soil coupled with limited area available at Site 13 (for stockpiling, equipment, etc.) precludes the use of on-site treatment as a feasible technology for soil remediation.

- Site 13 was previously used for wood preserving operations. Wood was treated by dipping into a tank containing PCP; after dipping, the PCP-treated wood was placed on racks to dry. Site 13 also contains the DPW wash rack, which is still in service. The wash rack is a bermed concrete area where trucks and other equipment are steam/chemically cleaned. The drainage from this area flows to an oil/water separator prior to discharge via the storm sewer.

- Wood treating operations took place at Site 13 from the early 1960s to 1974. In 1975 all PCP and sludge were removed from the tank; the tank itself was dismantled and removed in 1982. Tank dimensions and materials of construction are unknown.

- Groundwater flow at Site 12 is south/southwest, towards the drainage canal (FWES, 1996). The water table lies approximately 4 to 6 feet below grade.

- Groundwater beneath Site 13 flows to the west/southwest. The water table lies approximately 4 to 5 feet below grade.

- Soils underlying both sites consist of clayey and silty sand with some clay lenses and gravel. The sand layer is underlain by a layer of clay at depths ranging from 19 to 24 feet below grade.

- The groundwater at Site 12 is contaminated with VOCs, including PCE, TCE, and vinyl chloride. Inorganics are also present at levels exceeding MCLs. The groundwater at Site 13 is contaminated with VOCS and SVOCs (mainly PCP) as well as inorganics.

3.3.2 Evaluation and Selection Criteria for Representative Process Options

For the feasible technologies, process options are evaluated prior to selecting a particular option to represent the technology. Process options are evaluated as described below:

- o Evaluation of process option effectiveness focuses on: 1) ability to process the estimated quantities of material and to meet contaminant reduction goals; 2) effectiveness of protecting human health and the environment during the construction and implementation phases; and 3) reliability of the technology with respect to contaminants and site conditions.
- o Evaluation of implementability augments the evaluation of technical implementability used to screen technologies. This assessment includes institutional factors such as permits and availability of services/materials.
- o At this stage, cost evaluation is very preliminary and relies upon engineering judgement and vendor-provided information to generate a relative cost of process options within a technology type.

3.3.3 Screening and Evaluation of Soil Technologies

In the following subsections, potential technologies for remediation of the PCP contaminated soils at Site 13 are briefly described and summarized with the results of the screening and evaluation. For those technologies which were not retained for further evaluation, the rationale for their elimination is included. The screening evaluations for each identified technology are summarized in Table 3-3. The evaluation and selection of process options for soil technologies is presented in Table 3-4.

3.3.3.1 No Action

No Action is not a category of technologies but an option that does not include any remedial measures. No Action does allow for periodic reviews of the site and reevaluation of the need for remedial action.

No Action

Description: No Action is not a category of technologies but a group of activities which can be used to address the soil contamination problem when no remedial measures will be implemented. The No Action alternative will be constructed later in this report as required by the National Contingency Plan (NCP). The No Action approach includes periodic site reviews.

Initial Screening: Data from soil samples contained during the RI (1993) indicate that a small area of soils at Site 13 exceeds USEPA Risk-Based Concentrations (RBCs) for PCP in industrial soils. The area of soil contamination is not paved, and the existing fence around the DPW storage area does not enclose any of the contaminated soil. Thus, potential exposure to the contaminated soil may persist. Reduction in toxicity, mobility or volume of contaminated soil

TABLE 3-3 (Sheet 1 of 3)

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
1. No Action	o Site Reviews			
	. Five-year reviews	The site and available data are reviewed to determine if remedial action is needed.	X	Provides baseline against which other remedial technologies can be compared.
2. Limited Action (Institutional Controls)	o Monitoring			
	. Monitor and analyze soil and groundwater	Samples are collected and analyzed for contaminants and migration of contaminants is assessed.	X	Provides baseline against which other remedial technologies can be compared.
	o Public Awareness			
	. Post warning signs, inform local officials and hold public meetings, etc.	Community relation activities are performed.	X	Required for effective implementation of Limited Action.
	o Restrict Access/Use			
	. Access Restrictions (fence)	Access restricted by fencing the contaminated area.	X	Required for effective implementation of Limited Action.
	. Deed Restrictions	Land use restrictions would be specified in the real estate transactions of the property.	X	Required for effective implementation of Limited Action.
3. Containment	o Capping			
	. Soil Cap	Contaminated soil is covered with clean soil layer.		Will not prevent infiltration of surface water.
	. Clay cap	Contaminated soil is covered with low permeability clay layer.		Containment will effectively prevent infiltration through the hotspot soils; subject to erosion and weathering.

X Indicates that option is technically feasible.

TABLE 3-3 (Sheet 2 of 3)

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
	. Synthetic membranes	Synthetic membranes are thin flexible membranes made of PVC, rubber, etc. used to cover contaminated soil.		Same as clay cap, but due to complexity it is impractical for the small area involved.
	. Chemical sealants	Chemical sealants, stabilizers and/or and cements are added to top soil to create stronger and less permeable surface seal.	X	Containment will prevent infiltration; since area is small and site is mostly paved already, asphalt cap is appropriate.
	. Multimedia cap	Multimedia cap is a combination of two or more single layer caps to cover contaminated soil.		Same as synthetic membranes.
4. Removal	o Removal			
	. Excavation	Excavation involves removing contaminated soil using backhoes, bulldozers, front end loaders.	X	Required component of many potential process options.

X Indicates that option is technically feasible

TABLE 3-3 (Sheet 3 of 3)

INITIAL SCREENING OF SOIL REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
5. Treatment/Disposal	o Transportation Technologies			
	. Trucks	Trucks can be used to bring equipment and materials to the site and to transport soil.	X	Potentially feasible for off-site transportation of excavated soils.
	. Trains	Trains can be used to bring equipment and materials to the site and to transport soil and rubbles.		Not feasible due to non-existence of rail connection at Sites 12 and 13 and treatment and disposal facilities.
	o Disposal Technologies			
	. Construction of an on-site RCRA landfill	A new RCRA landfill facility can be constructed within the site boundary for disposal of contaminated soil.		Not feasible due to restrictive site conditions (small area, high water table).
	. Existing off-site RCRA landfill	The contaminated soil or waste would be hauled to an existing RCRA landfill which is already permitted to accept hazardous material.	X	Feasible for disposal of treated soils.
	. On-site nonhazardous landfill	The treated soil would be redeposited on-site.		Not feasible since small volume of soil and available area precludes cost effective on-site treatment.
	. Off-site nonhazardous landfill	The treated soil can be hauled to an existing landfill which is already permitted to accept.	X	Feasible for disposal of soils treated at on off-site facility.

X Indicates that option is technically feasible

TABLE 3-4 (Sheet 1 of 2)

EVALUATION OF PROCESS OPTIONS FOR SOIL
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Effectiveness	ImplementabilityCost
1. No Action	o Site Reviews*		
	. Five-year reviews*	- Useful for documenting conditions - Reduction in volume and toxicity of contaminated groundwater left to natural attenuation	- Easily implementedNo capital, No operating and maintenance (O&M), low periodic cost for reviews
2. Limited Action (Institutional Controls)	o Monitoring*		
	. Monitor and analyze groundwater and sediment*	- Useful for documenting conditions - Reduction in volume and toxicity of contaminated groundwater left to natural attenuation	- Easily implementedNo capital, low (O&M)
	o Public Awareness*		
	. Post warning signs, inform local officials, hold public meetings, etc.*	- Does not actively reduce contamination - Keeps the community involved with issues	- Easily implementedLow capital, low O&M - Public participation required
	o Restricted Access*		
	. Access restrictions (fence)*	- Prevents direct contact with the soil, but does not actively reduce contamination	- Easily implementedLow capital, low O&M
	. Deed restrictions*	- Effectiveness depends on continued future implementation - Reduces risks to humans, but does not actively reduce contamination	- Easily implementedLow capital, low O&M
3. Containment	o Capping*		
	. Chemical sealants*	- Effective for preventing exposure to contaminated soils - Does not reduce toxicity or volume of contaminated soil	- Easily implementedLow capital, low O&M

*Technology and process options retained.

TABLE 3-4 (Sheet 2 of 2)

EVALUATION OF PROCESS OPTIONS FOR SOIL
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Effectiveness	Implementability	Cost
4. Removal	o Removal*			
	. Excavation*	- Effective at removing contaminated soil - Will not reduce volume or toxicity of contaminated soil and requires subsequent treatment/disposal	- Easily implemented	Low capital, no O&M
5. Disposal	o Transportation Technologies*			
	. Trucks*	- Effective for transportation	- Easily implemented	Low capital, no O&M
	o Disposal Technologies			
	. Existing off-site RCRA landfill*	- Removes contaminated or treated soil from the site	- Easy to locate	Lump Sum
	. Off-Site Landfill*	- Removes contaminated or treated soil from the site	- Easy to locate	Lump Sum

*Technology and process options retained.

would be left to natural attenuation, since no treatment would be implemented. Under the No Action alternative, the contaminated soil would continue to leach contaminants of concern to the groundwater. However, No Action is retained through the detailed evaluation as a baseline comparison for other alternatives.

3.3.3.2 Limited Action (Institutional Controls)

Limited Action is a category of technologies which includes monitoring and restrictions to minimize exposure to the contamination. The Limited Action technologies include public awareness programs, access restrictions (fences), and deed restrictions.

Public Awareness Program

Description: A Public Awareness Program is a group of activities which can be used to address the site contamination problem when no remedial measures will be implemented. The public awareness program would include informing local officials, holding public meetings and presentations, press releases, mailing of fact sheets, posting warning signs, etc.

Initial Screening: The levels of PCP in the contaminated soil exceeds USEPA RBCs for industrial soils. In this category, reduction in toxicity, mobility and volume of contaminated soil would be left to natural attenuation, since no treatment would be implemented. The contaminated soil would continue to leach contaminants of concern to the groundwater and the volume of contaminated groundwater would increase. The public does not have complete knowledge of the soil contamination and the risks at this time. A public awareness program would inform the public about the site contamination and would potentially reduce exposures to the contamination. Therefore, a public awareness program is retained for further consideration as a process option.

Access Restriction (Fence)

Description: Access to the site and use would be restricted by constructing a new fence around the areas containing PCP contamination.

Initial Screening: Fencing around the contaminated soil areas would effectively prevent exposure to the contaminated soil. The contaminants would not be removed and would continue to leach into the groundwater. The volume of contaminated groundwater would increase due to contaminant migration. However, fencing is the most effective action to prevent site access that could be easily implemented. Therefore, this option is retained for further consideration.

Deed Restrictions

Description: This technology would restrict the future use of land at the site so that public exposure to the contaminated soil and groundwater would be minimal. Deed restrictions are institutional controls to restrict land and water use, and these limitations would be specified in the real estate transactions of property.

Initial Screening: These types of restrictions may be difficult to implement because they would result in essentially taking the property rights from the owner. In addition, institutional controls may result in economic impacts on the real estate value of the site. However, this technology may be feasible since the current owner is a government agency. Therefore, this option is retained for further consideration.

3.3.3.3 Containment

Containment is a remedial action providing isolation of contaminant source soil from the uncontaminated soil. Capping technologies can be used to contain contaminated soil, minimize human exposure to soil and reduce leaching of contaminants from the soil to groundwater. Capping of contaminated soil could be achieved by utilizing any one or a combination of soil caps, clay caps, synthetic membranes, chemical sealants and multimedia caps.

Soil Cap

Description: A soil cap can be installed over contaminated soil to prevent direct contact with contaminants. A soil cap would have a high permeability relative to clay, and would allow percolation of surface water, runoff, etc.

Initial Screening: Soil caps are not typically used for containment of contaminated soils because high permeabilities allow percolation and leaching of contaminants from the underlying contaminated soils into the groundwater. A soil cap would not meet RCRA capping requirements, and would not prevent leaching of contaminants from underlying contaminated soils. A soil cap is therefore eliminated from further consideration.

Clay Cap

Description: Clay layers are commonly used as cover for landfills which contain both hazardous and nonhazardous wastes. Bentonite, a natural clay with high swelling properties, is often mixed with on-site soil and water to produce a low permeability layer. A low permeability clay cap would not only physically isolate the source but also reduce the leaching of contaminants to groundwater by creating a low permeability barrier.

Initial Screening: Clay, which consists of fine material, is susceptible to erosion from climatic and storm forces if not properly protected by soil and vegetative cover, and is suitable only as a temporary cover. Proper particle distribution is essential to create a low permeability cap. Clay caps are also susceptible to cracking, settling, ponding of liquids and naturally occurring invasions by burrowing animals and deep rooted vegetation. This technology will not meet RCRA capping requirements. The area is currently used for storage by the DPW and would be subject to vehicle traffic, which would rapidly degrade the clay cap. Therefore, a clay cap is eliminated from further consideration.

Synthetic Membranes

Description: Flexible synthetic membranes are made of polyvinyl chloride (PVC), high density polyethylene (HDPE), chlorinated polyethylene (CPE), ethylene propylene rubber, butyl rubber, Hypalon neoprene (synthetic rubber) and elasticized polyolefin. Thin sheets are available in sections of variable width and the sheets are overlain and spliced in the field (according to manufacturer's specifications). Special adhesives and sealants are used to ensure liner integrity.

Initial Screening: Synthetic liners are labor intensive relative to clay caps since sealing materials require special field installation methods. Careful consideration should be given in selection of the material of the synthetic liners to withstand the chemicals present in the hazardous waste site. In addition to these disadvantages, the integrity of synthetic liners can be damaged by uneven (differential) settling and invasion by burrowing animals and deep rooted plants. This technology will not meet RCRA capping requirements and also has the same limitations as a clay cap. Therefore, synthetic membranes are eliminated as a process option.

Chemical Sealants

Description: Chemical stabilizers and cements can be added to relatively small amounts of on-site soils to create stronger and less permeable surface sealants. Portland cement or bitumen (emulsified asphalt or tar) is suitable for mixing with sandy soils to stabilize and waterproof them. Other soil additives include chemical dispersants and swell reducers. Soluble salts such as sodium chloride, tetrasodium pyrophosphate and sodium polyphospate are added primarily to fine grained soils with clay to deflocculate the soils, increase their density, reduce permeability and facilitate compaction.

Initial Screening: Extensive mixing, spreading and compaction are required to achieve a low permeability cap. Proper combination of sealant chemicals and strict moisture control of the sealant mixture is essential to ensure the desired results. Chemical sealants will not meet RCRA capping requirements. However, the area to be capped is relatively small (250 sq. ft.) and since a large portion of the surrounding area is already covered with asphalt, paving would be appropriate. Therefore, an asphalt cap (chemical sealant) is retained as a process option.

Multimedia Cap

Description: The multimedia cap is a combination of two or more of the single layer capping technologies. The disadvantage of one can be compensated by the advantage of another. Most caps recommended for hazardous waste projects are multilayer caps such as the three layered system which conforms to EPA's guidance under RCRA for landfill caps. The multimedia cap would consist of a 2 foot clay liner, a 40 mil synthetic liner, 1 foot of sand, 2 feet of top soil, filter fabric, and vegetation on the surface.

Initial Screening: The performance of a properly installed, multilayered cap is generally excellent. However, after time, the integrity of the synthetic liner becomes uncertain and should be investigated regularly. This technology will meet RCRA capping requirements. However, the area to be capped is small and installation of a full cap would be impracticable. Therefore, a multimedia cap is eliminated as a process option.

3.3.3.4 Removal

This process involves physical removal of contaminated soil, usually with the intention of subsequent treatment and/or disposal. This category includes excavation and is a preliminary or support technology as a part of process options which first require removal of the contaminated soils.

Excavation

Description: Excavation refers to the use of construction equipment such as backhoes, bulldozers, front end loaders, and draglines that are typically used on land to excavate and handle contaminated soil.

Initial Screening: Excavation would be required as the initial material handling step in numerous process options. It is estimated that approximately 55 cy of contaminated soil need to be excavated for treatment and disposal. Excavation is retained for further consideration as a process option.

3.3.3.5 Disposal

Transportation Technologies

Modes of transportation must be considered in association with off-site treatment/disposal technologies screened in this section. Potential transportation technologies for site soil include trucks and trains.

Trucks

Description: Trucks can be used to deliver equipment and materials for remediation. In addition, water-tight trucks or tanker trailers could be used to haul and transport waste streams. Trucks will be properly decontaminated, weighed, and manifested before leaving the site. Regulations regarding hauling hazardous, non-hazardous materials, and oversized and heavy loads over public highways would have to be taken into consideration.

Initial Screening: There is road access to the NAB Little Creek Site 13 which connects to major highways. Truck transportation is flexible, as the number of trucks can be increased or decreased depending upon project requirements. This mode of transportation does not require special loading facilities at the site or unloading facilities at the destination. Trucks are thus retained for further evaluation as a process option.

Trains

Description: Transport of equipment and materials by rail was considered. Treated or untreated process residues could be put into water-tight tank cars for transport.

Initial Screening: At NAB Little Creek Site 13, there is no nearby rail spur, and construction of new rail to connect with nearby rail would be impractical due to the small amount of soil to be transported. Therefore, this technology is eliminated from further evaluation.

Disposal Technologies

This category of remedial technologies refers to disposal of contaminated soil on or off-site, with or without any treatment. The remedial technologies included are construction of a new on-site RCRA landfill, existing off-site RCRA landfill, on-site non-hazardous disposal, and/or off-site non-hazardous landfill.

Construction of an On-Site RCRA Landfill

Description: A new RCRA Subtitle C disposal facility could possibly be constructed within certain site boundaries. The permitting process requires extensive investigations and acceptance by regulatory agencies. Important factors affecting the regulatory acceptance would be the definition of site conditions, closeness to the wetland area and floodplain, buffer zone consideration, design, construction, operation, public uneasiness, closure, and post-closure monitoring.

Initial Screening: Due to the small amount of soil to be disposed of, construction of a RCRA landfill on site is impractical. In addition, the presence of the high water table could impair the long-term ability of a landfill to prevent contaminant migration. Therefore, an on-site RCRA landfill is eliminated from further evaluation due to site-specific limiting conditions.

Existing Off-Site RCRA Landfill

Description: Contaminated and treated soil could be hauled to an existing RCRA Subtitle C landfill facility which is already permitted to accept hazardous materials. This provides a possible solution to the disposal problem, but unit costs may be high due to transportation distance and disposal fee structure.

Initial Screening: In addition to high disposal cost, there may be a limitation on the types of contaminated soil that can be disposed of at these facilities. The Land Disposal Restrictions prohibit off-site landfilling without treatment, thus this alternative may not be feasible without treatment of the soil. However, the use of an off-site RCRA landfill may be required as a component of alternatives requiring disposal of treated soil. The off-site RCRA landfill option is retained for further consideration.

On-Site Non-Hazardous Disposal

Description: This technology would allow for the on-site redeposition of treated soil and sediment.

Initial Screening: Due to the small amount of potentially contaminated soil, on-site treatment would be impractical. Soil would have to be treated off-site and returned to the site, which is also impractical due to transportation costs. Therefore, this technology is eliminated from further consideration as a process option.

Off-Site Non-Hazardous Disposal

Description: Soil and sediment can be disposed of off-site in a nonhazardous landfill after treatment.

Initial Screening: This technology is feasible for off-site disposal of soil and sediment after off-site treatment at a permitted facility. Therefore, this option is retained for further consideration.

3.3.4 Screening and Evaluation of Groundwater Technologies

In the following subsections, potential groundwater remedial technologies are briefly described and summarized with the results of the screening and evaluation. Technologies will be evaluated with respect to both Sites 12 and 13. For those technologies which are not retained for further evaluation, the rationale for their elimination is included. The screening evaluations for each identified technology are summarized in Table 3-5. The evaluation and selection of process options for groundwater technologies is presented in Table 3-6.

3.3.4.1 No Action

No Action is not a category of technologies but an option that does not include any remedial measures. No Action includes periodic site reviews.

No Action

Description: No Action is not a category of technologies but a group of activities which can be used to address the groundwater contamination problem when no remedial measures will be implemented. The No Action alternative will be evaluated later in this report as required by the National Contingency Plan (NCP). The No Action approach includes reviews to assess the need for further remedial action.

Initial Screening: The SRI assessment showed that the contaminated groundwater presents an excess cancer risk above 10^{-6} and a Hazard Index greater than 1.0. Levels of both organic and inorganic compounds exceed MCLs. The contaminated groundwater underlying Sites 12 and 13 site is not currently used for municipal or private potable water purposes in the vicinity of the site. However, residential development is occurring in proximity of the site and consequently, a potential risk to public health could exist with unrestricted use of site and groundwater in the future, assuming no remediation. Reduction in toxicity, mobility or volume of contaminated groundwater is left to natural attenuation, since no treatment is implemented. However, No Action is retained throughout the detailed evaluation as a baseline for comparison with other alternatives.

TABLE 3-5 (Sheet 1 of 5)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
1. No Action	o Site Reviews			
	. Five-year reviews	The site and available data are reviewed to determine if remedial action is needed.	X	Provides baseline against which other remedial technologies can be compared. Required for consideration by NCP.
2. Limited Action (Institutional Controls)	o Monitoring			
	. Monitor and analyze groundwater	Samples are collected and analyzed for contaminants and migration of contaminants is assessed.	X	Provides baseline against which other remedial technologies can be compared. Required for consideration by NCP.
	o Public Awareness . Post warning signs, inform local officials and hold public meetings, etc.	Community relation activities are performed.	X	Required for effective implementation of Limited Action.
	o Restrict Access/Use			
	. Well Permit Requirements	Restrict or regulate the placement of new wells and continued use of existing wells at and around the site.		Applicable for large site; groundwater movement believed to be bounded within the site area.
3. Containment	o Barriers			
	. Sheet piling	Sheet piling is driven into soil and can be used as a barrier to limit the spread of contaminants.		Not applicable due to large extent of containment necessary and logistical considerations (i.e., developed site area).
	. Slurry walls	Slurry walls are constructed in vertical trench excavated under bentonite slurry.		Same as sheet piling.

X Indicates that option is technically feasible

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
	. Grout curtains	Grouting consists of injecting fluids into rock or soil mass, which set in place, reduce water flow, and strengthen the formation.		Same as sheet piling.
4. Extraction				
	o Extraction Technologies			
	. Pumping	Groundwater pumping and collection technologies involve extraction of contaminated groundwater for subsequent treatment and prevention of downgradient migration.	X	Potentially applicable for interception and recovery of contaminant plume at both Sites 12 and 13.
5. Treatment				
	o Chemical Treatment			
	. Neutralization/pH Adjustment	Neutralization is a chemical process in which acids and alkalies are neutralized to eliminate or reduce their reactivity and corrosiveness. pH adjustment may also be used to optimize other treatment processes.	X	Feasible for metals and suspended solids removal. Potentially required to optimize other treatment processes.
	. Chemical Precipitation	Chemical precipitation is a pretreatment process in which acid or base is added to the contaminated water to adjust the pH to the point where the lowest solubility of the compounds to be removed is reached. Other precipitants such as sodium sulfide or ferric chloride may be added to precipitate certain metals out of solution.	X	Potentially feasible for suspended solids and metals removal.

X Indicates that option is technically feasible

TABLE 3-5 (Sheet 3 of 5)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
	. Ion Exchange	Ion exchange is a chemical process in which selected contaminant ions in the aqueous phase are exchanged for innocuous ions in a fixed bed ion exchanger or counter-current exchanger.	X	Potentially feasible for metals removal.
	. UV-Chemical Oxidation	When catalyzed by ultraviolet light, a strong oxidant, such as hydrogen peroxide or ozone, reforms into hydroxyl radicals (strong oxidizer) which oxidize the organic contaminants in the groundwater to CO_2 and water.	X	Feasible for treatment of organic contaminants in site groundwater.
	o Physical Treatment			
	. Flocculation	Flocculation is a process to promote agglomeration and settling of suspended solids.	X	Potentially feasible for suspended solids and metals removal.
	. Clarification	Clarification is a gravity settling process which allows heavier solids to collect at the bottom of a containment vessel leaving clear liquid at the top.	X	Potentially feasible for suspended solids and metals removal.
	. Filtration	Filtration is a process of separating suspended and colloidal solids from a liquid mixture through a porous medium.	X	Potentially feasible for suspended solids and metals removal.
	. Air Stripping	Air stripping is a mass transfer process in which volatile organic contaminants in groundwater are transferred to gaseous (vapor) phase.	X	Effectively removes volatile contaminants.

X Indicates that option is technically feasible

TABLE 3-5 (Sheet 4 of 5)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
	. Steam Stripping	Steam stripping is a mass transfer process which uses steam to evaporate volatile organics from aqueous wastes into the gaseous (vapor) phase.	X	Feasible for treatment of volatile organics and some semivolatile organics in site groundwater.
	. Carbon Adsorption	Carbon adsorption is a process in which the organic contaminants in water are adsorbed onto activated carbon granules.	X	Feasible for treatment of organics in site groundwater.
	o *In Situ* Biological Treatment			
	. Aerobic	Aerobic treatment involves the use of native microbes or selectively adopted bacteria to degrade a variety of organic compounds under aerobic conditions. Treatment is effected without extraction of groundwater by introducing required constituents into the aquifer.	X	Feasible for treatment of organics in site groundwater.
	. Anaerobic	Anaerobic treatment is similar to aerobic treatment but takes place in the absence of oxygen. Treatment is effected without extraction of groundwater by introducing required constituents into the aquifer.	X	Feasible for treatment of organics in site groundwater.

X Indicates that option is technically feasible

TABLE 3-5 (Sheet 5 of 5)

INITIAL SCREENING OF GROUNDWATER REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Description	Technically Feasible	Screening Comments
6. Source Control				
	o Removal			
	. Excavation	Contaminated soils are excavated to prevent further leaching of contaminants from the soil into the groundwater.	X	No existing source areas identified or defined for either site; "hotspot" soils at Site 13 addressed previously.
7. Disposal				
	o Disposal Technologies			
	. POTW	Extracted groundwater would be pumped to publicly owned treatment works for treatment and disposal.	X	Feasible because a POTW is capable of removing organic contaminants from site groundwater. In addition, the Hampton Roads Sanitation District (HRSD) facility has accepted groundwater from previous pumping tests subject to pretreatment limitations.
	. TSD facility	Extracted groundwater would be transported to a commercial facility for treatment, storage and disposal.	X	Potentially feasible for short-term disposal prior to treatment plant construction.
	. Surface Water	Extracted groundwater would be discharged to on-site surface water after treatment to appropriate levels.	X	Potentially feasible for disposal of groundwater at Site 12 only; not feasible for Site 13 since no nearby surface waterbody.

X Indicates that option is technically feasible

TABLE 3-6 (Sheet 1 of 3)

EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Effectiveness	Implementability	Cost
1. No Action	o Site Reviews*			
	. Five-year reviews*	- Useful for documenting conditions - Reduction in volume and toxicity of contaminated groundwater left to natural attenuation	- Easily implemented	No capital, no Operating and Maintenance (O&M), low periodic cost for reviews
2. Limited Action (Institutional Controls)	o Monitoring*			
	. Monitor and analyze groundwater and sediment*	- Useful for documenting conditions - Reduction in volume and toxicity of contaminated groundwater left to natural attenuation	- Easily implemented	No capital if existing monitoring wells are used; low Operating and Maintenance (O&M)
	o Public Awareness*			
	. Post warning signs, inform local officials, hold public meetings, etc.*	- Does not achieve remediation objectives - Keeps the community involved with issues	- Easily implemented - Public participation required	Low capital, low O&M
	o Restrict Access/Use			
	. Well Permit Requirements	- Controls current and future use of groundwater - Does not provide treatment	- Easily implemented	Low capital, low O&M
3. Containment	o Barriers			
	. Groundwater Interception	- Effectively stops migration of contaminant plume - Allows treatment of contaminated groundwater in overburden aquifer	- Easily implemented	Low capital, low O&M
4. Extraction	o Extraction*			
	. Pumping*	- Effective in extracting contaminated groundwater - Reduces mobility of contaminants	- Easily implemented - Requires continuous maintenance	Low capital, moderate O&M

* Technology and process options retained.

TABLE 3-6 (Sheet 2 of 3)

EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Effectiveness	Implementability	Cost
5. Treatment	o Chemical Treatment			
	. Neutralization/pH Adjustment*	- Effective in optimizing other treatment processes and also neutralizing treated groundwater	- Easily implemented	Low capital, high O&M
	. Chemical Precipitation*	- Effective in precipitating suspend solids and metals contaminants from groundwater	- Easily implemented	Moderate capital, high O&M
	. Ion Exchange*	- Effective in removing low-level metal contamination - Aqueous specific resin and disposal of resins.	- Easily implemented	High capital, high O&M
	. UV-Chemical Oxidation*	- Effective in oxidizing organic contaminants	- Easily implemented - Requires skilled labor - High power requirement	High capital, high O&M
	o Physical Treatment			
	. Flocculation*	- Effective in flocculating chemical precipitants	- Easily implemented	Low capital, moderate O&M
	. Clarification*	- Effective in separating suspended particles from liquid phase	- Easily implemented	Moderate capital, low O&M
	. Filtration*	- Effective in separating less settable solids from liquid phase	- Easily implemented	Moderate capital, moderate O&M
	. Air Stripping*	- Effective at removing volatile contaminants - Requires vapor phase air pollution control.	- Easily implemented	Moderate capital, moderate O&M

* Technology and process options retained.

TABLE 3-6 (Sheet 3 of 3)

EVALUATION OF PROCESS OPTIONS FOR GROUNDWATER
SITES 12 AND 13 - NAB LITTLE CREEK

Remedial Actions	Remedial Technology Categories and Process Options	Effectiveness	Implementability	Cost
	. Steam Stripping	- Effective at removing volatiles and some semivolatiles - Requires vapor phase air pollution control	- Easily implemented	High capital, high O&M
	. Carbon Adsorption*	- Effective in removing organics - Needs regeneration or disposal of spent carbon	- Easily implemented	Moderate capital, high O&M
	o In Situ Biological Treatment	- Effective for removing organics in groundwater - Rapid cleanup	- Moderately difficulty to implement - Extensive pilot studies needed	High capital, high O&M
6. Source Control				
	o Removal			
	. Excavation	- Effective for removal of contaminated source materials	- Easily implemented	Low capital, no O&M
7. Disposal				
	o Technologies Disposal . TSD Facility*	- Effective for disposal of extracted groundwater	- Easily implemented	Lump Sum
	. Surface Water*	- Effective for disposal of treated groundwater	- Easily implemented	Low capital, low O&M

* Technology and process options retained.

3.3.4.2 Limited Action (Institutional Controls)

Limited Action is a category of technologies which does not address the groundwater contamination by treatment but would restrict or minimize exposure to contaminated groundwater. The Limited Action technologies include monitoring, a public awareness program and well permit requirements.

Public Awareness Program

Description: The Public Awareness Program is a group of activities which can be used to address the site contamination problem when no remedial measures will be implemented. The public awareness program would include informing local officials, holding public meetings and presentations, press releases, mailing of fact sheets, posting warning signs, etc.

Initial Screening: The SRI risk assessment showed that the contaminated groundwater presents excess cancer risk above 10^{-6} and a Hazard Index greater than 1.0. Reduction in toxicity, mobility and volume of contaminated groundwater is left to natural attenuation, since no treatment is implemented. The public has been notified, and information concerning the site has been provided throughout the RI/SRI/FS process. A public awareness program would continue to inform the public about the site contamination and could reduce any potential exposures to the contamination. Therefore, a public awareness program is retained for further consideration as a process option.

Well Permit Requirements

Description: These types of requirements might restrict or regulate the placement of new wells and continuation of existing wells at and around the site. This type of institutional control may be instituted by the county government or the state or by a newly formed agency. Well permit requirements might require residences and developments to have their wells monitored on a regular basis to determine whether the contaminants have migrated to their wells. In addition, if an existing well is found to be contaminated, a point of use treatment system may be necessary to allow for its continued use.

Initial Screening: This institutional control is difficult to implement at the state level, however it can be possible to implement at the town or zone of influence around the site level. In addition, a public awareness program and contamination monitoring program would be required. This institutional control may be a viable alternative for contamination at a large area site. Sites 12 and 13 are small and the groundwater movement is believed to be bounded by on-site drainage canals and streams. This option is therefore not applicable to these sites and is eliminated from further consideration.

3.3.4.3 Containment

Containment is a remedial action providing isolation of contaminated groundwater from the uncontaminated groundwater. Containment technologies include vertical barriers such as sheet piling, slurry walls, grout curtains, or groundwater interception in order to form a significant barrier to lateral contaminant migration. In order to successfully prevent lateral migration it is necessary for the barriers (except for groundwater interception technology) to be sealed into a horizontal confinement zone, normally using geological features such as a consistent clay layer beneath the contaminated area. In addition, for vertical barriers to be effective, the contaminated area needs to be covered at the top using a cap evaluated in the soil containment technologies.

At Site 12, no source area has clearly been defined; therefore, capping can not be performed and groundwater containment is not feasible. At Site 13, capping of the "hotspot" soil has been assessed and determined technically feasible. No other source areas have been defined at Site 13. Groundwater containment options are therefore discussed for Site 13 only.

Sheet Piling

Description: Sheet piling driven into the soil can be used as a barrier to limit the spread of contaminants via groundwater. This technique could also be extended whereby the soil within the enclosure is dewatered and work could proceed in a "dry" state. Steel sheet piling cutoffs require very little maintenance. Steel sheet piles should not be considered for use in very rocky soils.

Initial Screening: Sheet piling can be used in any hydraulic condition (such as low or high groundwater movements). Sheet piling is only feasible when it can key into a low permeability bottom clay layer. Although Site 13 has have a confining clay layer underneath the contaminated areas and the soil in and around the contaminated areas consists of clay, silt, sand and gravel, the extent of the groundwater plume and highly developed nature of the site make sheet piling impractical. In addition, containment of groundwater using sheet-piling is not effective in the absence of a confining horizontal layer. Therefore, this technology is eliminated from further consideration as a process option.

Slurry Walls

Description: Slurry walls are the most common subsurface barriers because they are a relatively inexpensive means of reducing groundwater flow in unconsolidated earth materials. Slurry walls are constructed in a vertical trench that is excavated under a slurry. This slurry, usually a mixture of bentonite and water, acts essentially like a drilling fluid. It hydraulically shores the trench to prevent collapse, and at the same time, forms a filter cake on the trench walls to prevent high fluid losses into the surrounding ground. In some cases, soil or cement are added to the bentonite slurry to form a soil-bentonite or cement-bentonite slurry wall.

Initial Screening: Slurry walls are economical and have a low permeability. However, due to the limitation discussed above for sheet piling, the slurry wall technology is eliminated from further evaluation.

Grout Curtains

Description: Grouting refers to a process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Numerous types of grouting materials are available and their applicability is often dictated by the soil grain size or size of the fractures, fissures and voids in the rock.

Initial Screening: Because of costs, grouted barriers and grout curtains are seldom used for containing groundwater flow in unconsolidated materials around hazardous waste sites. This technology is also subject to the limitations discussed above and is therefore eliminated from further evaluation.

3.3.4.4 Extraction

This process involves extraction of contaminated groundwater, usually with the intention of subsequent treatment and/or disposal. This category includes pumping, and is a preliminary or support technology as a part of process options which first require extraction of the contaminated groundwater.

Pumping

Description: Groundwater pumping and collection technologies involve extraction of contaminated groundwater for subsequent treatment and prevention of downgradient migration. The type of groundwater extraction wells depends upon the depth of contamination and hydrogeologic factors of the aquifer.

Initial Screening: Pumping and collection is most effective where the contaminated aquifer has a high hydraulic conductivity to sustain continuous pumping. Data from the SRI pump test indicates that this option is feasible. Due to similarities between the Site 12 and Site 13 hydrogeologic conditions, it is assumed that pumping is also feasible at Site 13. This option is therefore retained for further consideration.

3.3.4.5 Treatment

Treatment technologies are used to change the physical or chemical state of a contaminant or destroy the contaminant completely to reduce volume, toxicity or mobility of the contaminant present in site groundwater. The categories of technologies are thermal treatment, chemical treatment, physical treatment, biological treatment, and *in situ* treatment.

These technologies can be done at the site (on-site or *in situ*) or at an off-site treatment and disposal facility. On-site treatment can be performed in a transportable mobile treatment unit or permanently constructed treatment unit. It is expected that long-term treatment of contaminated groundwater pumped from the aquifer will necessitate construction of a treatment system on-site. All of the technologies discussed in this section are available for on-site installation or at off-site treatment facilities.

Chemical Treatment

Neutralization/pH Adjustment

Description: Neutralization is a process used to adjust the pH (acidity or alkalinity) of a groundwater stream to an acceptable level for discharge, usually from 6.0 to 9.0 pH units. pH adjustment is a partial neutralization process which makes the water either more acidic or more alkaline to enhance chemical/biochemical reactions. Adjustment of pH is accomplished by addition of acidic reagents to alkaline streams and vice versa. pH adjustment can also be used to optimize other treatment processes.

Initial Screening: Neutralization/pH adjustment is a conventional and widely demonstrated means of adjusting the pH of a stream before, during and/or after chemical precipitation. For this reason, neutralization/pH adjustment is retained for further consideration as a process option.

Chemical Precipitation

Description: Chemical precipitation is a process in which an acid or a base is added to a solution to adjust its pH to the point where the lowest solubility of the compounds to be removed is reached. Following similar principles, other precipitation agents such as lime, sodium sulfide or ferric chloride may be added for the removal of metals in groundwater. Sodium sulfide is sometimes used to achieve lower effluent metal concentrations. Metals can be precipitated out of solution as hydroxides, sulfides, carbonates, or other insoluble salts. The resulting residues are metal sludges, the treated effluent with an elevated pH and (in the case of sulfide precipitation) a small quantity of excess sulfide.

Initial Screening: Limitations to be considered during design include the fact that not all metals have a common pH at which they precipitate. If present, chelating and complexing agents can interfere with the process. Chemical precipitation is used effectively in conventional water treatment to remove metals and suspended solids. Therefore, chemical precipitation is retained for further consideration as a process option.

Ion Exchange

Description: Selected contaminant ions are removed from the aqueous phase by electrostatic exchange with relatively innocuous ions held by ion exchange resins. Ion exchange is used for the removal of all metallic cations or anions, inorganic anions, organic acids and organic amines. Fixed bed and counter-current systems are the most widely used ion exchangers, while continuous counter-current systems are suitable for high flows.

Initial Screening: Ion exchange can effectively lower all the metals in the groundwater to meet effluent criteria. Ion exchange would generate spent regeneration solution containing high metal concentrations and acid/caustic solutions. Treatment and/or disposal of these waste streams would result in additional costs. Ion exchange is retained for further evaluation as a polishing treatment for water to satisfy disposal standards, if required.

UV-Chemical Oxidation

Description: UV-chemical oxidation is a process which can destroy many organic contaminants in water. The chemical oxidants used are either hydrogen peroxide or ozone. Organic contaminants absorb UV (ultraviolet) light and may undergo changes in their chemical structures or may become more reactive with chemical oxidants. When catalyzed by ultraviolet light, oxidant (hydrogen peroxide or ozone) forms hydroxyl radicals. The hydroxyl radicals are strong chemical oxidants which react with the organic contaminants. If the reaction is carried to completion, organic compounds can be completely oxidized (broken down) to water and carbon dioxide.

Initial Screening: The UV-chemical oxidation process has been extensively studied over the past several years for its applicability for the broad spectrum of concentrated aqueous waste, industrial effluents and groundwaters containing toxic solvents and fuels. Since Sites 12 and 13 groundwater is contaminated with organic compounds and UV-chemical oxidation is effective in destruction of these chemicals, this technology is retained for further consideration.

Physical Treatment

Physical treatment is a category of technologies which utilize change of physical properties or processes to treat contaminants in groundwater to reduce their volume, toxicity or mobility. The physical technologies considered for groundwater treatment include clarification, flocculation, air stripping, steam stripping, carbon adsorption and sludge dewatering.

Flocculation

Description: Flocculation is a physical treatment technology which is used to enhance sedimentation and could be used as a pretreatment technology for removal of suspended solids and metals in groundwater. The contaminated water is mixed while a flocculating chemical is added. Flocculants adhere readily to suspended solids and with each other (agglomeration) so that the resultant particles are too heavy to remain in suspension. Slow mixing is provided by a mixing paddle. The extent of completion of flocculation is dependent upon the flow rate of the contaminated water, its composition and pH.

Initial Screening: Flocculation is primarily used for the removal of suspended solids and metals. This technology is used in many physical/chemical treatment systems and is therefore retained for further evaluation as a process option.

Clarification

Description: The primary function of clarification is to remove settleable suspended solids to produce a clear waste stream. The clarifier is equipped with a solids removal device to facilitate the process on a continuous basis. Clarifiers are commonly circular and their performance is based on design criteria such as surface loading rate and detention time.

Initial Screening: Clarification, which is a sedimentation process, has been shown to be applicable for the removal of suspended solids from chemical precipitation processes. This technology can be applied following chemical precipitation and is therefore retained as a process option.

Filtration

Description: Filtration is used to remove suspended and colloidal particles that are not easily settleable. The most common method of filtration is sand filtration or mixed media filters, such as sand and anthracite. Sand filtration is typically used after clarification to remove nonsettleable suspended and colloidal solids. A mixed media filtration system consists of a layer of anthracite and a layer of sand to affect the filtration and adsorption of fine particles, including those that would be generated during chemical precipitation. Fluid flow through the filter medium may be accomplished by gravity or by exerting pressure.

Initial Screening: Granular media filtration is typically used after gravity separation for additional removal of suspended solids prior to other treatment processes. Pretreatment by filtration is appropriate for membrane separation processes, ion exchange and carbon adsorption in order to prevent plugging or overloading of these processes. Filtration is often required to remove suspended solids remaining after clarification. The process is used as a pretreatment step for many technologies. Therefore, it is retained for further consideration as a process option.

Air Stripping

Description: Air stripping is a mass transfer process in which volatile organic contaminants in groundwater are transferred to the gaseous phase. Generally, organic compounds with a Henry's Law constant greater than 0.003 can effectively be removed by air stripping. Factors affecting the removal of specific organics from groundwater include temperature, pressure, air to water ratio and surface area available for mass transfer. Air-to-water volumetric ratios may range from 10:1 up to 300:1, and are typically 50:1. A packed column or tower with an air blower and counter-current flow of air to water is commonly used. The products are the stripped effluent (treated groundwater) and contaminated off-gas.

Initial Screening: Air stripping is an easily implementable technology and has been used to remove volatile organic contaminants in groundwater. The groundwater at Site 12 is contaminated with VOCs, and Site 13 groundwater contains both VOCs and SVOCs. Air stripping can effectively remove volatile contaminants from the groundwater. Subsequent treatment with carbon can remove SVOCs. Therefore, air stripping is retained for further consideration.

Steam Stripping

Description: Steam is used to evaporate volatile organics and most of the semivolatile organics from aqueous wastes. Steam stripping is essentially a continuous fractional distillation process carried out in a packed bed or tray tower. Steam provides direct heat to the column in which gas flows from the bottom to the top of the tower. The resulting residuals are contaminated steam condensate, recovered solvent and treated effluent. The organic vapors are sent through a condenser in preparation for further treatment. Steam stripping will treat less volatile and more soluble wastes than air stripping and can handle a wider concentration range (e.g., from less than 100 ppm to about 10 percent organics). The steam stripping process requires air pollution controls to eliminate toxic emissions.

Initial Screening: Steam stripping is normally used when the organic contaminants present in groundwater are not removable by conventional air stripping. Steam stripping is unnecessarily costly and is not needed for treatment of VOCs, however it is effective for the removal of semi-volatiles. Therefore, steam stripping is retained as a process option.

Carbon Adsorption

Description: Activated carbon selectively adsorbs constituents in hazardous wastes by a surface attraction phenomenon in which the organic molecules and some metals are attracted to the internal pores of the carbon granules. Activated carbon can be used for the adsorption of volatiles, semi-volatile organics, pesticides and herbicides in groundwater. Adsorption efficiency is chemical specific, depending upon the strength of the molecular attraction between adsorbent and adsorbate, molecular weight, electrokinetic charge, pH and surface area. Once the micropore surfaces are saturated with organics, the carbon is 'spent' and must be replaced with fresh carbon or regenerated. Activated carbon is an effective and reliable means of removing low solubility organics.

Initial Screening: Granular activated carbon is a highly developed organic removal technology. It is not particularly sensitive to changes in concentrations or flow rate, and unlike biological treatment, is not adversely affected by toxics. This technology is considered to be feasible for treating the organics present in the groundwater at the site, and is retained for further consideration as a process option.

In Situ Biological Treatment

In situ biological treatment groundwater treatment is a technology in which contaminants present in groundwater are degraded to simpler compounds (e.g., methane, carbon dioxide, water, etc.) by the action of microorganisms without extracting the groundwater from the aquifer. This can be accomplished in several ways, including stimulating indigenous microorganisms by the addition of oxygen and/or nutrients to the subsurface or the introduction of specialized microorganisms to degrade the contaminants of concern.

Biological processes can be characterized as either aerobic or anaerobic, depending on whether oxygen is present. If oxygen is present, aerobic biodegradation occurs, resulting in the complete oxidation of compound to carbon dioxide and water. In the absence of oxygen, anaerobic biodegradation occurs, typically resulting in only partial degradation of contaminants and the production of intermediate compounds which in some cases may be more toxic than the parent compound (e.g., the reductive dechlorination of TCE to vinyl chloride). In general, hydrocarbons (non-halogenated and some halogenated) are amenable to aerobic biodegradation, while highly substituted compounds (e.g. PCE) are generally more amenable to anaerobic treatment.

Initial Screening: Several of the contaminants of concern are chlorinated solvents which may not be effectively treated by aerobic biodegradation. However, anaerobic biodegradation, or a sequenced approach of aerobic and anaerobic treatment should be capable of biodegrading the organic COCs to the target concentration levels. Although the inorganic COCs are not amenable to biodegradation, *in situ* biodegradation is retained as a process option for treatment of the organic contaminants.

3.3.4.6 Source Control

Source control involves removal and/or treatment of the sources of contamination to prevent leaching of contaminants from the source to the groundwater.

Removal

Excavation

Description: This category of removal technologies refers to the use of conventional construction equipment for removing contaminated soils to prevent leaching of contaminants into the groundwater. At Site 12, groundwater contamination appears to be associated with a storm sewer which has since been removed. Much of the area formerly occupied by the storm sewer has been built upon or paved with appropriate mitigation measures taken during construction of the new commissary. Therefore, the source at Site 12 has apparently already been addressed. At Site 13, no source has been identified. Soils in the "hotspot" have been previously addressed.

Initial Screening: The source of Site 12 groundwater contamination (the storm sewer) has been removed. The Site 13 source has not been identified and hotspot soils are addressed separately. Therefore, excavation is eliminated as a process option.

3.3.4.7 Disposal

Publicly Owned Treatment Works (POTW)

Description: Under this technology, the groundwater extracted during dewatering of excavated soil would be pumped to a publicly owned treatment works plant (POTW) for treatment and discharge.

Initial Screening: A discharge of metals and volatile organics in the groundwater may disrupt existing POTW treatment processes. A permit would also be required for discharge to an off-site facility. The Hampton Roads Sanitation District (HRSD) facility is located adjacent to NAB Little Creek. Pretreated water from the SRI pump test was accepted by HRSD subject to a limit on VOCs (1 ppm per compound). Pretreatment may therefore be required before discharge to this facility. Based on these factors, this technology is retained for further evaluation.

Off-Site Treatment, Storage and Disposal (TSD) Facility

Description: Contaminated groundwater extracted during the short term dewatering period would be transported to a RCRA permitted TSD facility for treatment, storage, and disposal.

Initial Screening: Transportation of the groundwater to a treatment facility could potentially result in accidents and spills of contaminated water. It is likely that an on-site water treatment system would be constructed as part of a pump and treat system for the contaminated groundwater. Therefore, this alternative is eliminated from further consideration.

Discharge to Surface Water

Description: Contaminated groundwater extracted during dewatering and/or pumping is discharged to surface water on or near the site after treatment.

Initial Screening: The drainage canal is located adjacent to the Site 12 and 13 available for surface discharge of groundwater. No such discharge point is nearby to Site 13. Extensive treatment of the contaminated groundwater would be necessary before discharge, and the requirements of a NPDES discharge to surface water permit must be met. Since long-term treatment of the groundwater is intended, and surface waters at Site 12 are readily available for discharge, this option is retained for further evaluation at Site 12 but eliminated for consideration at Site 13.

3.4 COMBINATION OF POTENTIALLY APPLICABLE TECHNOLOGIES INTO FEASIBLE REMEDIAL ALTERNATIVES

Based upon the nature and extent of contamination, the results of the SRI risk assessment (discussed in Section 1.0), and the subsequent formulation of remedial objectives (discussed in Section 2.0), the following media requiring remedial action can be identified at Sites 12 and 13:

- Site 12 shallow groundwater;
- Site 13 shallow groundwater; and,
- Site 13 hotpsot soils.

Surface water and sediments in the drainage canal adjacent to Site 12 have not been addressed in this FS. Data from the RI and SRI indicate that the concentrations of COCs in these media are being effectively reduced via natural processes. In addition, the actual risk of exposure via the pathways identified in the SRI risk assessment are minimal, since the drainage canal is not used as a potable water source or for recreation/fishing.

In the following subsections, representative process options from the feasible technologies are combined into remedial alternatives for soil and groundwater. In the design phase of this project, other feasible options may be substituted for those selected.

As discussed in Section 3.0, four categories of general response actions (i.e., no action, limited action, containment, and treatment/disposal) were considered in the remedial alternative development for Sites 12 and 13. A No Action alternative provides the minimum baseline case for comparison with other alternatives. A Limited Action alternative adds administrative-type controls to the No Action alternative.

Site 12 (GW12) and Site 13 (GW13) Groundwater Alternatives

The subsurface characteristics and contaminants at both Site 12 and Site 13 are similar, and therefore, the same treatment alternatives were identified for each. The alternatives for contaminated groundwater were developed based on the following considerations:

- Volatile organic and inorganic contaminants above MCLs were identified in the shallow aquifer underlying Site 12. The original source of the contamination was a storm sewer system which received discharge from the former exchange laundry and dry cleaner. This storm sewer has been removed, and no other source area has been identified. Levels of volatile organics present in Site 12 monitoring wells decreased significantly between the

RI (1993) and the SRI (1995) sampling periods, indicating that the aquifer is flushing naturally. The estimated extent of the capture zone necessary for groundwater extraction is presented on Figure 3-1.

- Volatile, semivolatile, and inorganic contaminants above MCLs were identified in the shallow aquifer underlying Site 13. Only one potential source has been identified in the area of monitoring well LC13-GW8; this hotspot soil area is addressed separately. Levels of contaminants present in the groundwater underlying Site 13 have decreased between the RI and SRI, indicating that the aquifer is flushing naturally. The estimated extent of the capture zone necessary for groundwater extraction is presented on Figure 3-2.

- Although discharge to surface water is feasible at Site 12 due to the proximity of the drainage canal, the Hampton Roads Sanitation District (HRSD) facility has accepted pretreated groundwater from the SRI pumping test, subject to limitations on VOCs of 1 mg/l per compound. Discharge to the POTW is preferable as it reduces the pretreatment steps necessary prior to discharge.

Based upon these considerations, the following potential remedial alternatives for contaminated groundwater at both sites are identified:

- Alternative GW12(13)-1: No Action
- Alternative GW12(13)-2: Limited Action (Institutional Controls)
- Alternative GW12(13)-3: Extraction/Pretreatment/Discharge to POTW
- Alternative GW12(13)-4: *In-situ* (Biological) Treatment

The alternatives are evaluated separately for each site, as each has different contaminants of concern and estimated pumping rates/aquifer clean up times.

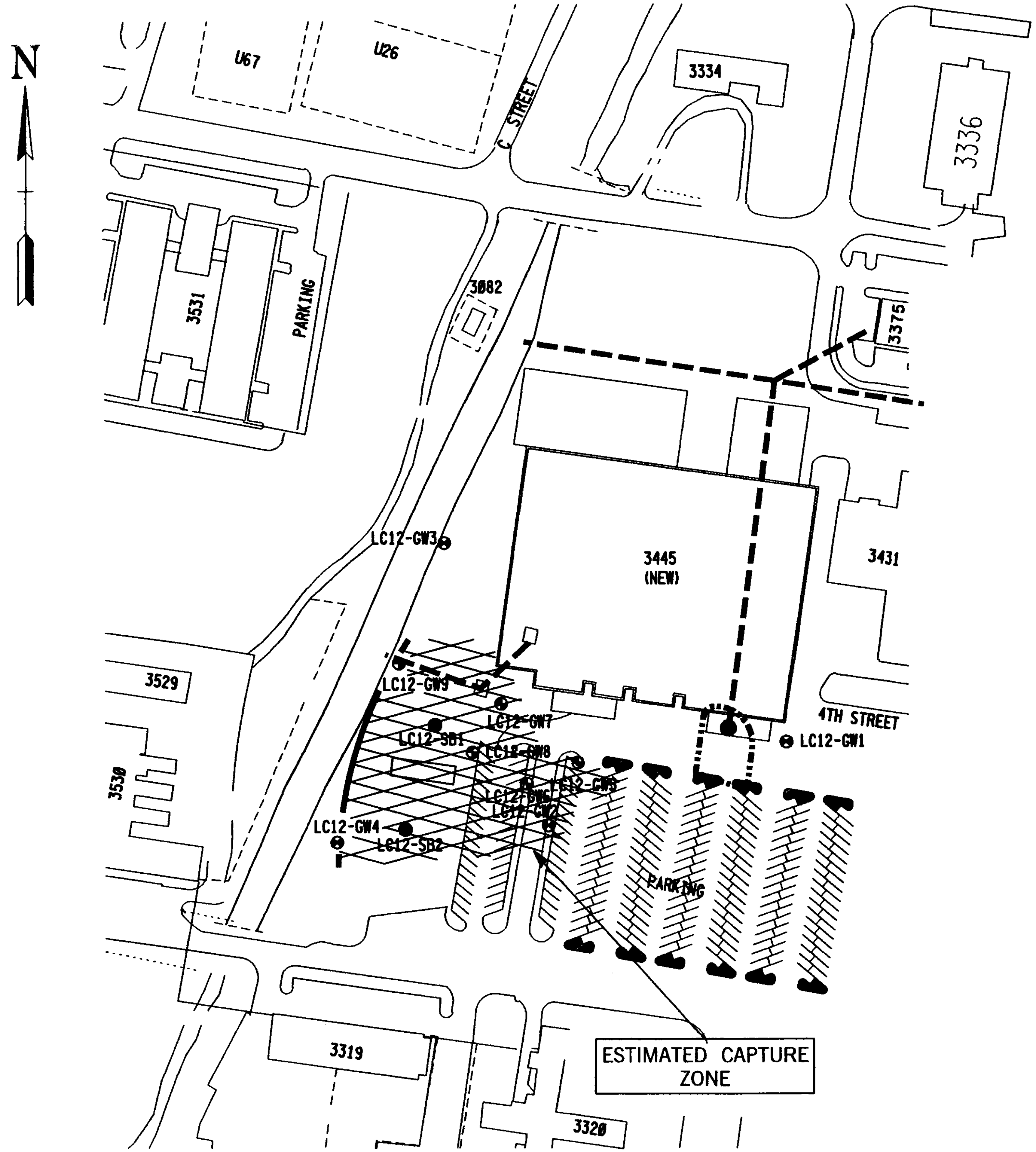
Site 13 Soil (S13) Alternatives

Alternatives to address the Site 13 hotspot soils were identified based on the following considerations:

- The only contaminant detected above USEPA RBC for industrial soils was PCP, which was detected in the area immediately surrounding monitoring well LC13-GW8 during RI activities. Additional sampling during the SRI indicated that the area of PCP soil contamination was highly localized.

- Based on these data, the area of contaminated soils consists of approximately 250 square feet. This area would be excavated to the water table (approximately 6 ft below grade) and the total volume to be excavated would be approximately 55 cy (Figure 3-3).

- Because of the small volume of contaminated soil and the present and active use of Site 13 as a storage area, on-site treatment is not considered practical with respect to logistical considerations or cost. Therefore, on-site treatment is not considered.



LEGEND

- FORMER WATER AND STORM SEWER LINE
- SITE BOUNDARY
- SOIL BORING (LC12-SB1)
- MONITORING WELL INSTALLED BY FWES (LC12-GW5)
- EXISTING MONITORING WELL INSTALLED BY FWES (LC12-GW1)

GRAPHIC SCALE

0 150' 300' 450'

1" = 150'-0"

REV.	DATE	DESCRIPTION	APPR.
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FIGURE 3-1

SITE 12
ESTIMATED GROUNDWATER
CAPTURE ZONE
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

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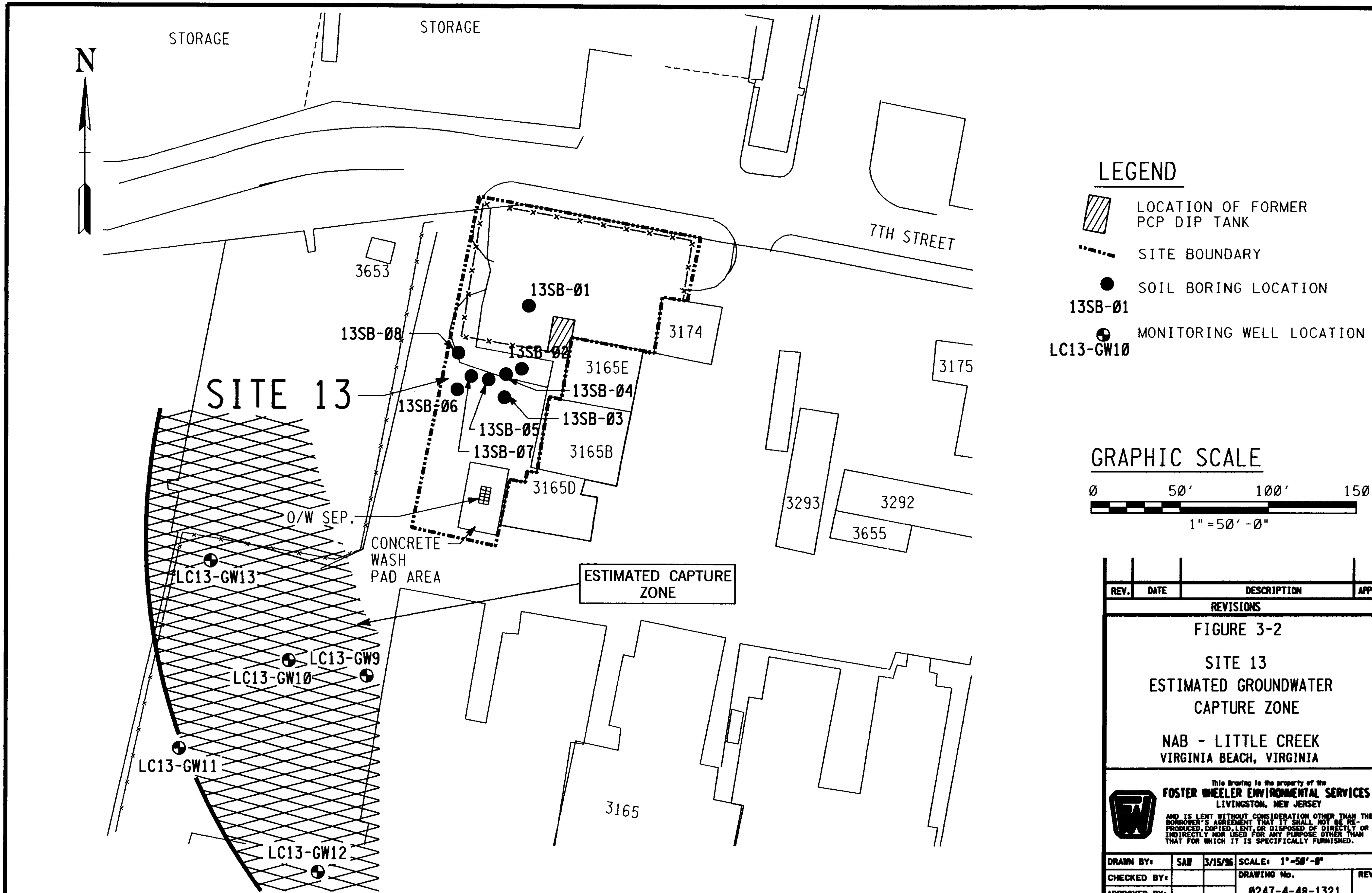

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FIGURE 3-2

SITE 13
ESTIMATED GROUNDWATER
CAPTURE ZONE

NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

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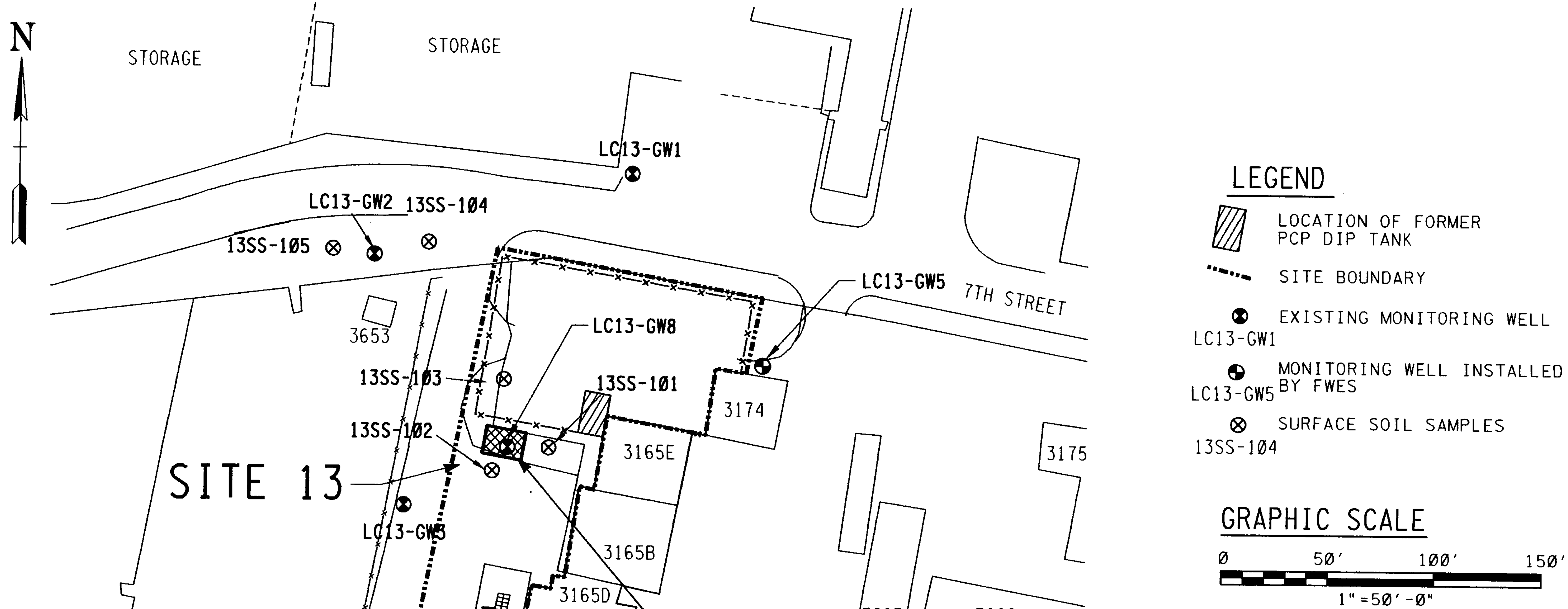

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FIGURE 3-3

SITE 13
HOTSPOT SOIL
EXCAVATION AREA
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

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The following potential remedial alternatives were developed for the contaminated soil hotspot at Site 13:

- Alternative S13-1: No Action
- Alternative S13-2: Limited Action (Institutional Controls)
- Alternative S13-3: Capping
- Alternative S13-4: Excavation/Off-Site Treatment and Disposal

4.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents a detailed description and evaluation of each remedial alternative that was identified in Section 3.0. The remedial alternatives are examined with respect to the requirements stipulated in CERCLA as amended, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (October 1988), "Technology Screening Guide for Treatment of CERCLA Soils and Sludges" (September 1988) and "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (December 1988). Section 4.1 discusses the evaluation processes used and the nine criteria against which the remedial actions are analyzed. Sections 4.2, 4.3 and 4.4 describe the alternatives in detail and evaluate each with respect to the evaluation criteria. Section 4.5 presents a comparative analysis of the remedial alternatives.

4.1 EVALUATION PROCESSES

An initial screening is usually performed on identified alternatives to reduce the number of alternatives for which detailed evaluation is necessary. Criteria used in the preliminary screening step include effectiveness, implementability, and cost factors. However, due to the small number of alternatives identified for Sites 12 and 13, the initial screening step will be bypassed, and all identified alternatives will be subject to a detailed evaluation as described below.

The detailed analysis of the remedial alternatives consists of the following components and processes:

- Definitions of each alternative, with respect to the volumes and areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- Assessment and summary of each alternative against the nine evaluation criteria as defined by the RI/FS Guidance document.

- Comparative analysis among the remedial alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

Based on the statutory preferences and the remedial response objectives developed in Section 2.0, remedial alternatives shall meet the following requirements during evaluation and selection:

- Protection of human health and the environment (CERCLA Section 121 (b)).

- Attainment of the applicable or relevant and appropriate requirements (ARARs) of federal and state laws (CERCLA Section 121(d)(2)(A) or warranting a waiver under CERCLA Section 121(d)(4)).

- Reflection of a cost-effective solution, taking into consideration short- and long-term costs (CERCLA Section 121(a)).

- Use of permanent solutions and treatment technologies or resource recovery technologies to the maximum extent practicable (CERCLA Section 121(b)).

- Satisfaction of the preference for remedies that employ treatments that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances as a principal element, or explanation of reasons why such remedies were not selected (CERCLA Section 121(b)).

In order to address the CERCLA requirements adequately, nine evaluation criteria have been developed. These criteria are discussed and defined in the EPA Guidance for Conducting RI/FS under CERCLA (Interim Final, October 1988).

The first two criteria are the "threshold" factors. Any alternative that does not satisfy both of these criteria is dropped from further consideration in the detailed analysis. These are:

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)

Five "primary balancing" criteria are used to make comparisons and to identify the major trade-offs between the remedial alternatives. Alternatives that satisfy the threshold criteria are evaluated further using the following balancing criteria:

3. Long-term effectiveness
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

The remaining two criteria, state acceptance and community acceptance, are "modifying" factors. State acceptance will be evaluated in the Proposed Remedial Action Plan (PRAP) after receiving state comments on this Feasibility Study report. The PRAP will identify the remedial alternatives preferred by the Navy in discussions with EPA and the state. The final evaluation criterion, community acceptance, will be evaluated in the Record of Decision (ROD) after the public comment period is completed.

A discussion of the nine evaluation criteria is presented below. Then, each remedial alternative is evaluated with respect to the first seven criteria. At the completion of all detailed analyses, a summary section is included, wherein the statutory factors and criteria are compared for each remedial alternative to facilitate the remedy selection process.

<u>Overall Protection of Human Health and the Environment</u>

This evaluation criterion provides an overall assessment of protection based on a composite of long-term and short-term effectiveness factors. Evaluation of overall protection addresses:

- How well a specific site remedial action achieves protection over time;

- How well site risks are reduced; and
- How each source of contamination is to be eliminated, reduced, or controlled for each remedial alternative.

Compliance with ARARs

This evaluation criterion is used to determine how each remedial alternative complies with applicable or relevant and appropriate federal and state requirements as defined in CERCLA Section 121. Each alternative is evaluated in detail for:

- Compliance with contaminant-specific ARARs (e.g., RCRA Standards);
- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards);
- Compliance with location-specific ARARs (e.g., preservation of historic sites); and
- Compliance with appropriate criteria, advisories, and guidances (i.e., "To Be Considered" material).

Section 2.2 presents an overall list of ARARs and "To Be Considered" (TBC) material that were used to evaluate the remedial alternatives. Specific statutory or regulatory citations and their applications to the remedial alternative evaluations are contained in Sections 4.2, 4.3 and 4.4.

Long-Term Effectiveness

This evaluation criterion addresses the results of the remedial action in terms of the risk remaining at the site after the response objectives have been met. The components of this criterion include the magnitude of the remaining risks measured by numerical standards such as cancer risk levels; the adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals (i.e., the assessment of potential failure of the technical components).

Reduction of Toxicity, Mobility or Volume

This evaluation criterion addresses the statutory preference that treatment results in the reduction of principal threats of the total mass of toxic contaminants, the irreversible reduction in contaminant mobility, or the reduction of the total volume of contaminated media. Factors to be evaluated in this criterion include the treatment process employed; the amount of hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, or volume expected; and the type and quantity of treatment residuals.

Short-Term Effectiveness

This evaluation criterion addresses the impacts of the remedial action during the construction and implementation phases preceding the attainment of the remedial response objectives. Factors to be evaluated include protection of workers during the remedial actions, environmental impacts resulting from the implementation of the remedial actions, and the time required to achieve protection.

Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedial action and the availability of various services and materials required during its implementation. Technical feasibility factors include construction and operation difficulties, reliability of technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval and for activities needed to coordinate with other agencies. Factors employed in evaluating the availability of services and materials include availability of treatment, storage, and disposal services with required capacities; availability of equipment and specialists; and availability of prospective technologies for competitive bidding.

Cost

The types of costs that would be addressed include: capital costs, operation and maintenance (O&M) costs, costs of five-year reviews where required, present worth of capital and O&M costs, and potential future remedial action costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the installation of remedial alternatives. Other annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, license costs, maintenance reserve and contingency funds, rehabilitation costs, and costs for periodic site review.

This assessment evaluates the costs of the remedial actions on the basis of present worth. Present worth analysis allows remedial alternatives to be compared on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial alternative over its planned life. A required operating performance period is assumed for present worth and is a function of the discount rate and time. A discount rate of seven percent is assumed for a base calculation. The "study estimate" costs provided for the remedial actions are intended to reflect actual costs with an accuracy of -30 to +50 percent.

The breakdown of major facilities and construction components for the remedial alternatives, and the detailed breakdown of capital and annual operation and maintenance cost estimates are presented in Appendices A and B, respectively.

EPA/State Acceptance

This assessment evaluates the technical and administrative issues and concerns EPA and the Virginia Department of Environmental Quality (VDEQ) may have regarding each of the remedial alternatives. The factors to be evaluated include features of the actions that the EPA and VDEQ support, have reservations about, or oppose.

Community Acceptance

This assessment incorporates public input into the analysis of the remedial alternatives. Factors of community acceptance to be discussed include features of the supportiveness, reservations and opposition of the community.

4.2 ALTERNATIVE ANALYSIS FOR SITE 12 GROUNDWATER (GW12)

The following groundwater (GW12) remedial alternatives for Site 12 were identified in Section 3.4 and will be evaluated in detail against the seven evaluation criteria:

- Alternative GW12-1: No Action
- Alternative GW12-2: Limited Action (Institutional Controls)
- Alternative GW12-3: Extraction/Pretreatment/Discharge to POTW
- Alternative GW12-4: *In Situ* (Biological) Treatment

4.2.1 Alternative GW12-1: No Action

4.2.1.1 Description

The No Action alternative for the contaminated groundwater at Site 12 would only include five-year reviews of site conditions to assess the need for future actions. The contaminated groundwater would be left to natural attenuation without any treatment. Existing monitoring wells would be utilized to sample the groundwater to determine whether the concentration of the chemicals of concern have been lowered to cleanup levels through natural attenuation and to monitor the migration of contaminants. The site would be inspected during all sampling events to provide adequate maintenance/repair of the monitoring wells. Institutional management would also be required to review the site every five years as required by CERCLA as amended. A 30-year period is used for cost estimation purposes.

4.2.1.2 Assessment

Overall Protection of Human Health and the Environment

The No Action alternative would entail no removal of on-site contaminants or treatment of the contaminated groundwater. Preliminary groundwater modeling results indicate that it may take in excess of 30 years for natural attenuation to reduce all the primary contaminant concentrations to cleanup levels. This alternative would not actively reduce the toxicity, mobility, or volume of hazardous contaminants in the groundwater. The contaminated groundwater would continue to migrate downward and laterally off site. Adverse impacts on off-site groundwater quality would continue due to migration of the contaminants from the site. This alternative is not considered responsive to the remedial objectives, but, rather, provides a "base case" for comparison with other alternatives.

Compliance with ARARs

This alternative would not include any removal, treatment, or disposal of the contaminants in the groundwater. Federal and Virginia MCLs and groundwater standards are currently exceeded for the contaminants of concern in the groundwater underlying the site. Since MCLs are ARARs for groundwater that either is or may be used for drinking, Alternative GW12-1 will not satisfy contaminant-specific ARARs (Tables 2-3B, 2-4B). Long-term groundwater monitoring will comply with pertinent RCRA action-specific ARARs for groundwater monitoring (Table 2-3A). Applicable ARARs are identified and discussed in detail in Section 2.2.

Long-Term Effectiveness

Long-term risks associated with the No Action alternative are related to the continuous lateral migration of contaminants off-site. Groundwater migration would transport contaminants off-site via the drainage canal. The long-term effectiveness of this alternative is minimal. The potential baseline human health risks would still exist through the potential exposure pathways, primarily ingestion.

As required by CERCLA as amended, review and evaluation of site conditions would be performed every five years. If justified by the review, remedial actions could be required to pump and treat groundwater. This alternative is not considered to be effective over the long-term because contaminated groundwater would remain on-site and continue to migrate vertically and/or laterally off-site.

Reduction of Toxicity, Mobility or Volume

This alternative would not involve any removal, treatment or disposal of the contaminants in the groundwater and as such, no effective reduction in toxicity, mobility or volume would result. A gradual reduction in toxicity of contaminants would be achieved over time, though, as natural attenuation and dispersion of the groundwater would transport the contaminants vertically downward and off-site. However, the volume of contaminated groundwater would probably increase with time due to the migration of contaminants vertically downward and off-site.

Short-Term Effectiveness

Since this alternative involves no remedial activities, there are no threats to the community, and minimal risk to workers during site reviews. The workers would be provided with personal protection equipment to minimize direct contact risks and would be trained in health and safety procedures. All site activities would be conducted in accordance with the site-specific health and safety plan. Although this alternative may not result in any adverse environmental or hydrogeological impacts, groundwater contaminants would continue to migrate vertically down and off-site. This alternative relies on natural attenuation for achievement of cleanup levels. Although this alternative may require more than 30 years to achieve remedial objectives, a 30-year period was used for cost estimation purposes. This alternative could be implemented immediately.

Implementability

Technical Feasibility

For monitoring the contamination within the aquifer, existing wells would be utilized. The remaining activities will involve the collection of the samples, analyses for contaminants of concern and the evaluation of the extent of contamination, which are all proven and reliable activities.

Administrative Feasibility

This alternative would require administrative coordination in performing site reviews every five years. Coordination with state and NAB Little Creek authorities would be required in the future for reviewing the data and making the appropriate decisions. This alternative would not involve any discharge permits or off-site activities.

Availability of Services and Materials

This alternative would not involve any treatment, storage, or disposal. Equipment and technicians for sampling, monitoring, analytical work and site reviews are locally available and several vendors are available for competitive bids.

Cost

This alternative would not require any capital or annual O&M cost. Approximately $20,000 would be required for each five-year review, during which available data and site conditions are reviewed to determine if remedial action is required based on changes in site conditions. The present worth, calculated at a discount rate of 7 percent and 30-year period is $43,200. Data in support of these cost estimates are presented in Appendices A and B.

4.2.2 Alternative GW12-2: Limited Action (Institutional Controls)

4.2.2.1 Description

The Limited Action alternative for the contaminated groundwater underlying Site 12 would include a long-term monitoring program and an institutional control program to regulate the use of the contaminated aquifer.

The contaminated groundwater would be left to natural attenuation without any treatment. The long-term monitoring program would consist of semi-annual sampling for the contaminants of concern at existing wells on-site and around the site. A total of six existing wells (e.g., LC12-GW1, LC12-GW2, LC12-GW4, LC12-GW7, LC12-GW8, and LC12-GW9) would be utilized to sample the groundwater to determine whether the concentrations of the contaminants of concern have been lowered to cleanup levels through natural attenuation and to monitor the migration of contaminants. Well permit restrictions would be instituted to monitor and control use of groundwater from the contaminated aquifer. Public information meetings and presentations would be provided to increase public awareness of the site contamination. The site would be inspected during all sampling events to provide adequate maintenance/repair of the wells. Institutional management would also be required to review the site every five years as required by CERCLA as amended. A 30-year monitoring period is used for cost estimation purposes.

4.2.2.2 Assessment

Overall Protection of Human Health and the Environment

The Limited Action alternative would entail no removal of on-site contaminants or treatment of the contaminated groundwater. It may take in excess of 30 years for natural attenuation to reduce all the primary contaminant concentrations to cleanup levels. This alternative would not actively reduce the toxicity, mobility, or volume of hazardous contaminants in the groundwater. The ability of this alternative to prevent exposure would directly depend on the effectiveness of institutional controls. The volume of contaminated groundwater is expected to increase due to migration of contaminants. Adverse impacts on off-site groundwater may occur due to migration of the contaminants from the site. This alternative is not considered responsive to all the remedial objectives; however, it attempts to minimize exposures to contaminated groundwater by well permit restrictions. Overall protection of human health and the environment is not guaranteed.

Compliance with ARARs

This alternative would not include any removal, treatment, or disposal of the contaminants in the groundwater. Federal MCLs and Virginia groundwater standards are currently exceeded for the contaminants of concern in the groundwater underlying the site. The data obtained during the long-term monitoring program would be utilized to verify whether concentrations of the contaminants of concern have been lowered to clean-up levels through natural attenuation. Since MCLs and groundwater standards are ARARs for groundwater that either is or may be used for drinking, Alternative GW12-2 will not satisfy chemical-specific ARARs. Long-term groundwater monitoring will comply with pertinent RCRA action-specific ARARs.

Long-Term Effectiveness

Long-term risks associated with the Limited Action alternative are related to: (1) continuous lateral migration of contaminants off site, and (2) vertical migration of contaminants due to downward head gradient. Groundwater migration would transport contaminants off site. The long-term effectiveness of this alternative is uncertain. The potential human health risks would still exist through the potential exposure pathways. Any reduction in risk would depend on the success in minimizing the use of the groundwater through well permit restrictions.

A long-term groundwater monitoring program would be required to determine whether contaminant concentrations are being reduced through natural attenuation. As required by CERCLA as amended, review and evaluation of site conditions would be performed every five years. If justified by the review, remedial actions could be required to pump and treat groundwater. Institutional administration would be established to prevent any future use of groundwater in the affected and potentially affected areas. This alternative is not considered to be effective over the long-term because contaminated groundwater would remain on-site and continue to migrate vertically and/or laterally off-site.

Reduction of Toxicity, Mobility or Volume

This alternative would not involve any removal, treatment or disposal of the contaminants in the groundwater and as such, no effective reduction in toxicity, mobility or volume would result. A gradual reduction in toxicity of contaminants would be achieved over time, as natural attenuation and dispersion of the groundwater would transport the contaminant. However, the volume of contaminated groundwater would probably increase with time due to the migration of contaminants vertically downward and off-site.

Short-Term Effectiveness

As this alternative only involves sampling of the monitoring wells, there are no threats to the community, and minimal risk to workers sampling the wells during implementation of the alternative. The workers performing sampling activities would be provided with personal protection equipment to minimize direct contact risks and would be trained in health and safety procedures. All site activities would be conducted in accordance with the site-specific health and safety plan. Although this alternative may not result in any adverse environmental or hydrogeological impacts, groundwater contaminants would continue to migrate off site. This alternative relies on natural attenuation for achievement of cleanup levels. Although this alternative may require more than 30 years to achieve remedial objectives, a 30-year period was used for cost estimation purposes. The time required to implement the monitoring program and institutional controls is estimated to be six months.

Implementability

Technical Feasibility

Existing wells would be used for monitoring the contamination within the aquifer. Collection of samples, analyses for contaminants of concern and the evaluation of the extent of contamination are all proven and reliable activities.

Administrative Feasibility

Implementation of this alternative would require institutional controls to minimize the use of the contaminated groundwater. The effectiveness and reliability of institutional controls are uncertain due to potential violations. Additional time would have to be devoted to performing site reviews every five years. Coordination with state and local authorities would be required in the future for reviewing the data and making appropriate decisions regarding further action. This alternative would not involve any discharge permits or off-site activities.

Availability of Services and Materials

This alternative would not involve any treatment, storage, or disposal. Equipment and specialists for sampling, monitoring, analytical work and site reviews are locally available and several vendors are available for competitive bids.

Cost

The capital cost for this alternative is estimated to be $29,700. The annual operation and maintenance cost is estimated to be $20,400. In addition, approximately $20,000 would be required for each five-year review, during which available data and site conditions are reviewed to determine if remedial action is required based on changes in site conditions. The present worth, calculated at a discount rate of seven percent for a 30-year period is $326,000. Data in support of these cost estimates are presented in Appendices A and B.

4.2.3 Alternative GW-12-3: Extraction/Pretreatment/Discharge to POTW

4.2.3.1 Description

The major features of this alternative are groundwater extraction, collection, pretreatment and discharge of treated groundwater to the local POTW, the Hampton Roads Sanitation District (HRSD). In order to comply with HRSD influent requirements, the extracted groundwater would be pretreated via filtration for metals removal. Preliminary modeling indicates that it may take approximately 17 years to achieve remediation goals; therefore, the cost estimate is based on an operating period of 17 years. Pumping and treatment would be stopped when primary contaminant concentrations in groundwater reach remediation goals.

Extraction/Collection System

The extraction/collection system would consist of 2 wells located in the vicinity of well LC12-GW4 (see Figure 3-1). Based on the available data, each extraction well would be pumped at an approximate rate of 15 gpm (Appendix C). The optimal pumping rates and exact locations of the extraction wells would be determined during the design phase. Total flow to the on-site pretreatment system would be approximately 30 gpm. Extracted groundwater would be delivered to a collection tank before pretreatment.

The goal of this alternative is to restore groundwater to drinking water quality. However, based on the information obtained during the SRI, there is the possibility that this goal will not be achieved within a reasonable time frame. It may become apparent during the design, implementation, or operation of the groundwater extraction system that contaminant levels will cease to decline and will remain constant at levels higher than groundwater standards over some portion of the contaminant plume. It may also become apparent that natural attenuation processes will be effective at reducing a certain level of contamination in the aquifer in a similar time frame and at lower cost than extraction and treatment. The information obtained during the remedial design and long-term monitoring will be used to reassess the time frame and technical practicality of achieving cleanup standards and/or the remedy will be reevaluated. Modifications may include any or all of the following:

- Discontinue extraction/pumping at some locations where cleanup has been attained.

- Pulse pumping and alternate pumping to eliminate stagnation and/or allow adsorbed contaminants to partition into the groundwater.

- Install additional extraction points to facilitate or accelerate cleanup of the contaminated plume.

Pretreatment

The pretreatment system would consist of a filtration system designed for the removal of suspended solids and metals. Groundwater sampling data from the SRI shows that levels of all metals dropped significantly after filtration, and this unit operation should therefore provide sufficient pretreatment for metals reduction. Low level concentrations of volatile organic and semivolatile organics were also detected within the groundwater; therefore, it is assumed that pretreatment is not required to meet HRSD limitations for these compounds. The extracted groundwater would pass through a dual media pressure filter equipped with backwash pumps and automatic controls. The filter backwash would be returned to the collection tank for recycle through the system. Sludge would be periodically removed from the system and transported off-site for disposal. A schematic diagram of the pretreatment system is shown in Figure 4-1.

Discharge to POTW

Effluent from the pretreatment system would be discharged to the nearest sanitary sewer line via a metered control manhole, which would record flow to the POTW. Fees charged by the POTW would most likely be based upon volume of flow; additional fees may be imposed based upon wastewater characteristics and would be determined during the remedy implementation application process.

Groundwater would have to meet pretreatment requirements prior to discharge to the POTW. Preliminary discussions with the HRSD indicate that the POTW may be willing to accept the pretreated groundwater. Limitations on the concentrations of the pretreatment groundwater include 1 mg/L per volatile organic compound. It is anticipated that a detailed application would have to be prepared for approval by the POTW. The application would require information including (but not limited to) anticipated flow rates and volumes (on a daily, weekly and monthly basis); physical/chemical characteristics of the wastewater, including specific pollutants and concentrations; and a description of the on-site pretreatment facility.

4.2.3.2 Assessment

Overall Protection of Human Health and the Environment

This alternative would remove the contaminants of concern from the aquifer underlying the site and would control and ultimately eliminate migration of contaminated groundwater off-site. The treatment provided by the POTW would reduce the contaminants of concern in the groundwater to levels required by the POTW discharge permit. Ultimately, groundwater in the aquifer would

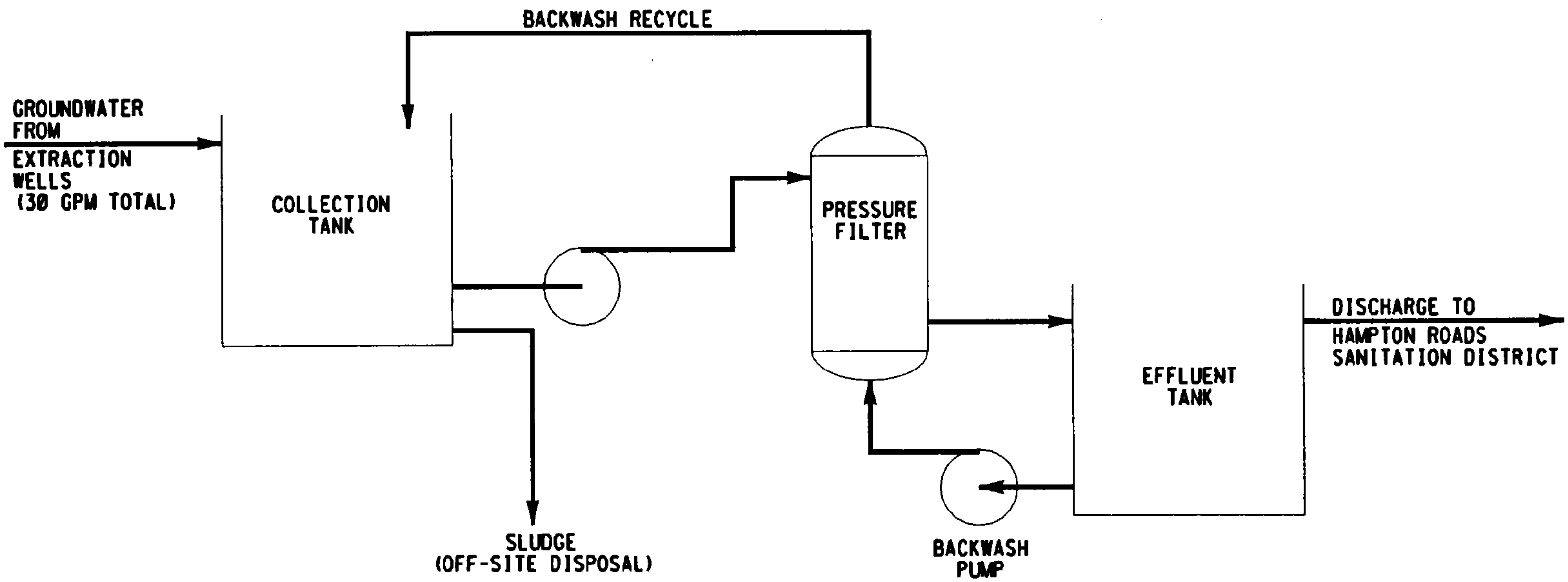

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FIGURE 4-1

SITE 12 PRETREATMENT SYSTEM NAB - LITTLE CREEK VIRGINIA BEACH, VIRGINIA

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be reduced to the ARAR-based cleanup levels. This alternative would result in protection of human health and the environment.

Compliance with ARARs

This alternative includes the extraction of contaminated groundwater for pretreatment and discharge to the local POTW. Extraction would be accomplished through the use of extraction wells. The construction of the extraction wells including conduits or piping and manholes or wet wells to facilitate the extraction of contaminated groundwater would be in compliance with all of the action and location-specific ARARs pertinent to this alternative (Tables 2-3 and 2-4). Any contaminated material generated during construction (e.g., soil, PPE) would be managed in accordance with all applicable regulations. All wells associated with pumping activities will be constructed in compliance with the federal and Virginia well construction requirements.

Contaminated groundwater would undergo pretreatment in accordance with the requirements of the local POTW and would subsequently be discharged to a sanitary sewer which would then transport the pretreated contaminated groundwater to the POTW for further treatment. This alternative would attain the chemical-specific ARARs identified for the site groundwater by removing the contaminated groundwater from the aquifer underlying the site; pretreating the groundwater to levels acceptable to the POTW based on their permit requirements; and discharging pretreated water to a sanitary sewer for transfer of the contaminated groundwater to a local POTW (Tables 2-3 and 2-4). Pretreatment would be conducted in accordance with federal and Virginia wastewater treatment requirements and federal RCRA and Virginia hazardous waste treatment requirements.

Any secondary hazardous waste generated during groundwater pretreatment would be managed and shipped off-site for treatment and disposal in a permitted hazardous waste TSD facility in compliance with federal RCRA and Virginia hazardous waste generator and federal RCRA, USDOT and Virginia hazardous waste transportation requirements. A sewer line connection would be constructed in order to allow for the discharge of pretreated groundwater into the POTW sanitary sewer line. The construction of this sewer line connection would be in accordance with all action and location specific ARARs applicable to this alternative (Tables 2-3 and 2-4).

This alternative would meet all chemical-, action- and location-specific ARARs pertinent to this alternative, which are identified and discussed in detail in Section 2.2.

Long-Term Effectiveness

The major benefits associated with this alternative include long-term minimization of contaminant migration off-site and removal of the contaminants of concern from the groundwater. Extracted groundwater would be pretreated to levels required by the POTW discharge permit and ultimately the ARAR-based cleanup levels would be achieved within the aquifer for primary contaminants of concern. The remediation would continue until concentration of the primary contaminants of concern in the influent to the pretreatment system are equal to or below the cleanup levels and/or to their corresponding upgradient concentrations.

Reduction of Toxicity, Mobility or Volume

This alternative would significantly reduce the overall toxicity, mobility and volume of contaminants by collecting contaminated groundwater from the aquifer for ultimate treatment at the local POTW.

Treatment residuals would consist of sludge from the pretreatment process. The sludge would be drummed for off-site transportation and disposal in accordance with all applicable requirements.

Short-Term Effectiveness

Potential short-term risks during implementation of this alternative would be from direct contact with contaminated groundwater during extraction and the pretreatment process. Proper operating procedures must be followed and precautions taken against normal construction hazards. Exposure risks would be mitigated through health and safety training and use of process controls such as automatic alarms and fail-safe shutdowns in case of leaks. Dust control measures such as wind screens and water sprays would be used to minimize fugitive dust emissions resulting from installation of the extraction wells and pretreatment system. Risks to the community due to increased traffic during transport of treatment residuals is expected to be minimal. No major environmental impacts are expected from this alternative.

The time required to implement this alternative including testing, design, bidding, selection of a contractor, negotiation with the POTW, and construction is expected to be approximately 2 years. Actual construction would take approximately 1 year; for costing purposes, this alternative is assumed to take 17 years.

Implementability

Technical Implementability

The primary process steps of this alternative, including groundwater extraction, pretreatment by filtration and discharge to the local POTW have been used extensively to treat contaminated groundwater.

All components of this alternative are well-developed, commercially available, and are not expected to incur major technical problems which would lead to schedule delays. The pretreatment process for this remedial alternative is a conventional wastewater treatment process and can be fabricated from off-the-shelf equipment. Proper operation and routine maintenance of the pretreatment system would be required to achieve treatment goals. During the operation of the pretreatment system, effectiveness would be monitored by periodic analysis of contaminants in the pretreated groundwater before discharge to the local POTW. Groundwater monitoring methods are also available and have been effectively used.

Administrative Feasibility

This alternative would require extensive institutional management to ensure proper operation, maintenance and overall execution. Additionally, this alternative would require extensive communication and negotiation with the HRSD. Withdrawal permits would be required for groundwater extraction. Although no permits are required for on-site treatment, substantive requirements must be met. Compliance with USEPA, U.S. Department of Transportation and State regulations would be required for the transport and disposal of pretreatment residuals. Long-term institutional management would be required for the groundwater treatment system.

Long-term groundwater monitoring would be required to measure performance of the treatment system. Frequent reviews would be essential in assessing the effectiveness of this alternative in terms of contaminant concentration reductions by groundwater extraction and to implement appropriate alterations in the treatment process.

Availability of Services and Materials

The pretreatment system for this alternative consists of a conventional wastewater treatment process and can be fabricated from off-the-shelf equipment. Commercial suppliers are available for all required equipment or services necessary to implement this alternative. Competitive bids can thus be obtained. Offsite facilities are available for the disposal of pretreatment residuals.

Cost

The capital cost for this alternative is estimated to be $293,900. The annual operation and maintenance cost is estimated to be $66,300. The present worth calculated at a discount rate of seven percent and a 17-year period is $984,400 including $43,200 for five-year reviews over a 30-year period. Data in support of these cost estimates are presented in Appendices A and B.

4.2.4 Alternative GW12-4: *In Situ* (Biological) Treatment

4.2.4.1 Description

The major component of this alternative is *in situ* treatment of contaminated groundwater. There are several different approaches that can be used to achieve *in situ* treatment of the contaminants of concern, including injection/extraction of air of oxygen (e.g., air sparging); or injection/extraction/recirculation of groundwater enhanced with oxygen or amended with hydrogen peroxide (H_2O_2), nutrients and/or cosubstrates. The selection of the most effective approach to *in situ* biodegradation can only be made after laboratory and/or pilot scale treatability studies have been performed to determine the most effective environment (e.g., aerobic, anaerobic or both) and the required amendments for complete degradation. However, the major features of this alternative are generally the same, regardless of the approach.

In situ biodegradation is accomplished by providing necessary nutrients and electron acceptors, and in some cases cosubstrates, to microorganisms in the groundwater, which then degrade contaminants of concern to simpler compounds (e.g., CO_2, H_2O, CH_4, etc.). Nutrients, in particular nitrogen and phosphorus, are typically added by injection of an aqueous solution to the aquifer through injection wells. Electron acceptors (e.g., oxygen for aerobic biodegradation, nitrate or CO_2 for anaerobic biodegradation) can be added either as an aqueous phase solution or in some cases, directly injected in a vapor state. Cosubstrates (e.g., acetate) are sometimes needed when the contaminant of concern cannot be used as a primary substrate, but rather is fortuitously degraded by a microorganism using a different substrate for growth. Many chlorinated solvents have been shown to only be partially degraded cometabolically, with the final product being a less chlorinated compound. However, by additional cometabolic processes, and/or use as a primary substrate, the chlorinated solvents of concern can ultimately be completely mineralized (i.e., to CO_2, H_2O, Cl).

Following laboratory and/or pilot-scale treatability studies to determine the most appropriate mode of degradation and required amendments, the full-scale treatment system would be installed. It would consist of an appropriate number of liquid and/or vapor injection wells, extraction wells (if required), and any needed ancillary equipment to provide chemicals to the injected stream. Additional monitoring wells downgradient of the *in situ* treatment zone might also be installed to ensure that migration of contaminants from the treatment area is not occurring. If extraction of groundwater for recirculation is required, some level of treatment of this water may be needed before reinjection. This may be accomplished by above ground biological treatment, or possibly, by carbon adsorption if contaminant levels are low. The level of treatment required would also be determined during laboratory or pilot scale-treatability studies.

For the purpose of development and evaluation of an *in situ* alternative, it is assumed that an air sparging/soil vapor extraction (AS/SVE) approach is implemented. An AS/SVE system uses air injection wells to introduce oxygen to the groundwater to enhance volatilization and biodegradation. Those volatile contaminants that are not biodegraded are volatilized and transferred to the vadose zone where the soil vapor is extracted. Equipment required for implementation of this alternative includes: sparge wells, vapor extraction wells, a compressor, a vacuum blower and possibly a vapor treatment system (e.g., carbon or oxidizer) for extracted vapor. It is estimated that approximately 50 air sparge wells and 50 vapor extraction wells would be installed in a grid in the vicinity of well LC12-GW4. A schematic diagram of the AS/SVE system is shown in Figure 4-2. Although an AS/SVE does not address all contaminants of concern (i.e., it does not provide treatment of inorganics), it was selected for evaluation as an alternative to pump-and-treat technologies.

4.2.4.2 Assessment

<u>Overall Protection of Human Health and the Environment</u>

This alternative would potentially remove the organic contaminants of concern from the groundwater via two mechanisms; biodegradation and volatilization. Biodegradation is a destructive process, resulting in complete mineralization if properly designed. Volatilization results in a transfer of contaminant from the groundwater to a vapor phase for treatment. Ultimately, the organic groundwater contaminant levels would be reduced to regulatory levels, and this alternative would be protective of human health and the environment. However, this approach would not reduce the levels of metals present in the groundwater.

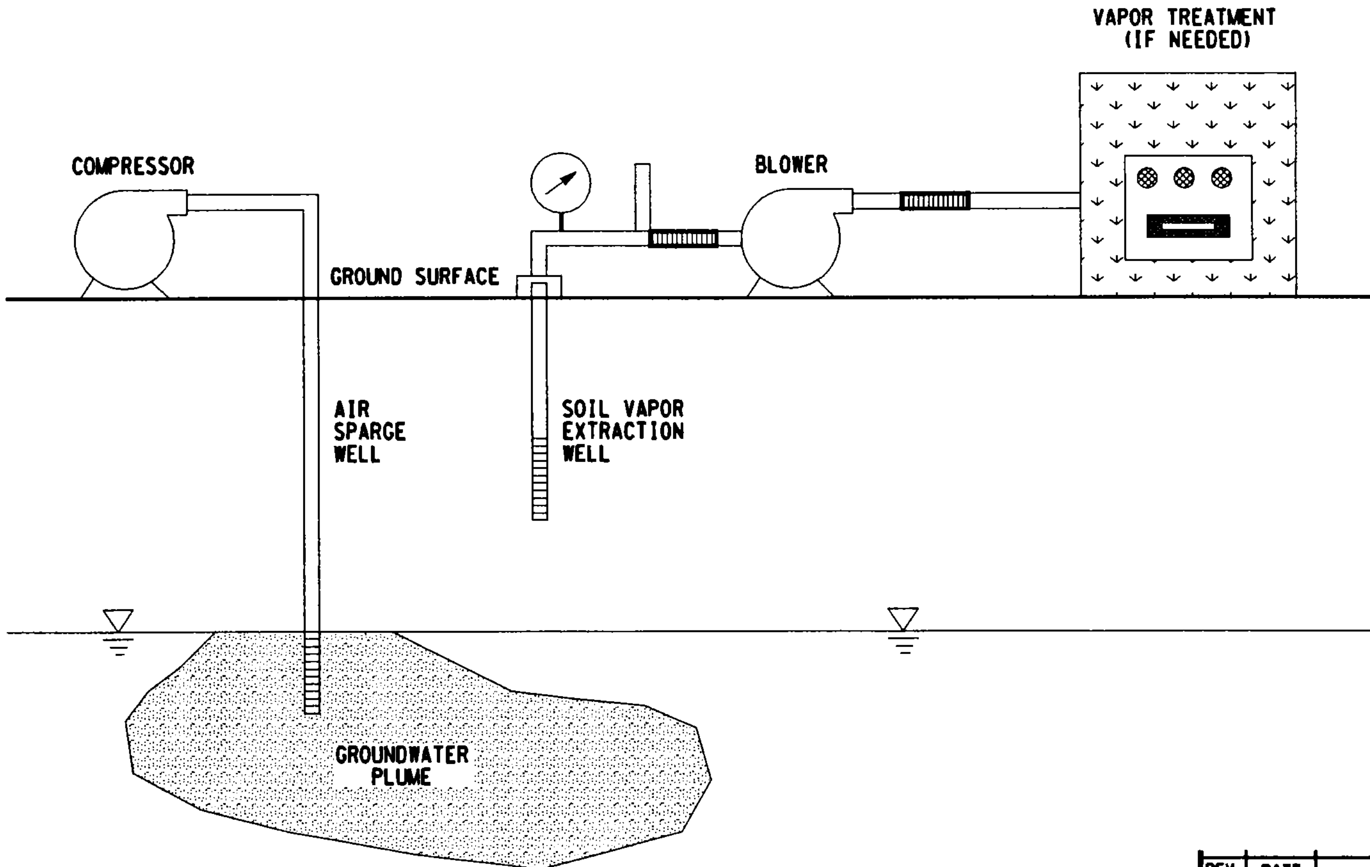

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FIGURE 4-2
SITE 12
AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

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Compliance with ARARs

This alternative would ultimately result in cleanup of contaminated groundwater such that compliance with some chemical-specific ARARs for organic compounds would be achieved. However, this alternative would not reduce the levels of inorganics detected and would therefore not meet those ARARs.

If the selected approach includes extraction of contaminated groundwater, this water would be treated to be in compliance with all chemical-specific ARARs prior to reinjection or discharge. Through proper design, construction, and operation of the treatment system, compliance with all action- and location-specific ARARs could be achieved.

Long-Term Effectiveness

Upon conclusion of the *in situ* remediation, organic contaminants of concern in the groundwater will have been reduced to levels in compliance with ARARs, and residual risks resulting from these compounds will have been reduced to acceptable levels. This alternative represents a permanent remedy for organic constituents, since the organic contaminants of concern would be degraded via biodegradation or removed from the groundwater via volatilization. This alternative will not address the inorganic contaminants present in the groundwater unless extraction and aboveground treatment options are utilized.

Reduction of Toxicity, Mobility and Volume

This alternative would result in a significant reduction in toxicity, mobility and volume of contaminated groundwater via biodegradation and volatilization. Biodegradation represents a destructive treatment technology that destroys the organic contaminants of concern. This alternative would not affect inorganic contaminants, unless groundwater was extracted and treated for metals (e.g., via filtration)

Volatilization is not a destructive treatment, but results in the reduction of toxicity, mobility and volume of contaminants in groundwater via the transfer of the contaminants from the groundwater to another phase (e.g., adsorbed to carbon). Depending on the method of disposal chosen for the activated carbon, the removed contaminants may be recovered or destroyed via thermal processes.

Short-Term Effectiveness

Potential short-term risks during implementation of this alternative are limited mainly to exposure of workers to contaminated soil and groundwater during installation of injection/ extraction/monitoring wells. These risks would be minimized through the proper implementation of a site-specific health and safety plan.

If the selected remediation approach includes extraction of vapor and/or groundwater, there would be potential exposure of workers and the public to fugitive emissions. This risk would be mitigated through proper design and implementation of the aboveground water or vapor collection and treatment system.

The time for implementation of this alternative cannot be accurately determined until laboratory and/or bench-scale treatability studies are completed. Typically, *in situ* bioremediation is completed in a relatively short period of time (e.g., one to five years). For evaluation of this alternative, a three-year remediation following a two-year period for testing and design is estimated.

Implementability

Technical Implementability

Many of the technologies that could potentially be selected for implementation of *in situ* bioremediation (e.g., air sparging, soil vapor extraction, nutrient addition, groundwater recirculation aboveground treatment, etc.) are readily available technologies that are relatively easy to install and operate. Nonetheless, there are some technical difficulties associated with the implementation of this alternative.

Biodegradation of chlorinated solvents is still considered an emerging technology, with few full-scale demonstrations having been completed. Therefore, laboratory and/or pilot-scale treatability studies would need to be performed to determine an effective treatment approach (if any) and to provide the needed data for the full-scale design.

For highly chlorinated solvents, most data to date indicate that complete degradation can only be achieved through a sequential anaerobic/aerobic treatment scheme. Creating such an environment *in situ* and under controlled conditions may be very difficult. Also, much of the data indicate that chlorinated solvents are only degraded cometabolically. There are both technical and administrative implications for addition of a cosubstrate into the groundwater, since the necessary cosubstrate may be a regulated contaminant. An air sparging/soil vapor extraction system minimizes many of these concerns, since any volatile organic contaminants that are not degraded will be removed by volatilization.

Administrative Feasibility

Administratively, this alternative would be relatively easy to implement. Depending on the treatment approach selected, substantive requirements of certain permits (e.g., groundwater diversion, discharge to groundwater, air emissions, etc.) may need to be met. However, there are no administrative barriers to the implementation of this alternative.

Availability of Services and Materials

There are vendors available to provide the services and materials required for implementation of this alternative, including laboratory and/or pilot-scale treatability studies needed for selection and design of the full-scale treatment system; however, *in situ* biodegradation is still considered an innovative technology, and the number of vendors providing these services is somewhat limited.

Cost

The capital cost based on an air sparging/soil vapor extraction scenario is $620,100; the annual O&M cost is $164,400; the net present worth using a discount rate of 7% over a 3-year remediation period is $1,094,700, including $43,200 for five-year reviews over a 30-year period.

4.3 ALTERNATIVE ANALYSIS FOR SITE 13 GROUNDWATER (GW13)

The following groundwater (GW) remedial alternatives for Site 13 were identified in Section 3.0 and will be evaluated in detail against the seven evaluation criteria:

- Alternative GW13-1: No Action
- Alternative GW13-2: Limited Action (Institutional Controls)
- Alternative GW13-3: Extraction/Pretreatment/Discharge to POTW
- Alternative GW13-4: *In Situ* Treatment of Groundwater

4.3.1 Alternative GW13-1: No Action

4.3.1.1 Description

The No Action alternative for the contaminated groundwater at Site 13 would only include five-year reviews of site conditions to assess the need for future actions. The contaminated groundwater would be left to natural attenuation without any treatment. Existing monitoring wells would be utilized to sample the groundwater to determine whether the concentration of the chemicals of concern have been lowered to cleanup levels through natural attenuation and to monitor the migration of contaminants. The site would be inspected during all sampling events to provide adequate maintenance/repair of the monitoring wells. Institutional management would also be required to review the site every five years as required by CERCLA as amended. A 30-year monitoring period is used for cost estimation purposes.

4.3.1.2 Assessment

Overall Protection of Human Health and the Environment

The No Action alternative would entail no removal of on-site contaminants or treatment of the contaminated groundwater. Preliminary groundwater modeling results indicate that it may take in excess of 30 years for natural attenuation to reduce all the primary contaminant concentrations to cleanup levels. This alternative would not actively reduce the toxicity, mobility, or volume of hazardous contaminants in the groundwater. The volume of contaminated groundwater is expected to increase due to continued contact with the source materials. The contaminated groundwater would continue to migrate downward and laterally off site. Adverse impacts on off-site groundwater quality would continue due to migration of the contaminants from the site. This alternative is not considered responsive to the remedial objectives, but, rather, provides a "base case" for comparison with other alternatives.

Compliance with ARARs

This alternative would not include any removal, treatment, or disposal of the contaminants in the groundwater. Federal and Virginia MCLs and groundwater standards are currently exceeded for the contaminants of concern in the groundwater underlying the site. Since MCLs are ARARs for groundwater that either is or may be used for drinking, Alternative GW13-1 will not satisfy contaminant-specific ARARs (Tables 2-3 and 2-4). Long-term groundwater monitoring will comply with pertinent RCRA action-specific ARARs for groundwater monitoring (Table 2-3). Applicable ARARs are identified and discussed in detail in Section 2.2.

Long-Term Effectiveness

Long-term risks associated with the No Action alternative are related to the continuous lateral migration of contaminants off-site. Groundwater migration would transport contaminants off-site. The long-term effectiveness of this alternative is minimal. The potential baseline human health risks would still exist through the potential exposure pathways, primarily ingestion.

As required by CERCLA as amended, review and evaluation of site conditions would be performed every five years. If justified by the review, remedial actions could be required to pump and treat groundwater. This alternative is not considered to be effective over the long-term because contaminated groundwater would remain on-site and continue to migrate vertically and/or laterally off-site.

Reduction of Toxicity, Mobility or Volume

This alternative would not involve any removal, treatment or disposal of the contaminants in the groundwater and as such, no effective reduction in toxicity, mobility or volume would result. A gradual reduction in toxicity of contaminants would be achieved over time, though, as natural attenuation and dispersion of the groundwater would transport the contaminants vertically downward and off-site. However, the volume of contaminated groundwater would probably increase with time due to the migration of contaminants vertically downward and off-site.

Short-Term Effectiveness

Since this alternative involves no remedial activities, there are no threats to the community, and minimal risk to workers during site reviews. The workers would be provided with personal protection equipment to minimize direct contact risks and would be trained in health and safety procedures. All site activities would be conducted in accordance with the site-specific health and safety plan. Although this alternative may not result in any adverse environmental or hydrogeological impacts, groundwater contaminants would continue to migrate vertically down and off-site. This alternative relies on natural attenuation for achievement of cleanup levels. Although this alternative may require more than 30 years to achieve remedial objectives, a 30-year period was used for cost estimation purposes. This alternative could be implemented immediately.

Implementability

Technical Feasibility

For monitoring the contamination within the aquifer, existing wells would be utilized. The remaining activities will involve the collection of the samples, analyses for contaminants of concern and the evaluation of the extent of contamination, which are all proven and reliable activities.

Administrative Feasibility

This alternative would require administrative coordination in performing site reviews every five years. Coordination with state and NAB Little Creek authorities would be required in the future for reviewing the data and making the appropriate decisions. This alternative would not involve any discharge permits or off-site activities.

Availability of Services and Materials

This alternative would not involve any treatment, storage, or disposal. Equipment and technicians for sampling, monitoring, analytical work and site reviews are locally available and several vendors are available for competitive bids.

Cost

This alternative would not require any capital or annual O&M costs. Approximately $20,000 would be required for each five-year review, during which available data and site conditions are reviewed to determine if remedial action is required based on changes in site conditions. The present worth, calculated at a discount rate of 7 percent and 30-year period is $43,200. Data in support of these cost estimates are presented in Appendices A and B.

4.3.2 Alternative GW13-2: Limited Action (Institutional Controls)

4.3.2.1 Description

The Limited Action alternative for the contaminated groundwater underlying Site 13 would include a long-term monitoring program and an institutional control program to regulate the use of the contaminated aquifer.

The contaminated groundwater would be left to natural attenuation without any treatment. The long-term monitoring program would consist of semi-annual sampling for the contaminants of concern at existing wells on-site and around the site. A total of six existing wells (e.g., LC13-GW5, LC13-GW9, LC13-GW10, LC13-GW11, LC13-GW12, and LC13-GW13) would be utilized to sample the groundwater to determine whether the concentrations of the contaminants of concern have been lowered to cleanup levels through natural attenuation and to monitor the migration of contaminants. Well permit restrictions would be instituted to monitor and control use of groundwater from the contaminated aquifer. Public information meetings and presentations would be provided to increase public awareness of the site contamination. The site would be inspected during all sampling events to provide adequate maintenance/repair of the wells. Institutional management would also be required to review the site every five years as required by CERCLA as amended. A 30-year monitoring period is used for cost estimation purposes.

4.3.2.2 Assessment

Overall Protection of Human Health and the Environment

The Limited Action alternative would entail no removal of on-site contaminants or treatment of the contaminated groundwater. It may take in excess of 30 years for natural attenuation to reduce all the primary contaminant concentrations to cleanup levels. This alternative would not actively reduce the toxicity, mobility, or volume of hazardous contaminants in the groundwater. The ability of this alternative to prevent exposure would directly depend on the effectiveness of institutional controls. The volume of contaminated groundwater is expected to increase due to migration of contaminants. Adverse impacts on off-site groundwater may occur due to migration of the contaminants from the site. This alternative is not considered responsive to all the remedial objectives; however, it attempts to minimize exposures to contaminated groundwater by well permit restrictions. Overall protection of human health and the environment is not guaranteed.

Compliance with ARARs

This alternative would not include any removal, treatment, or disposal of the contaminants in the groundwater. Federal MCLs and Virginia groundwater standards are currently exceeded for the contaminants of concern in the groundwater underlying the site. The data obtained during the long-term monitoring program would be utilized to verify whether concentrations of the contaminants of concern have been lowered to clean-up levels through natural attenuation. Since MCLs and groundwater standards are ARARs for groundwater that either is or may be used for drinking, Alternative GW13-2 will not satisfy chemical-specific ARARs. Long-term groundwater monitoring will comply with pertinent RCRA action-specific ARARs.

Long-Term Effectiveness

Long-term risks associated with the Limited Action alternative are related to: (1) continuous lateral migration of contaminants off site, and (2) vertical migration of contaminants due to downward head gradient. Groundwater migration would transport contaminants off site. The long-term effectiveness of this alternative is uncertain. The potential human health risks would still exist through the potential exposure pathways. Any reduction in risk would depend on the success in minimizing the use of the groundwater through well permit restrictions.

A long-term groundwater monitoring program would be required to determine whether contaminant concentrations are being reduced through natural attenuation. As required by CERCLA as amended, review and evaluation of site conditions would be performed every five years. If justified by the review, remedial actions could be required to pump and treat groundwater. Institutional administration would be established to prevent any future use of groundwater in the affected and potentially affected areas. This alternative is not considered to be effective over the long-term because contaminated groundwater would remain on site and continue to migrate vertically and/or laterally off site.

Reduction of Toxicity, Mobility or Volume

This alternative would not involve any removal, treatment or disposal of the contaminants in the groundwater and as such, no effective reduction in toxicity, mobility or volume would result. A gradual reduction in toxicity of contaminants would be achieved over time, as natural attenuation and dispersion of the groundwater would transport the contaminant. However, the volume of contaminated groundwater would probably increase with time due to the migration of contaminants vertically downward and off-site.

Short-Term Effectiveness

As this alternative only involves sampling of the monitoring wells, there are no threats to the community, and minimal risk to workers sampling the wells during implementation of the alternative. The workers performing sampling activities would be provided with personal protection equipment to minimize direct contact risks and would be trained in health and safety procedures. All site activities would be conducted in accordance with the site specific health and safety plan. Although this alternative may not result in any adverse environmental or hydrogeological impacts, groundwater contaminants would continue to migrate off-site. This alternative relies on natural attenuation for achievement of cleanup levels. Although this alternative may require more than 30 years to achieve remedial objectives, a 30-year period was used for cost estimation purposes. The time required to implement the monitoring program and institutional controls is estimated to be six months.

Implementability

Technical Feasibility

Existing wells would be used for monitoring the contamination within the aquifer. Collection of samples, analyses for contaminants of concern and the evaluation of the extent of contamination are all proven and reliable activities.

Administrative Feasibility

Implementation of this alternative would require institutional controls to minimize the use of the contaminated groundwater. The effectiveness and reliability of institutional controls are uncertain due to potential violations. Additional time would have to be devoted to performing site reviews every five years. Coordination with state and local authorities would be required in the future for reviewing the data and making appropriate decisions regarding further action. This alternative would not involve any discharge permits or off-site activities.

Availability of Services and Materials

This alternative would not involve any treatment, storage, or disposal. Equipment and specialists for sampling, monitoring, analytical work and site reviews are locally available and several vendors are available for competitive bids.

Cost

The capital cost for this alternative is estimated to be $29,700. The annual operation and maintenance cost is estimated to be $20,400. In addition, approximately $20,000 would be required for each five-year review, during which available data and site conditions are reviewed to determine if remedial action is required based on changes in site conditions. The present worth, calculated at a discount rate of seven percent and 30-year period is $326,000. Data in support of these cost estimates are presented in Appendices A and B.

4.3.3 Alternative GW-13-3: Extraction/Pretreatment/Discharge to POTW

4.3.3.1 Description

The major features of this alternative are groundwater extraction, collection, pretreatment and discharge of treated groundwater to the local POTW, the Hampton Roads Sanitation District (HRSD). In order to comply with HRSD influent requirements, the extracted groundwater would be pretreated via filtration for metals removal. Preliminary modeling indicates that it may take more than 20 years to achieve remediation goals; therefore, the cost estimate is based on an operating period of 20 years. Pumping and treatment would be stopped when primary contaminant concentrations in groundwater reach remediation goals.

Extraction/Collection System

The extraction/collection system would consist of 3 wells located in the vicinity of wells LC13-GW12 and LC13-GW13 (see Figure 3-2). Based on the available data, each extraction well would be pumped at an approximate rate of 10 gpm (see Appendix C). The optimal pumping rates and exact locations of the extraction wells would be determined during the design phase. Total flow to the on-site pretreatment system would be approximately 30 gpm. Extracted groundwater would be delivered to a collection tank before pretreatment.

The goal of this alternative is to restore groundwater to drinking water quality. However, based on the information obtained during the SRI, there is the possibility that this goal will not be achieved within a reasonable time frame. It may become apparent during the design, implementation, or operation of the groundwater extraction system that contaminant levels will cease to decline and will remain constant at levels higher than groundwater standards over some portion of the contaminant plume. It may also become apparent that natural attenuation processes will be effective at reducing a certain level of contamination in the aquifer in a similar time frame and at lower cost than extraction and treatment. The information obtained during the remedial design and long-term monitoring will be used to reassess the time frame and technical practicality of achieving cleanup standards and/or the remedy will be reevaluated. Modifications may include any or all of the following:

- Discontinue extraction/pumping at some locations where cleanup has been attained.

- Pulse pumping and alternate pumping to eliminate stagnation and/or allow adsorbed contaminants to partition into the groundwater.

- Install additional extraction points to facilitate or accelerate cleanup of the contaminated plume.

Pretreatment

The pretreatment system would consist of a filtration system designed for the removal of suspended solids and metals. Groundwater sampling data from the SRI indicates that levels of all metals detected dropped significantly after filtrating and this unit operation should therefore provide sufficient pretreatment for metals reduction. Low level concentrations of volatile organic and semivolatile organics were also detected within the groundwater; therefore, it is assumed that pretreatment is not required to meet HRSD limitations for these compounds. The extracted groundwater would pass through a dual media pressure filter equipped with backwash pumps and automatic controls. The filter backwash would be returned to the collection tank for recycle through the system. Sludge would be periodically removed from the system and transported off-site for disposal. The pretreatment system for Site 13 would be essentially the same as for Site 12, as shown schematically in Figure 4-1.

Discharge to POTW

Effluent from the pretreatment system would be discharged to the nearest sanitary sewer line via a metered control manhole, which would record flow to the POTW. Fees charged by the POTW would most likely be based upon volume of flow; additional fees may be imposed based upon wastewater characteristics and would be determined during the remedy implementation process.

Groundwater would have to meet pretreatment requirements prior to discharge to the POTW. Preliminary discussions with the HRSD indicate that the POTW may be willing to accept the pretreated groundwater. Limitations on the concentrations of the pretreatment groundwater include 1 mg/L per volatile organic compound. It is anticipated that a detailed application would have to be prepared for approval by the POTW. The application would require information including (but not limited to) anticipated flow rates and volumes (on a daily, weekly and monthly basis); physical/chemical characteristics of the wastewater, including specific pollutants and concentrations; and a description of the on-site pretreatment facility.

4.3.3.2 Assessment

Overall Protection of Human Health and the Environment

This alternative would remove the contaminants of concern from the aquifer underlying the site and would control and ultimately eliminate migration of contaminated groundwater off-site. The treatment provided by the POTW would remove the contaminants of concern in the groundwater levels required by the POTW discharge permit. Ultimately, groundwater in the aquifer would be reduced to the ARAR-based cleanup levels. This alternative would result in protection of human health and the environment.

Compliance with ARARs

This alternative includes the extraction of contaminated groundwater for pretreatment and discharge to the local POTW. Extraction would be accomplished through the use of extraction wells. The construction of the extraction wells including conduits or piping and manholes or wet wells to facilitate the extraction of contaminated groundwater would be in compliance with all of the action and location-specific ARARs pertinent to this alternative (Tables 2-3 and 2-4). Any contaminated material generated during construction (e.g., soil, PPE) would be managed in accordance with all applicable regulations. All wells associated with pumping activities will be constructed in compliance with the federal and Virginia well construction requirements.

Contaminated groundwater would undergo pretreatment in accordance with the requirements of the local POTW and would subsequently be discharged to a sanitary sewer which would then transport the pretreated contaminated groundwater to the POTW for further treatment. This alternative would attain the chemical-specific ARARs identified for the site groundwater by removing the contaminated groundwater from the aquifer underlying the site; pretreating the groundwater to levels acceptable to the POTW based on their permit requirements; and discharging pretreated water to a sanitary sewer for transfer of the contaminated groundwater to a local POTW (Tables 2-3 and 2-4). Pretreatment would be conducted in accordance with federal and Virginia wastewater treatment requirements and federal RCRA and Virginia hazardous waste treatment requirements.

Any secondary hazardous waste generated during groundwater pretreatment would be managed and shipped off-site for treatment and disposal in a permitted hazardous waste TSD facility in compliance with federal RCRA and Virginia hazardous waste generator and federal RCRA, USDOT and Virginia hazardous waste transportation requirements. A sewer line connection would be constructed in order to allow for the discharge of pretreated groundwater into the POTW sanitary sewer line. The construction of this sewer line connection would be in accordance with all action and location specific ARARs applicable to this alternative (Tables 2-3 and 2-4).

This alternative would meet all chemical-, action- and location-specific ARARs pertinent to this alternative, which are identified and discussed in detail in Section 2.2.

Long-Term Effectiveness

The major benefits associated with this alternative include long-term minimization of contaminant migration off-site and removal of the contaminants of concern from the groundwater. Extracted groundwater would be pretreated to levels required by the POTW discharge permit and ultimately the ARAR-based cleanup levels would be achieved within the aquifer for primary contaminants of concern. The remediation would continue until concentration of the primary contaminants of concern in the influent to the pretreatment system are equal to or below the cleanup levels and/or to their corresponding upgradient concentrations.

Reduction of Toxicity, Mobility or Volume

This alternative would significantly reduce the overall toxicity, mobility and volume of contaminants by collecting contaminated groundwater from the aquifer for ultimate treatment of the local POTW.

Treatment residuals would consist of sludge from the pretreatment process. The sludge would be drummed for off-site transportation and disposal in accordance with all applicable requirements.

Short-Term Effectiveness

Potential short-term risks during implementation of this alternative would be from direct contact with contaminated groundwater during extraction and the pretreatment process. Proper operating procedures must be followed and precautions taken against normal construction hazards. Exposure risks would be mitigated through health and safety training and use of process controls such as automatic alarms and fail-safe shutdowns in case of leaks. Dust control measures such as wind screens and water sprays would be used to minimize fugitive dust emissions resulting from installation of the extraction wells and pretreatment system. Risks to the community due to increased traffic during transport of treatment residuals is expected to be minimal. No major environmental impacts are expected from this alternative.

The time required to implement this alternative including testing, design, bidding, selection of a contractor, negotiation with the POTW, and construction is expected to be approximately 2 years. Actual construction would take approximately 1 year; for costing purposes, this alternative is assumed to take 20 years.

Implementability

Technical Implementability

The primary process steps of this alternative, including groundwater extraction, pretreatment by filtration and discharge to the local POTW have been used extensively to treat contaminated groundwater.

All components of this alternative are well-developed, commercially available, and are not expected to incur major technical problems which would lead to schedule delays. The pretreatment process for this remedial alternative is a conventional wastewater treatment process and can be fabricated from off-the-shelf equipment. Proper operation and routine maintenance of the pretreatment system would be required to achieve treatment goals. During the operation of the pretreatment system, effectiveness would be monitored by periodic analysis of contaminants in the pretreated groundwater before discharge to the local POTW. Groundwater monitoring methods are also available and have been effectively used.

Administrative Feasibility

This alternative would require extensive institutional management to ensure proper operation, maintenance and overall execution. Additionally, this alternative would require extensive communication and negotiation with the HRSD. Withdrawal permits would be required for groundwater extraction. Although no permits are required for on-site treatment, substantive requirements must be met. Compliance with USEPA, U.S. Department of Transportation and State regulations would be required for the transport and disposal of pretreatment residuals. Long-term institutional management would be required for the groundwater treatment system.

Long-term groundwater monitoring would be required to measure performance of the treatment system. Frequent reviews would be essential in assessing the effectiveness of this alternative in terms of contaminant concentration reductions by groundwater extraction and to implement appropriate alterations in the treatment process.

Availability of Services and Materials

The pretreatment system for this alternative consists of a conventional wastewater treatment process and can be fabricated from off-the-shelf equipment. Commercial suppliers are available for all required equipment or services necessary to implement this alternative. Competitive bids can thus be obtained. Off-site facilities are available for the disposal of pretreatment residuals.

Cost

The estimated capital cost for this alternative is estimated to be $299,300. The annual operation and maintenance cost is estimated to be $66,600. The present worth calculated at a discount rate of seven percent and a 20-year period is $1,048,100, including $43,200 for five-year reviews over a 30-year period. Data in support of these cost estimates are presented in Appendices A and B.

4.3.4 Alternative GW13-4: *In Situ* Biological Treatment of Groundwater

4.3.4.1 Description

The major component of this alternative is *in situ* treatment of contaminated groundwater. There are several different approaches that can be used to achieve *in situ* treatment of the contaminants of concern, including injection/extraction of air of oxygen (e.g., air sparging); or injection/extraction/recirculation of groundwater enhanced with oxygen (e.g., aerated or amended with H_2O_2, nutrients and constituents. The selection of the most effective approach to *in situ* biodegradation can only be made after laboratory and/or pilot-scale treatability studies have been performed to determine the most effective environment (e.g., aerobic, anaerobic or both and the required amendments for complete degradation. However, the major features of this alternative are generally the same, regardless of the approach.

In situ biodegradation is accomplished by providing necessary nutrients, electron acceptors, and in some cases cosubstrates, to microorganisms in the groundwater, which then degrade chemicals of concern to simpler compounds (e.g., CO_2, H_2O, CH_4, etc.). Nutrients in particular nitrogen and phosphorus, are typically added by injection of an aqueous solution to the aquifer through injection wells. Electron acceptors (e.g., oxygen for aerobic biodegradation, nitrate or CO_2 or anaerobic biodegradation) can be added either as an aqueous phase solution or, in some cases directly injected in a vapor state. Substrates (e.g., acetate) are sometimes needed when the contaminant of concern cannot be used as a primary substrate, but rather is fortuitously degraded by a microorganism using a different substrate for growth. Many chlorinated solvents have been shown to only be partially degraded cometabolically, with the final product being less chlorinated compound. However, by additional cometabolic processes, and/or use as a primary substrate, the chlorinated solvents of concern can ultimately be completely mineralized (i.e., to CO_2, H_2O, Cl).

Following laboratory and/or pilot-scale treatability studies to determine the must appropriate mode of degradation required amendments, the full-scale treatment system will be installed. It consist of an appropriate number of liquid and/or vapor injection wells, extraction wells (if required), and any needed ancillary equipment to provide chemical to the injected stream. Additional monitoring wells downgradient of the *in situ* treatment zone might also be installed to ensure that migration of contaminants from the treatment area is not occurring. If extraction of groundwater for recirculation is required some level of treatment of this water may be needed before reinjection. This may be accomplished by above ground biological treatment, a possible, by carbon adsorption if contaminant levels are low. The level of treatment required would also be determined during laboratory or pilot scale-treatability studies.

For the purpose of development and evaluation of an *in situ* alternative, it is assumed that an air sparging/soil vapor extraction (AS/SVE) approach is implemented. An AS/SVE system uses air injection wells to introduce oxygen to the groundwater to enhance volatilization and biodegradation. These contaminants that are not biodegradation. Those contaminants that are not biodegraded are volatilized and transferred to the vadose zone where, the soil vapor is extracted. Equipment required for implementation of this alternative include: sparge wells, vapor extraction wells, a compressor, a vacuum blower and possibly a vapor treatment system (e.g., carbon or oxidizer) for extracted vapor. It is estimated that approximately 20 air sparge wells and 20 vapor extraction wells would be installed in a grid in the vicinity of wells LC13-GW12 and LC13-GW13. The system would be essentially the same as that shown for Site 12 in Figure 4-2.

4.3.4.2 Assessment

Overall Protection of Human Health and the Environment

This alternative would potentially remove the contaminants of concern from the groundwater via two mechanisms, biodegradation and volatilization. Biodegradation is a destructive process, resulting in complete mineralization if properly designed. Volatilization results in a transfer of contaminant from the groundwater to a vapor phase for treatment. Ultimately, the groundwater contaminant levels would be reduced to regulatory levels, and this alternative would be protective of human health and the environment.

Compliance with ARARs

This alternative would ultimately result in cleanup of contaminated groundwater such that compliance with all chemical-specific ARARs for organic compounds would be achieved. However, inorganic compounds would not be reduced.

If the selected approach includes extraction of contaminated groundwater, this water would be treated to be in compliance with chemical-specific ARARs for inorganic constituents prior to reinjection or discharge.

Through proper design, construction, and operation of the treatment system, compliance with all action- and location specific ARARs could be achieved. Therefore, this alternative may comply with ARARs if properly implemented.

Long-Term Effectiveness

Upon conclusion of the *in situ* remediation, organic contaminants of concern in the groundwater will have been reduced to levels in compliance with ARARs, and residual risks resulting from these compounds will have been reduced to acceptable levels. This alternative represents a permanent remedy for organic constituents, since the organic contaminants of concern would be degraded via biodegradation or removed from the groundwater via volatilization. This alternative will not address the inorganic contaminants present in the groundwater unless extraction and above-ground treatment options are utilized.

Reduction of Toxicity, Mobility and Volume

This alternative would result in a significant reduction in toxicity, mobility and volume of contaminated groundwater via biodegradation and volatilization. Biodegradation represents a destructive treatment technology that destroys the organic contaminants of concern. This alternative would not affect inorganic contaminants, unless groundwater was extracted and treated for metals (e.g., via filtration).

Volatilization is not a destructive treatment, but results in the reduction of toxicity, mobility and volume of contaminants in groundwater via the transfer of the contaminants from the groundwater to another phase (e.g., adsorbed to carbon). Depending on the method of disposal chosen for the activated carbon, the removed contaminants may be recovered or destroyed via thermal processes.

Short-Term Effectiveness

Potential short-term risks during implementation of this alternative are limited mainly to exposure of workers to contaminated soil and groundwater during installation of injection/extraction/monitoring wells. These risks would be minimized through the proper implementation of a site-specific health and safety plan.

If the selected remediation approach includes extraction of vapor, and/or groundwater, there would be potential exposure of workers and the public to fugitive emissions. This risk would be mitigated through proper design and implementation of the aboveground water or vapor collection and treatment system.

The time for implementation of this alternative cannot be accurately determined until laboratory and/or bench scale treatability studies are completed. Typically, *in situ* bioremediation is completed in a relatively short period of time (e.g., one to five years). For evaluation of this alternative, a three-year remediation following a two-year period for testing and design is estimated.

Implementability

Technical Implementability

Many of the technologies that could potentially be selected for implementation of *in situ* bioremediation (e.g. air sparging) soil vapor extraction, nutrient addition, groundwater recirculation aboveground treatment, etc.) are readily available technologies that are relatively easy to install and operate. Nonetheless, there are some technical difficulties associated with the implementation of this alternative.

Biodegradation of chlorinated solvents is still considered an emerging technology, with few full-scale demonstrations having been completed. Therefore, laboratory and/or pilot scale treatability studies would need to be performed to determine an effective treatment approach (if any) and to provide the needed data for the full-scale design.

For highly chlorinated solvents, most data to date indicate that complete degradation can only be achieved through a sequential anaerobic/aerobic treatment scheme. Creating such an environment *in situ* and under controlled conditions may be very difficult. Also, much of the data indicate that chlorinated solvents are only degraded cometabolically. There are both technical and administrative implications for addition of a substrate into the groundwater, since the necessary substrate may be a regulated contaminant. An air sparging/soil vapor extraction system minimizes many of these concerns, since any contaminants that are not degraded will be removed by volatilization.

Administrative Feasibility

Administratively, this alternative would be relatively easy to implement. Depending on the treatment approach selected, substantive requirements of certain permit (e.g., groundwater diversion, discharge to groundwater, air emissions, etc.) may need to be met. However, there are no administrative barriers to the implementation of this alternative.

Availability of Services and Materials

There are vendors available to provide the services and materials required for implementation of this alternative, including laboratory and/or pilot-scale treatability studies needed for selection and design of the full-scale treatment system; however, *in situ* biodegradation is still considered an innovative technology, and the number of vendors providing these services is somewhat limited.

Cost

The capital cost based on an air sparging/soil vapor extraction scenario is $450,000; the annual O&M cost is $153,900; the net present worth using a discount rate of 7% over a 3 year remediation period is $897,100, including $43,200 for five-year reviews over a 30-year period.

4.4 ALTERNATIVE ANALYSIS FOR SITE 13 SOIL HOTSPOT (S13)

The following soil remedial alternatives were identified in Section 3.0 and will be evaluated in detail against the seven evaluation criteria.

- Alternative S13-1: No Action
- Alternative S13-2: Limited Action (Institutional Controls)
- Alternative S13-3: Capping
- Alternative S13-4: Excavation/Off-Site Treatment and Disposal

4.4.1 Alternative S13-1: No Action

4.4.1.1 Description

The No Action alternative at Site 13 will consist of leaving the contaminated soil in place at the site. The area of hotspot soil contamination is currently covered with gravel. Because this alternative does not include contaminant removal, institutional management would be required to review the site data every five years as required by CERCLA as amended. These five-year reviews would include the reassessment of human health and the environmental risks due to the contaminated soil left on site.

4.4.1.2 Assessment

Overall Protection of Human Health and the Environment

The No Action alternative would not entail removal or other on-site containment or treatment of the contaminated soil. It would not, therefore, provide adequate protection of human health and the environment since there would not be any immediate reduction in the toxicity, mobility or volume of the contaminants. The risk of direct contact with contaminated soils would not be controlled. Migration of PCP from the soil to the groundwater would continue.

Compliance With ARARs

This alternative fails to eliminate the source of contamination. It does not satisfy any of the contaminant-specific ARARs, as contaminated soil would remain on site and continue to cause a release into the environment. Activities associated with the site reviews would be performed in compliance with action-specific ARARs. There are no location-specific ARARs pertinent to this alternative.

Long-Term Effectiveness

The No Action alternative would not meet the remedial response objectives. Soil in excess of the target cleanup levels would be left on site and would continue to pose a health risk via direct contact. The potential for contaminant migration from soil into the groundwater through leaching would still remain. The No Action alternative would slowly reduce the level of contamination within the hotspot area via leaching and migration. Although it is not possible to accurately determine the time required for natural attenuation or degradation without comprehensive contaminant modeling, it is estimated that more than 30 years would be required before natural degradation and transport mechanisms significantly reduce the toxicity and concentration of PCP in the soil. Future risk for groundwater exposures might be greater as the contaminant migrates to the aquifer. Eventually, natural attenuation and dilution are likely to decrease potential risk.

Reduction of Toxicity, Mobility or Volume

This alternative would not involve any containment, removal, treatment or disposal of the contaminated soils. Migration of PCP from the soil hotspot into groundwater would continue. Therefore, this alternative would not result in any immediate reduction in the toxicity, mobility or volume of the contaminant. Over time, through natural attenuation, PCP concentrations would eventually decline.

Short-Term Effectiveness

The No Action alternative will not achieve any of the remedial action objectives. No construction would be involved in this alternative, therefore there are no short-term threats to neighboring communities and no significant impacts on public health and the environment during the implementation activities. Workers performing site review activities would be potentially exposed to contaminated soil and would require personal protection equipment to minimize the risks of direct contact.

Failure of this alternative to restrict access to the site could result in the exposure to contaminants by the public resulting in excess risk as discussed in Section 1.3 of this report. This alternative would not result in substantial improvement over current conditions. Semivolatile organic contamination would persist at the site for many years.

Implementability:

Technical Feasibility

No treatment is employed in this alternative. Additional remedial action can be easily undertaken, if necessary; however, it may be necessary to go through the FS/ROD process again.

Administrative Feasibility

Long-term institutional management would be associated with this alternative for the soil monitoring program and the five-year reviews.

Availability of Services and Materials

This alternative does not involve any treatment, storage or disposal services. Equipment and specialists for sampling, monitoring, analytical work and site reviews are readily available. Numerous vendors exist allowing for a competitive bid process.

Cost

There is no capital or annual O&M cost for the No Action alternative. The cost of five-year reviews for the site has a present worth of $43,200 based on $20,000 per review and a seven percent discount rate for a 30-year period. Data in support of these cost estimates are provided in Appendices A and B.

4.4.2 Alternative S13-2: Limited Action (Institutional Controls)

4.4.2.1 Description

The Limited Action alternative for the soil at Site 13 would consist of a long-term monitoring program, installation of site security measures, a public awareness program and restrictions on land use. Soil would be monitored semi-annually for PCP. For cost estimation purposes, it is estimated that five soil samples would be collected and analyzed.

A security fence would be installed around the hotspot to prevent access to the contaminated area. Warning signs would be posted along the perimeter of the fence identifying the site as containing hazardous materials.

The Limited Action alternative also includes the institution of deed restrictions for land use, and the development and maintenance of a public awareness and an education program for the community in the area surrounding Site 13. This program would include preparation and distribution of informational press releases and circulars, the convening of public meetings and instituting land use restrictions. These activities will require the involvement of local government and various health departments and environmental agencies.

Because this alternative does not include contaminant removal, the site will have to be reviewed every five years for a period of 30 years per requirements of CERCLA as amended. These five-year reviews would include the reassessment of human health and environmental risks due to the contaminated material left on site, using data obtained from the monitoring program.

4.4.2.2 Assessment

Overall Protection of Human Health and the Environment

The Limited Action alternative would not meet the remedial objectives for soil. The contaminated materials would not be removed, contained or treated. Institutional controls would reduce the likelihood of exposure to contaminated soils but could not guarantee that no exposures would occur, and migration of contaminants from the soil into the groundwater would continue.

Compliance with ARARs

This alternative does not eliminate the source of contamination. It does not satisfy any of the identified contaminant-specific ARARs. Location- and action-specific ARARs will be followed where possible, and waivers will be obtained as necessary.

Long-Term Effectiveness

The Limited Action alternative would slowly reduce the level of contamination from the source area by natural leaching, migration and degradation. Natural attenuation is a very slow process, and it will take a long period of time to achieve the designated soil cleanup criteria for the contaminants.

The implementation of this alternative would not have any beneficial effects on the environment. Potential long-term adverse environmental impacts exist because the contaminated soils would remain on site. The potential for contaminant migration from soil into groundwater through leaching and chemical release from soil to air through vaporization and entrainment in dust still remains. The long-term monitoring program would be an effective method for monitoring the trend of contaminant migration. Installation of a security fence and maintenance of public education programs and land use restrictions would minimize exposure risk to the community.

Reduction of Toxicity, Mobility or Volume

This alternative does not involve any containment, removal, treatment or disposal actions for contaminated soil. In addition, the mobility of the contaminants would remain unchanged and therefore, the potential to continue to contaminate the groundwater remains. Over time, through natural attenuation, contaminant concentrations would eventually decline. However, the time needed to reach the acceptable risk levels is unknown.

Short-Term Effectiveness

The Limited Action alternative will not achieve any of the remedial action objectives. No major construction would be involved in this remedial alternative; therefore, there are no short-term threats to neighboring communities and no significant impacts on public health and the environment during implementation activities. A minor potential exists for the monitoring crew to contact contaminated soil during the installation of the security fence and sampling. However, this would be mitigated by following the site-specific health and safety plan. Monitoring programs and institutional programs can be instituted in approximately six months.

Implementability

Technical Feasibility

The monitoring program designed for this site would be easily implemented and would be effective at monitoring contaminant migration. The land use restrictions and public awareness program could be easily implemented. Installation of fence and other security measures are easily accomplished.

Administrative Feasibility

Considerable long-term institutional management would be associated with this alternative for maintenance of institutional controls, the soil monitoring program and the 5-year reviews.

Availability of Services and Materials

The monitoring equipment and analytical laboratories are commercially available and proven. Services and materials required for security measures and site monitoring and sampling are readily available in the area. Numerous vendors would be available for competitive bids.

Cost

The capital cost for this alternative is estimated to be $33,500. The annual operation and maintenance costs are estimated to be $25,200 for soil sampling. The present worth cost of five-year reviews for the site is $43,200. The total present worth, calculated based on a discount rate of seven percent and a 30-year period is $389,400. Data in support of these cost estimates are presented in Appendices A and B.

4.4.3 Alternative S13-3: Capping

4.4.3.1 Description

The major features of this alternative include the construction of an asphalt cap over the soil hotspot at Site 13. The soil hotspot currently covered by gravel encompasses an area of approximately 250 sq. ft. Monitoring well LC13-GW8, which is currently located within the hotspot, would be abandoned in order to facilitate construction of the cap.

The asphalt cap would include a crushed stone layer which would be placed directly on top of the hotspot surface. Prior to construction of the asphalt cap, the hotspot area would be compacted and graded in order to improve the performance of the cap. A 6-inch layer of asphalt, would then be placed over the hotspot area.

Because this alternative does not include contaminant removal, the site will have to be reviewed every five years for a period for 30 years for requirements of CERCLA as amended. These five-year reviews would include the reassessment of human health and environmental risks due to the contaminated soil left on site, using data obtained from the monitoring program.

The surface of the constructed cap would be graded to allow for precipitation to be directed to existing drainage channels surrounding the Site 13 hotspot.

4.4.3.2 Assessment

Overall Protection of Human Health and the Environment

This alternative would meet the remedial response objectives for the Site 13 hotspot soil. The contaminated soils would be covered by an impervious asphalt cap, eliminating the risk of direct contact and inhalation. The cap would prevent precipitation from infiltrating the unsaturated soils, thereby minimizing the transport of contaminants from the unsaturated soils to the groundwater.

Compliance with ARARs

This alternative does not eliminate the source of contamination. It therefore does not satisfy any of the identified chemical-specific ARARs. Location- and action-specific ARARs will be followed where possible and waivers will be obtained as necessary.

Long-Term Effectiveness

This alternative would meet the remedial response objectives. The asphalt cap would prevent direct contact with the contaminated hotspot soils. The cap would also prevent precipitation from infiltrating through the contaminated unsaturated soils, thereby minimizing the transport of contaminants from the unsaturated soils to the groundwater. However, untreated contaminated soils would be left onsite; therefore, the potential for migration of residual contamination exists should the cap fail.

The cap would require continued inspection and maintenance in order to maintain integrity. It may need repair or replacement in the future. In addition, future use of the capped area would be limited.

Reduction of Toxicity, Mobility or Volume

The asphalt cap would not reduce the toxicity or volume of the contaminants in the soil, but would reduce the mobility of contaminants within the unsaturated soils. Over time, through natural attenuation, contaminant concentrations would eventually decline. However, the time to reach acceptable risk levels is unknown.

Short-Term Effectiveness

The short-term risks associated with this alternative include on-site worker safety. During construction of the cap, grading of the existing hotspot surface would be performed. However, as the area is currently covered with gravel, the risks are expected to be minimal. Proper operational procedures and construction techniques will be implemented in order to minimize the risk of on-site accidents. The short-term impacts on the environment would be traffic problems and an increase in noise levels due to the construction activity. However as the area of the cap is small (i.e., approximately 250 square feet), these impacts will be minimal.

Proper dust control measures, such as water spray, would be implemented to further reduce any risks to on-site working and the public during construction of the cap. A soil erosion prevention and sediment control plan would be developed and employed during the remedial activities. The period for implementation of this alternative if estimated to be 9-12 months, including engineering.

Implementability

Technical Feasibility

Preparation of the hotspot area would require the use of standard construction procedures and equipment for grading and compaction. These traditional earthworking operations and equipment are commercially available. Sufficient land is available within close proximity to the Site 13 soil hotspot area for staging and operations.

Administrative Feasibility

Implementation of this alternative would require restriction of site access during the remediation process. Significant long-term management of an inspection and maintenance program to ensure the functional integrity of the cap would be required. Land use restrictions of the capped area would also require enforcement.

Availability of Services and Materials

Adequate space is available for staging and construction operations. Placement of an asphalt cap would utilize common construction equipment, which is readily available through numerous vendors.

Cost

The capital cost for this alternative is estimated to be $26,000. The annual operation and maintenance costs are estimated to be $1,300. The present worth cost of five-year reviews for the site is $43,200. The total present worth, calculated based on a discount rate of seven percent and a 30-year period is $85,300. Data in support of these cost estimates are presented in Appendices A and B.

4.4.4 Alternative S13-4: Excavation/Off-Site Treatment and Disposal

4.4.4.1 Description

This alternative consists of excavation of approximately 55 cubic yards of contaminated soil and transportation of all contaminated materials to an off-site RCRA permitted facility for treatment and disposal or appropriate reuse. The area to be excavated consists of approximately 250 square feet surrounding well LC13-GW8, which would be properly abandoned as part of this alternative. Clean fill would be used to restore excavated areas. The area would then be graded with gravel.

4.4.4.2 Assessment

Overall Protection of Human Health and the Environment

The excavation and removal of contaminated soil from the site would eliminate the potential human health risks and prevent leaching of contaminants into groundwater. This remedial alternative involves off-site treatment which would totally reduce the toxicity, mobility and volume of hazardous contaminants from the Site 13 hotspot. No secondary waste management would be required on site except for decontamination water from the decontamination of equipment and personnel. This alternative would restore the contaminated area and would result in overall protection of human health and the environment.

Compliance with ARARs

Alternative S13-4 will comply with ARARs. Compliance with chemical-specific ARARs is achieved by excavation of contaminated soils and transportation off-site for treatment and disposal. Location-specific ARARs will be satisfied by "Technical Impracticality" reviews as needed. All activities will be conducted in accordance with pertinent action-specific ARARs.

Long-Term Effectiveness

The excavation and removal of contaminated soil from the site would reduce the potential human health risks associated with direct contact with contaminated soils and the leaching of contaminants into groundwater. Excavated soil would be replaced by clean soil. Following remediation, the contaminated area would be restored and the site would not require any further maintenance or monitoring.

Reduction of Toxicity, Mobility or Volume

Excavation and off-site treatment and disposal constitute a treatment which would result in a permanent remedy. Semivolatile organic contaminants in the soil would be treated and disposed of in a controlled off-site landfill or reused appropriately. Hence this treatment alternative would completely eliminate the toxicity, mobility and volume of contaminants at the site.

Short-Term Effectiveness

The potential public health threats to workers and area residents would include direct contact with contaminated soils and inhalation of fugitive dust and organic vapors generated during excavation and soil handling. The area would be secured using a fence and access would be restricted to authorized personnel only. Dust control measures such as wind screens and water sprays would be used to minimize fugitive dust emission resulting from excavation. Air monitoring for particulates and organic vapors would be conducted throughout the site remediation activities.

The risk to workers would be minimized by the use of adequate preventive measures such as enclosed cabs on backhoes and proper personal protection equipment to prevent direct contact with contaminated soil and inhalation of fugitive dust and volatile organics. All site activities would be in accordance with a site-specific health and safety plan. Short-term impacts on the environment resulting from removal of vegetation and destruction of habitat in the soil would be minimal since the hotspot area has minimal vegetation. Impacts would be temporary and would be mitigated by restoring the remediated area. Erosion and sediment control measures such as silt curtains would be provided during excavation activities to control migration of contaminated soil.

The short-term impacts on the environment would be due to an increase in traffic and noise pollution resulting from hauling of excavated soil to off-site treatment facilities and bringing new soil in for fill. Transportation of excavated soil may introduce short-term risks with the possibility of spillage along the transport route. A traffic control plan developed with the assistance of local authorities would be implemented to minimize potential traffic problems.

A total period of two years is estimated for this remedial alternative for design, bidding, selecting a contractor, procurement of off-site treatment and disposal facilities, and remediation of soil.

Implementability

Technical Feasibility

All the components of this remedial alternative are well developed and commercially available. The contaminated soils would have to undergo a series of analyses prior to acceptance for treatment and disposal at the off-site facility. Sufficient land is available at the site for staging, excavation and transportation. Excavation and transportation of contaminated soils to an off-site treatment facility can be performed with no difficulty.

Administrative Feasibility

Implementation of this alternative would require public access restriction to the site during the remediation process. Contractual procurement of off-site treatment and disposal facilities would be required. Coordination with state and local agencies would also be required. The transportation of hazardous waste to an off-site facility would require appropriate permits and coordination with the Department of Transportation (DOT) and local traffic department. Traffic control plans would be required before remediation. The off-site treatment and disposal facilities would have to be in compliance with appropriate permit conditions such as RCRA.

Availability of Services and Materials

There are a number of off-site treatment and disposal facilities which can treat soils contaminated with PCP as found at the Site 13 soil hotspot. Excavation and transportation utilize common construction equipments and should not pose any problems.

Cost

Total capital cost of this alternative is estimated at $30,100. No operation and maintenance is required for this alternative and five-year reviews are not required since contamination would be removed from the site. Detailed supportive data used to derive at these estimates are presented in Appendices A and B.

4.5 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the results of the comparative analysis of remedial alternatives for each of the sites. The comparative analysis is presented qualitatively, identifying substantive differences between each of the alternatives. As with the detailed evaluation of alternatives, the following criteria are used for the comparative analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness
- Reduction of toxicity, mobility or volume
- Short-term effectiveness
- Implementability
- Cost

4.5.1 Comparison of Site 12 Groundwater Alternatives

Overall Protection of Human Health and the Environment

Alternative GW12-1 (No Action) offers the least overall protection of human health and the environment since there is no reduction in the toxicity, mobility or volume of contaminants, except that which occurs over an extended period of time due to natural attenuation of contaminants. There would be no increase in risk of exposure for workers or the community during implementation of the alternative, since there would be no remedial activities; however, the current risks of exposure would not be reduced.

Alternative GW12-2 (Limited Action) provides a slightly higher level of protection of human health, since groundwater use restrictions would be implemented to reduce exposures to contaminated groundwater. However, since no remediation of contamination takes place under this alternative, it is not protective of the environment. After implementation of the alternative, risks would be slightly reduced as long as the administrative restrictions were maintained.

Alternative GW12-3 (Extraction/Pretreatment/Discharge to POTW) would reduce the risk of exposure to contaminated groundwater by extracting, treating and discharging contaminated groundwater. Although it may take many years (e.g., 17 years) for contaminant levels in the groundwater to be reduced to acceptable levels, this alternative would provide long-term protection of human health and the environment. There would be a small increase in risk of exposure to contaminated groundwater for workers during implementation of this alternative. After implementation of the alternative, the risk of exposure to contaminated groundwater would be significantly reduced.

Alternative GW12-4 (*In situ* Biological Treatment) would reduce the risk of exposure to contaminated groundwater by biologically degrading contaminants *in situ*. This alternative would likely be protective of human health and the environment more quickly than Alternative GW12-3, since it could be completed in approximately 3 years, versus approximately 17 years for Alternative GW12-3. However, this alternative would not address inorganic constituents in the groundwater. This alternative would also result in an increase in risk of exposure for workers, approximately equal to that in Alternative GW12-3, during installation. After implementation of the alternative, the risk of exposure to contaminated groundwater would be significantly reduced.

Compliance with ARARs

Alternatives GW12-1 and GW12-2 would not comply with chemical-specific ARARs. Existing contaminant concentrations in the groundwater, which already exceed chemical-specific ARARs, would continue to exceed these levels. Monitoring and other activities associated with these alternatives would be implemented in such a manner so as to comply with location- and action-specific ARARs, if any are triggered by these activities.

Alternatives GW12-3 and GW12-4 would not initially comply with chemical-specific ARARs, since the groundwater contaminant concentrations would not be immediately reduced by implementation of this alternative. However, by treating the groundwater (either after extraction or *in situ*), it is expected that these alternatives would eventually result in compliance with chemical-specific ARARs. However, Alternative GW12-4 would not comply with chemical-specific ARARs for inorganic constituents. Through proper design and implementation of these alternatives, compliance with location- and action-specific ARARs would be achieved.

Long-Term Effectiveness

Alternative GW12-1 does not remove or contain the groundwater contamination. Therefore, the current risks from exposure to contaminated groundwater would remain, and future risk may even be greater as the contaminant plume continues to migrate. There is the potential that additional remedial activities might be necessary in the future.

Alternative GW12-2 also does not remove or contain the groundwater contamination, but does provide some reduction in the risk of exposure to contaminated groundwater via use restrictions, provided these restrictions are adequately maintained and enforced. Long-term monitoring would be required under this alternative, and there is the potential that additional remedial activities might be necessary in the future.

Alternatives GW12-3 and GW12-4 both provide treatment of the contaminated groundwater, significantly reducing the off-site migration of contaminated groundwater and ultimately reducing the risk of exposure to contaminated groundwater. Long-term monitoring would be required under these alternatives to ensure that the cleanup goals are achieved and that contaminant levels do not increase due to an undetected source. These alternatives provide a permanent remedy for the contaminated groundwater; upon conclusion of these remedial actions, no further remediation should be required.

Reduction of Toxicity, Mobility or Volume

Alternatives GW12-1 and GW12-2 provide no removal or treatment of contaminated groundwater, and therefore provide no reduction in toxicity, mobility or volume of contaminated materials.

Alternatives GW12-3 and GW12-4, would reduce the toxicity, mobility and volume of contaminated groundwater via extraction and/or treatment. Upon completion of either of these alternatives, groundwater contaminant levels would be reduced to levels that comply with all chemical-specific ARARs.

Short-Term Effectiveness

Alternative GW12-1 involves no remedial activities and Alternative GW12-2 includes only monitoring and administrative actions; therefore, the implementation of these alternatives results in minimal short-term risks to workers or the community. Implementation of alternative GW12-1 would be immediate, while implementation of Alternative GW12-2 would require approximately 6 months.

Alternatives GW12-3 and GW12-4 include a moderate level of construction activities for installation of wells and any required aboveground treatment system. Workers would be subject to a slightly increased risk of exposure to contaminants during installation of wells and operation of the treatment system. These risks would be minimized through the implementation of a site-specific health and safety plan (e.g., use of personal protective equipment) and appropriate engineering controls (e.g., dust suppression). Implementation of both of these alternatives could be completed in approximately 1 year; however, operation of the systems is expected to continue for approximately 17 years for Alternative GW12-3, and for approximately 3 years for Alternative GW12-4.

Implementability

Alternative GW12-1 would be easily implemented, as it does not include any remedial activities. Administratively, Alternative GW12-2 would be somewhat more difficult to implement, since it deals with water use restrictions. Alternative GW12-2 includes long-term monitoring.

Alternative GW12-3 would be more difficult to implement than Alternatives GW12-1 or GW12-2, since it would involve on-site construction. However, this alternative could be implemented using readily available technologies. Administratively, Alternative GW12-3 would be difficult to implement, since it would require extensive negotiations with HRSD and coordination for off-site disposal of sludges. This alternative would require long-term monitoring.

Alternative GW12-4 would be moderately difficult to implement; on-site construction activities would be minor, consisting of well installation and construction or mobilization of a small treatment system. However, *in situ* treatment technologies are still considered innovative. In addition, effective operation requires intensive monitoring and assessment. Administratively, coordination with local authorities and other agencies may be required for vapor discharges; however, this alternative does not involve any off-site transportation of hazardous materials. This alternative would require long-term monitoring.

Cost

The net present value (NPV) of the groundwater remedial alternatives for Site 12 range from $43,200 to $1,094,700 based on a discount rate of 7%. Alternatives GW12-1 and GW12-2 are the least expensive to implement, with NPVs of $43,200 and $326,000, respectively, but provide no treatment of the contaminated groundwater. Alternatives GW12-3 and GW12-4 are significantly more expensive, with NPVs of $984,400 and $1,094,700, respectively, and both provide treatment of contaminated groundwater.

4.5.2 Comparison of Site 13 Groundwater Alternatives

Overall Protection of Human Health and the Environment

Alternative GW13-1 (No Action) offers the least overall protection of human health and the environment since there is no reduction in the toxicity, mobility or volume of contaminants, except that which occurs over an extended period of time due to natural attenuation of contaminants. There would be no increase in risk of exposure for workers or the community during implementation of the alternative, since there would be no remedial activities; however, the current risks of exposure would not be reduced.

Alternative GW13-2 (Limited Action) provides a slightly higher level of protection of human health, since groundwater use restrictions would be implemented to reduce exposures to contaminated groundwater. However, since no remediation of contamination takes place under this alternative, it is not protective of the environment. After implementation of the alternative, risks would be slightly reduced as long as the administrative restrictions were maintained.

Alternative GW13-3 (Extraction/Pretreatment/Discharge to POTW) would reduce the risk of exposure to contaminated groundwater by extracting, treating and discharging contaminated groundwater. Although it may take many years (e.g., 20 years) for contaminant levels in the groundwater to be reduced to acceptable levels, this alternative would not provide long-term protection of human health and the environment. There would be a small increase in risk of exposure to contaminated groundwater for workers during implementation of this alternative. After implementation of the alternative, the risk of exposure to contaminated groundwater would be significantly reduced.

Alternative GW13-4 (*In situ* Biological Treatment) would reduce the risk of exposure to contaminated groundwater by biologically degrading contaminants *in situ*. This alternative would likely be protective of human health and the environment more quickly than Alternative GW13-3, since it could be completed in approximately 3 years, versus approximately 20 years for Alternative GW13-3. However, this alternative would not address inorganic constituents in the groundwater. This alternative would also result in an increase in risk of exposure for workers during installation, approximately equal to that in Alternative GW13-3. After implementation of the alternative, the risk of exposure to contaminated groundwater would be significantly reduced.

Compliance with ARARs

Alternatives GW13-1 and GW13-2 would not comply with chemical-specific ARARs. Existing contaminant concentrations in the groundwater, which already exceed chemical-specific ARARs, would continue to exceed these levels. Monitoring and other activities associated with these alternatives would be implemented in such a manner so as to comply with location- and action-specific ARARs, if any are triggered by these activities.

Alternatives GW13-3 and GW13-4 would not initially comply with chemical-specific ARARs, since the groundwater contaminant concentrations would not be immediately reduced by implementation of this alternative. However, by treating the groundwater (either after extraction or *in situ*), it is expected that these alternatives would eventually result in compliance with chemical-specific ARARs, although Alternative GW13-4 would not comply with chemical specific ARARs for inorganic compounds. Through proper design and implementation of these alternative, compliance with location- and action-specific ARARs would be achieved.

Long-Term Effectiveness

Alternative GW13-1 does not remove or contain the groundwater contamination. Therefore, the current risks from exposure to contaminated groundwater would remain, and future risk may even be greater as the contaminant plume continues to migrate. Long-term monitoring and assessment would be required under this alternative, and there is the potential that additional remedial activities might be necessary in the future.

Alternative GW13-2 also does not remove or contain the groundwater contamination, but does provide some reduction in the risk of exposure to contaminated groundwater via use restrictions, provided these restrictions are adequately maintained and enforced. There is the potential that additional remedial activities might be necessary in the future.

Alternatives GW13-3 and GW13-4 both provide treatment of the contaminated groundwater, significantly reducing the off-site migration of contaminated groundwater and ultimately reducing the risk of exposure to contaminated groundwater. Long-term monitoring would be required under these alternatives to ensure that the cleanup goals are achieved and that contaminant levels do not increase due to an undetected source. These alternatives provide a permanent remedy for the contaminated groundwater; upon conclusion of these remedial actions, no further remediation should be required.

Reduction of Toxicity, Mobility or Volume

Alternatives GW13-1 and GW13-2 provide no removal or treatment of contaminated groundwater, and therefore provide no reduction in toxicity, mobility or volume of contaminated materials.

Alternatives GW13-3 and GW13-4 would reduce the toxicity, mobility and volume of contaminated groundwater via extraction and/or treatment.

Short-Term Effectiveness

Alternative GW13-1 involves no remedial activities and Alternative GW13-2 includes only monitoring and administrative actions; therefore, the implementation of these alternatives results in minimal short-term risks to workers or the community. Implementation of Alternative GW13-1 would be immediate, while implementation of Alternative GW13-2 would require approximately 6 months.

Alternatives GW13-3 and GW13-4 include a moderate level of construction activities for installation of wells and any required aboveground treatment system. Workers would be subject to an slightly increased risk of exposure to contaminants during installation of wells and operation of the treatment system. These risks would be minimized through the implementation of a site-specific health and safety plan (e.g., use of personal protective equipment) and appropriate engineering controls (e.g., dust suppression). Implementation of both of these alternatives could be completed in approximately 1 year; however, operation of the systems is expected to continue for approximately 20 years for Alternative GW13-3, and for approximately 3 years for Alternative GW13-4.

Implementability

Alternative GW13-1 would be easily implemented, as it does not include any remedial activities. Administratively, Alternative GW13-2 would be somewhat more difficult to implement, since it deals with water use restrictions. Alternative GW13-2 includes long-term monitoring.

Alternative GW13-3 would be more difficult to implement than Alternatives GW13-1 or GW13-2, since it would involve on-site construction. However, this alternative could be implemented using readily available technologies. Administratively, Alternative GW13-3 would be difficult to implement, since it would require extensive negotiations with HRSD and coordination for off-site disposal of sludges. This alternative would require long-term monitoring.

Alternative GW13-4 would be moderately difficult to implement; on-site construction activities would be minor, consisting of well installation and construction or mobilization of a small treatment system. However, *in situ* treatment technologies are still considered innovative. In addition, effective operation requires intensive monitoring and assessment. Administratively, coordination with local authorities and other agencies may be required for vapor discharges; however, this alternative does not involve any off-site transportation of hazardous materials. This alternative would require long-term monitoring.

Cost

The net present value (NPV) of the remedial alternatives for Site 13 range from $43,200 to $1,048,100 based on a discount rate of 7%. Alternatives GW13-1 and GW13-2 are the least expensive to implement, with NPVs of $43,200 and $326,000, respectively, but provide no treatment of the contaminated groundwater. Alternatives GW13-3 and GW13-4 are significantly more expensive, with NPVs of $1,048,100 and $897,100, respectively, and both provide treatment of contaminated groundwater.

4.5.3 Comparison of Site 13 Soil Hotspot Alternatives

Overall Protection of Human Health and the Environment

Alternative S13-1 (No Action) offers the least overall protection of human health and the environment since there is no reduction in the toxicity, mobility or volume of contaminants, except that which occurs over an extended period of time due to natural attenuation of contaminants. There would be no increase in risk of exposure for workers or the community during implementation of the alternative, since there would be no remedial activities; however, the current risks of exposure to contaminated soil would not be reduced.

Alternative S13-2 (Limited Action) provides a higher level of protection of human health, since access restrictions would be implemented to reduce exposures to contaminated soil; however, since no remediation of contamination takes place under this alternative, it is not protective of the environment. There would be only a slight increase in risk of exposure for workers and the community during implementation of this alternative due to minor disturbances to the site during installation of access restrictions. After implementation of the alternative, risks would be slightly reduced as long as the administrative and physical restrictions were maintained.

Alternative S13-3 (Capping) would reduce the risk of exposure to contaminated soils. However, since contamination is not removed, this alternative would not provide long-term protection of human health and the environment. There would be a small increase in risk of exposure for workers and the community during implementation of this alternative due to disturbances to the site during installation of the cap. After implementation of the alternative, the risk of exposure to contaminated soils would be significantly reduced. Land use restrictions would be implemented to further reduce the risk of exposures and to ensure cap integrity.

Alternative S13-4 (Excavation/Off-Site Treatment and Disposal) would be protective of human health and the environment. This alternative would completely eliminate the identified contaminated soil by excavation and off-site treatment and disposal. Alternative S13-4 would result in increased risk of exposure for workers and the community due to disturbance of contaminated soil during excavation and transportation of the contaminated soil off site. Upon completion of this alternative, the risk of exposure to contaminated soil would be completely eliminated.

Compliance with ARARs

Alternatives S13-1 and S13-2 would not comply with chemical-specific ARARs. Existing contaminant concentrations in the soil exceed chemical-specific ARARs and would not be reduced through the implementation of either of these alternatives. Monitoring and other activities associated with these alternatives would be implemented in such a manner as to comply with location- and action-specific ARARs, if any are triggered by these activities.

Alternative S13-3 would not comply with chemical-specific ARARs, since capping does not eliminate the contaminants in the soil. Monitoring and other activities associated with this alternative would be implemented in such a manner as to comply with location- and action-specific ARARs, if any are triggered by these activities.

Alternative S13-4 would comply with chemical-specific ARARs, since all soils exceeding ARAR contaminant levels would be excavated and disposed of off site. Additional activities associated with this alternative would be implemented in such a manner as to comply with location- and action-specific ARARs, if any are triggered by these activities.

Long-Term Effectiveness

Alternative S13-1 does not remove or contain the source of contamination. Therefore, the current risks from exposure to contaminated soil would remain. There is the potential that additional remedial activities might be necessary in the future.

Alternative S13-2 also does not remove or contain the source of contamination, but does provide some reduction in the risk of exposure to contaminated soil via access restrictions, provided these restrictions are adequately maintained and enforced. Long-term monitoring would be required under this alternative, and there is the potential that additional remedial activities might be necessary in the future.

Alternative S13-3 provides containment of the contaminated source area, significantly reducing the risk of exposure to contaminated soil and reducing migration of contaminants from the source area to groundwater. Long-term maintenance would be required under this alternative to ensure the integrity of the cap. It is possible that the cap may not prevent migration of contamination from the source area to the groundwater, and that additional remedial activities could be necessary in the future.

Alternative S13-4 provides removal of the contaminated soils. This alternative provides a permanent remedy, in that contaminated soils removed from the site would not pose any future risk and would not be subject to any further remedial action in the future. No long-term monitoring or maintenance would be required.

Reduction of Toxicity, Mobility or Volume

Alternatives S13-1 and S13-2 provide no removal or treatment of contaminated soils, and therefore provide no reduction in toxicity, mobility or volume of contaminated materials.

The cap that would be installed in Alternative S13-3, if properly maintained, should prevent exposures to contaminated soil and reduce the migration of contaminants from the soil to the groundwater. However, capping provides no reduction in toxicity or volume.

Alternative S13-4 provides a reduction in toxicity, mobility and volume of contaminated soil by excavation and off-site treatment and disposal of contaminated media. Contaminated soil removed from the site would no longer pose any risk of exposure or further contamination of the groundwater.

Short-Term Effectiveness

Alternative S13-1 involves no remedial activities, and therefore results in no increase in short-term risks to workers or the community. Implementation of this alternative would be immediate.

Alternative S13-2 includes administrative actions and minimal construction activities (e.g. fence construction). Workers and the nearby community would be subject to a slightly increased risk of exposure to contaminants due to disturbance of contaminated soil during these activities. These risks would be minimized through the implementation of a site-specific health and safety plan and appropriate engineering controls (e.g. dust suppression). Implementation of this alternative could be completed in approximately 6 months.

Alternative S13-3 includes construction activities for placement of a cap over the source area. Workers and the nearby community would be subject to an increased risk of exposure to contaminants due to disturbance of contaminated soil (e.g. grading) during these activities. These risks would be minimized through the implementation of a site-specific health and safety plan (e.g., use of personal protective equipment) and appropriate engineering controls (e.g., dust suppression). Implementation of this alternative could be completed in approximately 1 year.

Alternative S13-4 includes the most intensive construction activities, including excavation and off-site transportation of contaminated soil. Workers and the nearby community would be subject to a significant increase in the risk of exposure to contaminants due to disturbance of contaminated soil during excavation and transportation of contaminated materials for off-site treatment (if necessary) and disposal. These risks would be mitigated to the maximum extent possible by implementation of a site-specific health and safety plan, a site-specific traffic control plan and appropriate engineering controls (e.g. dust suppression). This alternative could be completed in approximately 2 years.

Implementability

Alternative S13-1 would be easily implemented, as it does not include any remedial activities. Alternative S13-2 would also be relatively easy to implement, since it includes only minor construction activities (e.g., fence) and would not require a significant administrative effort.

Technically, Alternative S13-3 would be slightly more difficult to implement than Alternatives S13-1 or S13-2, since in does involve on-site construction. However, capping is a readily available and well-developed technology that could be completed using conventional construction techniques. Administratively, this alternative would be relatively easy to implement. Long-term maintenance of the cap would be required.

Technically, Alternative S13-4 would be relatively easy to implement, since it involves excavation of soil which is a readily available and well-developed technology that could be completed using conventional construction techniques. Off-site RCRA storage, treatment and disposal facilities are available for treatment and disposal of contaminated soil. Administratively, this alternative would be moderately difficult to implement, since it would require coordination with the local authorities and other agencies for transportation, treatment and disposal of hazardous materials.

Cost

The net present value (NPV) of the soil remedial alternatives for Site 13 range from $30,100 to $389,400 based on a discount rate of 7%. Alternative S13-4 is the least expensive to implement, with an NPV of $30,100 and provides total removal of the source area. Alternative S13-1 is slightly more expensive, with an NPV of $43,200, and provides no containment or treatment of contaminated soil. Alternative S13-3 is more expensive, with an NPV of $85,300, and provides containment of the contaminated soil, but no treatment. Alternative S13-2 is the most expensive alternative, with an NPV of $389,400, and provides only administrative controls and access restrictions.

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APPENDIX A

LIST OF MAJOR FACILITIES AND CONSTRUCTION COMPONENTS FOR REMEDIAL ALTERNATIVES

TABLE A-1
ALTERNATIVE GW12-1: NO ACTION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
No Additional Action Required		

TABLE A-2
ALTERNATIVE GW12-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES[1]	DESCRIPTION
I. PUBLIC AWARENESS PROGRAM	LS	Hold two public meetings to describe risks from groundwater, and prepare technical handouts for residents.
II. WELL PERMIT RESTRICTIONS	LS	Establish appropriate requirements for new wells and periodic testings of all existing and new wells.

(1) LS = Lump Sum

TABLE A-3 (Sheet 1 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SITE PREPARATION		
1. Security Fence	100 lf	8 ft high chain link fence with triple-strand barbed wire top.
2. Warning Signs	2	4 ft x 3 ft PVC signs.
II. SUPPORT FACILITIES		
1. Office Trailers	1	Office trailer (30 ft L x 7.5 W x 7 ft H)
2. Decontamination Trailer	1	Health and safety trailer with shower facility (30 ft L x 7.5 ft W x 7 ft H)
III. GROUNDWATER EXTRACTION		
1. Extraction Wells	2	Stainless steel 6" diameter wells with 10 ft stainless steel screen.
2. Pumps	2	Submersible pump 15 gpm each, TDH 120 ft.
3. Piping	200 ft	1 inch diameter pipe buried below ground.
IV. COLLECTION		
1. Collection Tank	1	300 gallon groundwater storage.
2. Pumps	2	30 gpm each centrifugal pump (one operating, one standby), 30 ft TDH, stainless steel.
V. FILTRATION SYSTEM		
1. Dual media pressure filters	2	1.5 ft diameter by 6 ft high dual media filter complete with backwash pump and automatic controls (one operating, one standby).
2. Process piping	50 ft.	1 inch diameter pipe.

TABLE A-3 (Sheet 2 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
VI. SLUDGE HANDLING SYSTEM		
1. Sludge pumps	2	0.5 gpm each (one operating, one standby), carbon steel diaphragm pump.
2. Filter press	1	0.5 gpm, suitable for intermittent operation.
3. Filtrate pumps	2	0.5 gpm each (one operating, one standby), carbon steel.
VII. TREATED WATER DISPOSAL		
1. Treated water tank	1	300 gallon groundwater storage tank.
2. Discharge pipeline	1000 ft	1 inch diameter, PVC pipe
3. Discharge pumps	2	Discharge pumps, 30 gpm each, centrifugal pump.
VIII. BUILDING	LS	For above treatment facility.
IX. ELECTRICAL	LS	For above treatment facility.
X. INSTRUMENTATION AND CONTROLS	LS	For above treatment facility.
XI. PROCESS WATER SUPPLY	LS	For above treatment facility.
XII. FOUNDATIONS AND PADS	LS	For above treatment facility.
XIII. HEALTH AND SAFETY	LS	Health and safety equipment and monitoring.
XIV. MOBILIZATION/DEMOBILIZATION	LS	Mobilization, set up and demobilization of labor and equipment.

TABLE A-4
ALTERNATIVE GW12-4: *IN SITU* BIOLOGICAL TREATMENT

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION		ESTIMATED QUANTITIES	DESCRIPTION
I.	SITE PREPARATION		
1.	Security Fence	100 lf	8 ft high chain link fence with triple-strand barbed wire top.
2.	Warning Signs	2	4 ft x 3 ft PVC signs
II.	SUPPORT FACILITIES		
1.	Office trailer	1	30 ft x 7.5 ft x 7 ft office trailer
2.	Decontamination	1	Health and safety trailer with shower facility.
III.	AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM		
1.	Sparge wells	50	PVC wells for air injection
2.	Vent wells	50	PVC wells for soil vapor extraction
3.	Compressor	1	Compressor to supply air for sparging
4.	Vacuum Blower	1	Vacuum blower for soil vapor extraction
5.	Vapor Phase Carbon Treatment System	1	Reduce vapor concentrations to levels acceptable for discharge to atmosphere
6.	Process piping	2,000 ft	PVC pipe to connect wells and process units
7.	Pilot test	LS	Pilot test to determine required flow rates, well spacing, treatment requirements, etc.
IV.	BUILDING	LS	Building to house treatment system and controls
V.	ELECTRICAL	LS	Wiring for treatment system
VI.	INSTRUMENTATION AND CONTROLS	LS	I&C for treatment system
VII.	FOUNDATIONS AND PADS	LS	Foundations/pads for treatment system
VIII.	HEALTH AND SAFETY	LS	Health and safety equipment and monitoring
IX.	MOBILIZATION/DEMOBILIZATION	LS	Mobilization, set-up, demobilization of equipment and personnel.

TABLE A-5
ALTERNATIVE GW13-1: NO ACTION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
No Additional Action Required		

TABLE A-6
ALTERNATIVE GW13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES(1)	DESCRIPTION
I. PUBLIC AWARENESS PROGRAM	LS	Hold two public meetings to describe risks from groundwater, and prepare technical handouts for residents.
II. WELL PERMIT RESTRICTIONS	LS	Establish appropriate requirements for new wells and periodic testings of all existing and new wells.

(1) LS = Lump Sum

TABLE A-7 (Sheet 1 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SITE PREPARATION		
1. Security Fence	100 lf	8 ft high chain link fence with triple-strand barbed wire top.
2. Warning Signs	2	4 ft x 3 ft PVC signs.
II. SUPPORT FACILITIES		
1. Office Trailers	1	Office trailer (30 ft L x 7.5 W x 7 ft H)
2. Decontamination Trailer	1	Health and safety trailer with shower facility (30 ft L x 7.5 ft W x 7 ft H)
III. GROUNDWATER EXTRACTION		
1. Extraction Wells	3	Stainless steel 6" diameter wells with 10 ft stainless steel screen.
2. Pumps	3	Submersible pump 15 gpm each, TDH 120 ft.
3. Piping	200 ft	1 inch diameter pipe buried below ground.
IV. COLLECTION		
1. Collection Tank	1	300 gallon groundwater storage.
2. Pumps	2	30 gpm each centrifugal pump (one operating, one standby), 30 ft TDH, stainless steel.
V. FILTRATION SYSTEM		
1. Dual media pressure filters	2	1.5 ft diameter by 6 ft high dual media filter complete with backwash pump and automatic controls (one operating, one standby).
2. Process piping	50 ft.	1 inch diameter pipe.

TABLE A-7 (Sheet 2 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
VI. SLUDGE HANDLING SYSTEM		
1. Sludge pumps	2	0.5 gpm each (one operating, one standby), carbon steel diaphragm pump.
2. Filter press	1	0.5 gpm, suitable for intermittent operation.
3. Filtrate pumps	2	0.5 gpm each (one operating, one standby), carbon steel.
VII. TREATED WATER DISPOSAL		
1. Treated water tank	1	300 gallon groundwater storage tank.
2. Discharge pipeline	1000 ft	1 inch diameter, PVC pipe
3. Discharge pumps	2	Discharge pumps, 30 gpm each, centrifugal pump.
VIII. BUILDING	LS	For above treatment facility.
IX. ELECTRICAL	LS	For above treatment facility.
X. INSTRUMENTATION AND CONTROLS	LS	For above treatment facility.
XI. PROCESS WATER SUPPLY	LS	For above treatment facility.
XII. FOUNDATIONS AND PADS	LS	For above treatment facility.
XIII. HEALTH AND SAFETY	LS	Health and safety equipment and monitoring.
XIV. MOBILIZATION/DEMOBILIZATION	LS	Mobilization, set up and demobilization of labor and equipment.

TABLE A-8
ALTERNATIVE GW13-4: *IN SITU* BIOLOGICAL TREATMENT

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SITE PREPARATION		
1. Security Fence	100 lf	8 ft high chain link fence with triple-strand barbed wire top.
2. Warning Signs	2	4 ft x 3 ft PVC signs
II. SUPPORT FACILITIES		
1. Office trailer	1	30 ft x 7.5 ft x 7 ft office trailer
2. Decontamination	1	Health and safety trailer with shower facility.
III. AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM		
1. Sparge wells	20	PVC wells for air injection
2. Vent wells	20	PVC wells for soil vapor extraction
3. Compressor	1	Compressor to supply air for sparging
4. Vacuum Blower	1	Vacuum blower for soil vapor extraction
5. Vapor Phase Carbon Treatment System	1	Reduce vapor concentrations to levels acceptable for discharge to atmosphere
6. Process piping	1,000 ft	PVC pipe to connect wells and process units
7. Pilot test	LS	Pilot test to determine required flow rates, well spacing, treatment requirements, etc.
IV. BUILDING	LS	Building to house treatment system and controls
V. ELECTRICAL	LS	Wiring for treatment system
VI. INSTRUMENTATION AND CONTROLS	LS	I&C for treatment system
VII. FOUNDATIONS AND PADS	LS	Foundations/pads for treatment system
VIII. HEALTH AND SAFETY	LS	Health and safety equipment and monitoring
IX. MOBILIZATION/DEMOBILIZATION	LS	Mobilization, set-up, demobilization of equipment and personnel.

TABLE A-9
ALTERNATIVE S13-1: NO ACTION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
No Additional Action Required		

TABLE A-10
ALTERNATIVE S13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION		ESTIMATED QUANTITIES[1]	DESCRIPTION
I.	PUBLIC AWARENESS PROGRAM	LS	Hold two public meeetings to describe risks from the contaminated soil, and prepare technical handouts for residences.
II.	LAND USE RESTRICTIONS	LS	Establish land use restriction in the contaminated soil area.
III.	SECURITY		
	1. Fence	100 lf	8 ft high chain link fence with triple-strand barbed wire top.
	2. Warning Signs	2	4 ft x 3 ft PVC signs.

(1) LS = Lump Sum

TABLE A-11
ALTERNATIVE S13-3: CAPPING

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION			ESTIMATED QUANTITIES	DESCRIPTION
I.	WELL ABANDONMENT		LS	Abandon well LC13-GW8 in accordance with applicable requirements.
II.	ASPHALT CAP		250 sf	
	1.	Gravel Base	30 sy	6-inch thick gravel base placed over compacted surface
	2.	Asphalt Layer	250 sf	6-inch thick asphalt layer on top of the gravel
III.	GRADE CAP SURFACE		250 sf	Grade asphalt cap for proper drainage.
IV.	LAND USE RESTRICTIONS		LS	Implement land use restrictions to ensure future integrity of the cap.
V.	HEALTH AND SAFETY		LS	Health and safety equipment and monitoring.

TABLE A-12
ALTERNATIVE S13-4: EXCAVATION/OFF-SITE TREATMENT AND DISPOSAL

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

	FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I.	WELL ABANDONMENT	LS	Abandon well LC13-GW8 in accordance with applicable requirements.
II.	CONTAMINATED SOIL EXCAVATION	55 cy	Excavation of contaminated soil and sediments.
III.	TRANSPORTATION	55 cy	Transport contaminated soil to off-site RCRA permitted facility.
IV.	OFF-SITE TREATMENT AND DISPOSAL	1,300 cy	Off-site treatment and disposal at RCRA permitted facility including testing, monitoring and secondary waste management.
V.	CLEAN FILL	55 cy	Clean fill plus 6 inch gravel layer soil in excavated areas.
VI.	HEALTH AND SAFETY	LS	Health and safety equipment and monitoring.

APPENDIX B

CAPITAL AND OPERATION AND MAINTENANCE COST ESTIMATES

TABLE B-1
ALTERNATIVE GW-1: NO ACTION

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction	Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
No Additional Action Required						

TABLE B-2
ALTERNATIVE GW12-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

CAPITAL COST ESTIMATES (1996 DOLLARS)

Facility/Construction	Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I. PUBLIC AWARENESS PROGRAM	LS	Included in installation		10,000	10,000	10,000
II. WELL PERMIT RESTRICTIONS	LS	Included in installation		12,000	12,000	12,000

Total Direct Construction Cost (TDCC)	22,000
Contingency @ 20% of TDCC	4,400
Engineering @ 10% of TDCC	2,200
Legal and Administrative @ 5% of TDCC	1,100
Total Construction Cost	29,700

*All numbers are rounded to the nearest hundred.

TABLE B-3 (Sheet 1 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost		Installation Cost		Direct Construction Cost*
			Unit	Total	Unit	Total	
I.	SITE PREPARATION						
	1. Security Fence	100 lf	18	1,800	8	800	2,600
	2. Warning Signs	2	80	160	20	40	200
II.	SUPPORT FACILITIES						
	1. Office Trailer	1	15,000	15,000	INCLUDED		15,000
	2. Decontamination Trailer	1	40,000	40,000	INCLUDED		40,000
III.	GROUNDWATER EXTRACTION						
	1. Extraction Wells	2	1,000	2,000	1,000	2,000	4,000
	2. Pumps	2	1,500	3,000	500	1,000	4,000
	3. Piping	200 ft	1	200	5	1,000	1,200
IV.	COLLECTION						
	1. Collection Tank	1	3,000	3,000	300	300	3,300
	2. Pumps	2	1,500	3,000	500	1,000	4,000
V.	FILTRATION SYSTEM						
	1. Dual media pressure filters	2	10,000	20,000	2,000	4,000	24,000
	2. Process piping	100 ft.	1	100	5	500	600
VI.	SLUDGE HANDLING SYSTEM						
	1. Sludge pumps	2	750	1,500	500	1,000	2,500
	2. Filter press	1	20,000	20,000	2,000	2,000	22,000
	3. Filtrate pumps	2	1,500	3,000	500	1,000	4,000

TABLE B-3 (Sheet 2 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
VII.	TREATED WATER DISPOSAL						
	1. Treated water tank	1	3,000	3,000	300	300	3,300
	2. Discharge pipeline	1,000 ft	1	1,000	5	5,000	6,000
	3. Discharge Pumps	2	1,500	3,000	500	1,000	4,000
VIII.	BUILDING	LS	10,000	10,000	INCLUDED		10,000
IX.	ELECTRICAL	LS	INCLUDED		20,000	20,000	20,000
X.	INSTRUMENTATION AND CONTROLS	LS	INCLUDED		10,000	10,000	10,000
XI.	PROCESS WATER SUPPLY	LS	INCLUDED		1,000	1,000	1,000
XII.	FOUNDATIONS AND PADS	LS	2,000	2,000	4,000	4,000	6,000
XIII.	HEALTH AND SAFETY	LS	INCLUDED		10,000	10,000	10,000
XIV.	MOBILIZATION/DEMOBILIZATION	LS	INCLUDED		20,000	20,000	20,000

Total Direct Construction Cost (TDCC)	217,700
Contingency @ 20% of TDCC	43,500
Engineering @ 10% of TDCC	21,800
Legal & Administrative @ 5% of TDCC	10,900
Total Construction Cost	293,900

TABLE B-4 (Sheet 1 of 2)
ALTERNATIVE GW12-4: *IN SITU* BIOLOGICAL TREATMENT

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I.	SITE PREPARATION						
	1. Security Fence	100 lf	18	1,800	8	800	2,600
	2. Warning Signs	2	80	160	20	40	200
II.	SUPPORT FACILITIES						
	1. Office Trailer	1	15,000	15,000	INCLUDED		15,000
	2. Decontamination Trailer	1	40,000	40,000	INCLUDED		40,000
III.	AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM						
	1. Sparge wells	50	1,000	50,000	1,000	50,000	100,000
	2. Vent wells	50	1,000	50,000	1,000	50,000	100,000
	3. Compressor	1	15,000	15,000	1,500	1,500	16,500
	4. Vacuum Blower	1	20,000	20,000	2,000	2,000	22,000
	5. Vapor Phase Carbon Treatment System	1	9,000	9,000	1,000	1,000	10,000
	6. Process piping	2,000 ft	1	2,000	5	10,000	12,000
	7. Pilot test	LS	INCLUDED		20,000	20,000	20,000
IV.	BUILDING	LS	10,000	10,000	INCLUDED		10,000
V.	ELECTRICAL	LS	INCLUDED		50,000	50,000	50,000
VI.	INSTRUMENTATION AND CONTROLS	LS	INCLUDED		25,000	25,000	25,000
VII.	FOUNDATIONS AND PADS	LS	2,000	3,000	4,000	4,000	6,000

TABLE B-4 (Sheet 2 of 2)
ALTERNATIVE GW12-4: IN SITU BIOLOGICAL TREATMENT

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
VIII.	HEALTH AND SAFETY	LS	INCLUDED		10,000	10,000	10,000
IX.	MOBILIZATION/DEMOBILIZATION	LS	INCLUDED		20,000	20,000	20,000

Total Direct Construction Cost (TDCC)	459,300
Contingency @ 20% of TDCC	91,900
Engineering @ 10% of TDCC	45,900
Legal & Administrative @ 5% of TDCC	23,000
Total Construction Cost	620,100

TABLE B-5
ALTERNATIVE GW13-1: NO ACTION

CAPITAL COST ESTIMATES (1996 DOLLARS)

Facility/Construction	Estimated Quantities	Material Cost		Installation Cost		Direct Construction Cost*
		Unit	Total	Unit	Total	
No Additional Action Required						

TABLE B-6
ALTERNATIVE GW13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

CAPITAL COST ESTIMATES (1996 DOLLARS)

Facility/Construction	Estimated Quantities	Material Cost		Installation Cost		Direct Construction Cost*
		Unit	Total	Unit	Total	
I. PUBLIC AWARENESS PROGRAM	LS	Included in installation		10,000	10,000	10,000
II. WELL PERMIT RESTRICTIONS	LS	Included in installation		12,000	12,000	12,000

Total Direct Construction Cost (TDCC)	22,000
Contingency @ 20% of TDCC	4,400
Engineering @ 10% of TDCC	2,200
Legal and Administrative @ 5% of TDCC	1,100
Total Construction Cost	29,700

*All numbers are rounded to the nearest hundred.

TABLE B-7 (Sheet 1 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I.	SITE PREPARATION						
	1. Security Fence	100 lf	18	1,800	8	800	2,600
	2. Warning Signs	2	80	160	20	40	200
II.	SUPPORT FACILITIES						
	1. Office Trailer	1	15,000	15,000	INCLUDED		15,000
	2. Decontamination Trailer	1	40,000	40,000	INCLUDED		40,000
III.	GROUNDWATER EXTRACTION						
	1. Extraction Wells	3	1,000	3,000	1,000	3,000	6,000
	2. Pumps	3	1,500	4,500	500	1,500	6,000
	3. Piping	200 ft	1	200	5	1,000	1,200
IV.	COLLECTION						
	1. Collection Tank	1	3,000	3,000	300	300	3,300
	2. Pumps	2	1,500	3,000	500	1,000	4,000
V.	FILTRATION SYSTEM						
	1. Dual media pressure filters	2	10,000	20,000	2,000	4,000	24,000
	2. Process piping	100 ft.	1	100	5	500	600
VI.	SLUDGE HANDLING SYSTEM						
	1. Sludge pumps	2	750	1,500	500	1,000	2,500
	2. Filter press	1	20,000	20,000	2,000	2,000	22,000
	3. Filtrate pumps	2	1,500	3,000	500	1,000	4,000

TABLE B-7 (Sheet 2 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
VII.	TREATED WATER DISPOSAL						
	1. Treated water tank	1	3,000	3,000	300	300	3,300
	2. Discharge pipeline	1,000 ft	1	1,000	5	5,000	6,000
	3. Discharge Pumps	2	1,500	3,000	500	1,000	4,000
VIII.	BUILDING	LS	10,000	10,000	INCLUDED		10,000
IX.	ELECTRICAL	LS	INCLUDED		20,000	20,000	20,000
X.	INSTRUMENTATION AND CONTROLS	LS	INCLUDED		10,000	10,000	10,000
XI.	PROCESS WATER SUPPLY	LS	INCLUDED		1,000	1,000	1,000
XII.	FOUNDATIONS AND PADS	LS	2,000	2,000	4,000	4,000	6,000
XIII.	HEALTH AND SAFETY	LS	INCLUDED		10,000	10,000	10,000
XIV.	MOBILIZATION/DEMOBILIZATION	LS	INCLUDED		20,000	20,000	20,000

Total Direct Construction Cost (TDCC)	221,700
Contingency @ 20% of TDCC	44,300
Engineering @ 10% of TDCC	22,200
Legal & Administrative @ 5% of TDCC	11,100
Total Construction Cost	299,300

TABLE B-8 (Sheet 1 of 2)
ALTERNATIVE GW13-4: *IN SITU* BIOLOGICAL TREATMENT

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I.	SITE PREPARATION						
	1. Security Fence	100 lf	18	1,800	8	800	2,600
	2. Warning Signs	2	80	160	20	40	200
II.	SUPPORT FACILITIES						
	1. Office Trailer	1	15,000	15,000	INCLUDED		15,000
	2. Decontamination Trailer	1	40,000	40,000	INCLUDED		40,000
III.	AIR SPARGE/SOIL VAPOR EXTRACTION SYSTEM						
	1. Sparge wells	20	1,000	20,000	1,000	20,000	40,000
	2. Vent wells	20	1,000	20,000	1,000	20,000	40,000
	3. Compressor	1	15,000	15,000	1,500	1,500	16,500
	4. Vacuum Blower	1	20,000	20,000	2,000	2,000	22,000
	5. Vapor Phase Carbon Treatment System	1	9,000	9,000	1,000	1,000	10,000
	6. Process piping	1,000 ft	1	1,000	5	5,000	6,000
	7. Pilot test	LS	INCLUDED		20,000	20,000	20,000
IV.	BUILDING	LS	10,000	10,000	INCLUDED		10,000
V.	ELECTRICAL	LS	INCLUDED		50,000	50,000	50,000
VI.	INSTRUMENTATION AND CONTROLS	LS	INCLUDED		25,000	25,000	25,000
VII.	FOUNDATIONS AND PADS	LS	2,000	3,000	4,000	4,000	6,000

TABLE B-8 (Sheet 2 of 2)
ALTERNATIVE GW13-4: IN SITU BIOLOGICAL TREATMENT

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost		Installation Cost		Direct Construction Cost*
			Unit	Total	Unit	Total	
VIII.	HEALTH AND SAFETY	LS	INCLUDED		10,000	10,000	10,000
IX.	MOBILIZATION/DEMOBILIZATION	LS	INCLUDED		20,000	20,000	20,000

Total Direct Construction Cost (TDCC)	333,300
Contingency @ 20% of TDCC	66,700
Engineering @ 10% of TDCC	33,300
Legal & Administrative @ 5% of TDCC	16,700
Total Construction Cost	450,000

TABLE B-9
ALTERNATIVE S13-1: NO ACTION

CAPITAL COST ESTIMATES (1996 DOLLARS)

Facility/Construction	Estimated Quantities	Material Cost		Installation Cost		Direct Construction Cost*
		Unit	Total	Unit	Total	
No Additional Action Required						

TABLE B-10
ALTERNATIVE S13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

CAPITAL COST ESTIMATES (1996 DOLLARS)

Facility/Construction	Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I. PUBLIC AWARENESS PROGRAM	LS	Included in installation		10,000	10,000	10,000
II. LAND USE RESTRICTIONS	LS	Included in installation		12,000	12,000	12,000
III. SECURITY						
1. Fence	100 lf	18	1,800	8	800	2,600
2. Warning signs	2	80	160	20	40	200

Total Direct Construction Cost (TDCC)	24,800
Contingency @ 20% of TDCC	5,000
Engineering @ 10% of TDCC	2,500
Legal and Administrative @ 5% of TDCC	1,200
Total Construction Cost	33,500

*All numbers are rounded to the nearest hundred.

TABLE B-11
ALTERNATIVE SC13-3: CAPPING

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I.	WELL ABANDONMENT	LS	Included in Installation		1,200	1,200	1,200
II.	ASPHALT	250 sf					
	1. Gravel Base	30 sy	2	60	2	60	100
	2. Asphalt Layer	250 sf	2	500	2	500	1,000
III.	GRADE CAP SURFACE	250 sf	Included in Installation				
IV.	LAND USE RESTRICTIONS		Included in Installation		12,000	12,000	12,000
V.	HEALTH AND SAFETY	LS			1,000	1,000	1,000

Total Direct Construction Cost (TDCC)	15,300
Contingency @ 40% of TDCC	6,100
Engineering @ 20% of TDCC	3,100
Legal & Administrative @ 10% of TDCC	1,000
Total Construction Cost	26,000

*All numbers are rounded to the nearest hundred

TABLE B-12
ALTERNATIVE S13-4: EXCAVATION/OFF-SITE TREATMENT AND DISPOSAL

CAPITAL COST ESTIMATES (1996 dollars)

Facility/Construction		Estimated Quantities	Material Cost Unit	Material Cost Total	Installation Cost Unit	Installation Cost Total	Direct Construction Cost*
I.	WELL ABANDONMENT	LS		0	1,200	1,200	1,200
II.	CONTAMINATED SOIL EXCAVATION	55 cy	0	0	12	660	700
III.	TRANSPORTATION	55 cy	Included in Item VI				
IV.	OFF-SITE TREATMENT AND DISPOSAL	55 cy	Included		210	11,600	11,600
V.	CLEAN FILL	55 cy	26	1,400	14	800	2,200
VI.	HEALTH AND SAFETY	LS			2,000	2,000	2,000

Total Direct Construction Cost (TDCC)	17,700
Contingency @ 40% of TDCC	7,100
Engineering @ 20% of TDCC	3,500
Legal & Administrative @ 10% of TDCC	1,800
Total Construction Cost	30,100

*All numbers are rounded to the nearest hundred

TABLE B-13
ALTERNATIVE GW12-1: NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. FIVE YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25, & 30
Total Present Worth of O&M**		$43,200	

* All numbers rounded to nearest hundred.
** Present worth analysis based on 30-year period and 7% discount rate.

TABLE B-14
ALTERNATIVE GW12-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. MONITORING			
1. Groundwater Sampling	2 persons @ $60/hr - 60 hrs/yr	7,200	1-30
2. Laboratory Analysis	16 water samples @ $200/sample	3,200	1-30
3. Report	1 person @ $90/hr - 80 hrs/yr	7,200	1-30
II. MAINTENANCE	8% of capital cost	1,800	1-30
III. CONTINGENCY	5% of annual O&M cost	1,000	1-30
Total Annual O&M Cost		20,400	1-30
Present Worth of O&M*		253,100	
IV. FIVE YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25, & 30
Present worth of reviews		43,200	
Total Present Worth of O&M**		$296,300	

* All numbers rounded to nearest hundred.
** Present worth analysis based on 30-year period and 7% discount rate.

TABLE B-15 (Sheet 1 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. EXTRACTION			
1. Power for groundwater extraction pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-17
II. COLLECTION			
1. Power for collection pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-17
III. FILTRATION SYSTEM			
1. Power for sludge pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-17
2. Power for filtrate pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-17
3. Off-Site Pretreatment Sludge Disposal	10 tons/yr @ $300/ton	3,000	1-17
4. Power for Treated Water Discharge Pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-17
5. Discharge to HRSD		2,000	1-17
IV. LABOR	1 operator @ $40/hr 8 hr/week	16,600	1-17

TABLE B-15 (Sheet 2 of 2)
ALTERNATIVE GW12-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
V. MAINTENANCE COST	8% of capital cost	17,400	1-17
VI. MONITORING	Sampling as per GW12-2 33,600	17,600	1-17
VIII. CONTINGENCY	5% of annual O&M cost	3,200	1-17
Total Annual O&M Cost	66,300		
Present Worth of O&M**	690,500		

* All numbers rounded to nearest hundred
** Present worth analysis based on 17-year period and 7% discount rate. Includes $43,200 for five-year reviews for a 30-year period.

TABLE B-16
ALTERNATIVE GW12-4: *IN SITU* BIOLOGICAL TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. AS/SVE SYSTEM			
1. Blower	50 HP @ $.10/kwh	32,700	1-3
2. Compressor	75 HP @ $.10/kwh	49,000	1-3
3. Carbon Replacement	2,000 lb/yr, @$2/lb	4,000	1-3
II. LABOR	1 operator @$40/hr 1 day/week	16,600	1-3
III. MAINTENANCE	8% of capital cost	36,700	1-3
IV. MONITORING	Sampling as per Alternative GW12-2	17,600	1-3
V. CONTINGENCY	5% of annual O&M cost	7,800	1-3
Total Annual O&M Cost	164,400		
Present Worth of O&M**	474,600		

* All numbers rounded to nearest hundred
** Present worth analysis based on 3-year period and 7% discount rate. Includes $43,200 for five-year reviews for a 30-year period.

TABLE B-17
ALTERNATIVE GW13-1: NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. FIVE YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25, & 30
Total Present Worth of O&M**		$43,200	

* All numbers rounded to nearest hundred.
** Present worth analysis based on 30-year period and 7% discount rate.

TABLE B-18
ALTERNATIVE GW13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. MONITORING			
1. Groundwater Sampling	2 persons @ $60/hr - 60 hrs/yr	7,200	1-30
2. Water Laboratory Analysis	16 water samples @ $200/sample	3,200	1-30
3. Report	1 person @ $90/hr - 80 hrs/yr	7,200	1-30
II. MAINTENANCE	8% of capital cost	1,800	1-30
III. CONTINGENCY	5% of annual O&M cost	1,000	1-30
Total Annual O&M Cost		20,400	1-30
Present Worth of O&M*		253,100	
IV. FIVE YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25, & 30
Present worth of reviews		43,200	
Total Present Worth of O&M**		$296,300	

* All numbers rounded to nearest hundred.
** Present worth analysis based on 30-year period and 7% discount rate.

TABLE B-19 (Sheet 1 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. EXTRACTION			
1. Power for groundwater extraction pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-20
II. COLLECTION			
1. Power for Feed pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-20
III. FILTRATION SYSTEM			
1. Power for Sludge Pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-20
2. Power for filtrate pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-20
3. Off-Site Pretreatment	10 tons/yr @ $300/ton	3,000	1-20
4. Power for Treated Water Discharge Pumps	At $0.10/KWH Total 2.0 HP 36 KWH/day	1,300	1-20
5. Discharge to HRSD		2,000	1-20
IV. LABOR	1 operator @ $40/hr 8 hr/week	16,600	1-20

TABLE B-19 (Sheet 2 of 2)
ALTERNATIVE GW13-3: EXTRACTION/PRETREATMENT/DISCHARGE TO POTW

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
V. MAINTENANCE COST	8% of capital cost	17,700	1-20
VI. MONITORING	Water sampling as per GW12-2	17,600	1-20
X. CONTINGENCY	5% of annual O&M cost	3,200	1-20
Total Annual O&M Cost	66,600		
Present Worth of O&M**	748,800		

* All numbers rounded to nearest hundred
** Present worth analysis based on 20-year period and 7% discount rate. Includes $43,200 for five-year reviews for a 30-year period.

TABLE B-20
ALTERNATIVE GW13-4: *IN SITU* BIOLOGICAL TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. AS/SVE SYSTEM			
1. Blower	@ $.10/kwh, 50 HP	32,700	1-3
2. Compressor	@ $.10/kwh, 75 HP	49,000	1-3
3. Carbon Replacement	2,000 lb/yr, @$2/lb	4,000	1-3
II. LABOR	1 operator @$40/hr 1 day/week	16,600	1-3
III. MAINTENANCE	8% of capital cost	26,700	1-3
IV. MONITORING	Sampling as per Alternative GW12-2	17,600	1-3
V. CONTINGENCY	5% of annual O&M cost	7,300	1-3
Total Annual O&M Cost	153,900		
Present Worth of O&M**	447,100		

* All numbers rounded to nearest hundred
** Present worth analysis based on 3-year period and 7% discount rate. Includes $43,200 for five-year reviews for a 30-year period.

TABLE B-21
ALTERNATIVE S13-1: NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. FIVE-YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25 & 30
Total Present Worth O&M**		$43,200	

* All numbers are rounded to nearest hundred.
** Present worth analysis based on a 30-year period and 7% discount rate.

TABLE B-22
ALTERNATIVE S13-2: LIMITED ACTION (INSTITUTIONAL CONTROLS)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 DOLLARS)

Item	Basis of Estimate	Annual O&M Cost Estimate*	Year
I. MONITORING			
1. Soil Sampling	2 persons @ $60/hr 40 hrs per year	4,800	1-30
2. Soil Laboratory Analysis	10 soil samples @ $1,000/sample	10,000	1-30
3. Report	1 person @ $90/hr - 80 hrs/yr	7,200	1-30
II. MAINTENANCE	8% of Capital Cost	2,000	1-30
III. CONTINGENCY	5% of annual O&M Cost	1,200	1-30
Total Annual O&M Cost Present Worth of O&M**		25,200 312,700	1-30
IV. FIVE YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25 & 30
Present worth of reviews		43,200	
Total Present Worth of O&M**		$355,900	

* All numbers rounded to nearest hundred.
** Present worth analysis based on 30-year period and 7% discount rate.

TABLE B-23
ALTERNATIVE S13-3: CAPPING

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate	Year
I. MAINTENANCE	8% of capital cost	1,200	1-30
II. CONTINGENCY	5% of annual O&M cost	100	1-30
Total Annual O&M Cost		1,300	1-30
Present Worth of O&M		16,100	1-30
III. FIVE-YEAR REVIEWS	$20,000 per review		5, 10, 15, 20, 25 & 30
Present Worth of Reviews		43,200	
Total Present Worth of O&M*		59,300	

* Present worth analysis based on 30-year period and 7.00% discount rate.
** All numbers rounded to nearest hundred.

TABLE B-24
ALTERNATIVE S13-4: EXCAVATION/
OFF-SITE TREATMENT AND DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1996 dollars)

Item	Basis of Estimate	Annual O&M Cost Estimate	Year
This Alternative Does Not Require Operation And Maintenance			

APPENDIX C

PROJECTED AQUIFER CLEANUP TIMES

APPENDIX C

PROJECTED AQUIFER CLEANUP TIME

Overview

The projected time to aquifer cleanup at each site was initially estimated using a flush model, which calculated the number of aquifer flush volumes, at a selected pumping rate, to reduce each of the groundwater compound concentrations to cleanup standards. A separate calculation was performed for each compound to estimate solute mass loss through intrinsic bioremediation, and the corresponding cleanup time.

The aquifer cleanup time for each compound was estimated by taking the lesser of the cleanup durations derived in the flushing and biodegradation models. Applied individually, the models are probably conservative, and actual cleanup times may be faster. Details of the flushing and bioremediation model are provided below.

Aquifer Flushing

The number of aquifer "flushes" needed to lower groundwater compound concentrations to an established MCL is mainly determined by the compound's distribution coefficient or Kd. The Kd quantifies the tendency of most organic compounds to sorb to an aquifer matrix and is approximated as follows (W. C. Walton, 1991):

Kd = [Soil-water coefficient (Koc)] x [Fraction of Organic Carbon (OC)]

The Kd for each groundwater compound was computed using published Koc values and an estimated aquifer carbon fraction of 0.005 or 0.5%. However, actual values are not available for the site. As shown in Table 3-1, highly mobile groundwater constituents like vinyl chloride have a low Kd, thus are weakly sorbed to the aquifer and are quickly removed by flushing. Conversely, pentachlorophenol strongly sorbs to the aquifer and would require an estimated 220 aquifer flush volumes to meet groundwater cleanup standards.

The model is conservative in that the maximum detected groundwater concentration is used as input for the model and concentration reductions due to recharge dilution, dispersion, biodegradation and other reactions are ignored.

Projected groundwater pumping rates were calculated for Sites 12 and 13 in order to establish an approximate cleanup period. The width of the capture zone, normal to groundwater flow, was determined by the corresponding plume (compound exceedence) width for sites 12 and 13. Groundwater data for this evaluation was obtained from the SRI. The projected capture zone width required for Site 12 is 225.0 feet at well LC12-GW4 and 275.0 feet across wells LC13-GW12 and LC13-GW13 for Site 13. Required groundwater extraction rates for each scenario were calculated using a analytical solution developed by Keely and Tsang (1983), which is rewritten as follows:

Q = Transmissivity (T) x Groundwater Gradient (I) x Capture Zone Width

Aquifer parameters were obtained from the pump test at Site 12 and groundwater elevation maps provided in the SRI. The model assumes homogeneous and isotropic aquifer conditions, a uniform flow field and discharge of the treated groundwater outside the influence (side or downgradient) of the system capture zone. Actual capture zone dimensions will be influenced by local variations in aquifer permeability, thickness and groundwater flow.

The extraction rate for site 12 was calculated at approximately 30 GPM and would probably require installation of two groundwater recovery wells. Site 13 may require installation of three recovery wells, at a total groundwater extraction rate of approximately 30 GPM. Based upon the aforementioned assumptions, initial aquifer cleanup times are 17 years for Site 12 and 20 years for Site 13. Calculations and model data are summarized in Table 3-1.

Aquifer Biodegradation

An analytical model can be used to predict the duration of an analyte in the aquifer, with or without active remediation. Since the biodegradation rate of most organic compounds has been shown to be logarithmic, a first order decay equation is used to calculate the duration of cleanup:

$$t = \frac{-ln\,(C/Co)}{K}$$

where:

C = final concentration (MCL)

Co = initial (maximum) concentration

$$k = \frac{0.693}{t_{1/2}}$$

$t_{1/2}$ = Compound half-life, and

t = time

A range of groundwater biodegradation rates were obtained for each compound in the "Handbook of Environmental Degradation Rates" (Howard et al., 1995). High and low biodegradation rates, corresponding to aerobic and anerobic aquifer environments, were averaged and applied to the calculation for each compound. This assumption allows for transient anaerobic conditions in the aquifer. Actual compound degradation rates will vary depending on the aquifer carbon content, dissolved oxygen concentration and the presence of other solutes. Applied compound degradation rates and estimated aquifer cleanup times are summarized in Table 3-1.

The biodegradation model is likewise conservative in that there is no allowance for dilution, dispersion and aquifer solute loss due to outflow (capture and treatment).